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Technical Report

**Access, Terminals, Transmission and Multiplexing (ATTM);
Reverse Power Feed for Remote Nodes**

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Foreword

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

Introduction

As various European operators consider the deployment of fibre-fed remote nodes that contain ADSL2+/VDSL2 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. ETSI TM6 has agreed to create a new document that defines a reverse power feed transmission standard and which allows European operators to source suitably compliant equipment for inclusion in their networks.

1 Scope

The present document identifies the scope of a reverse power feed standard or standards that will allow operators to be able to source suitably compliant equipment for inclusion in their networks.

The present document will identify the requirements for reverse power feed, consider the coexistence of reverse power feed with POTS and scenarios involving the deployment of reverse power feed for cabinet and distribution point locations.

Other issues for consideration include:

- Safety.
- Efficiency.
- Power Back-up.
- Performance monitoring (for further study).
- Reliability (for further study).
- Power-sharing (for further study).
- Billing (for further study).

Other issues such as local laws, unbundling rules and cost are considered out of scope.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

For a specific reference, subsequent revisions do not apply.

Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:

if it is accepted that it will be possible to use all future changes of the referenced document for the purposes of the referring document;

for informative references.

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

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2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

Not applicable.

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area. For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] IEEE 802.3: "LAN/MAN CSMA/CD (Ethernet) Access Method".

NOTE: Available at http://standards.ieee.org/getieee802/802.3.html.

[i.2] IR Cooper, DW Faulkner: "Reverse Powering Over DSL".

[i.3] ON Semiconductor AND8333/D: "High Power PoE Applications, On Semiconductor application sheet", April 2008.

[i.4] ETSI TR 102 614: "Environmental Engineering (EE); Reverse powering of small access network node by end-user equipment : A4 interface".

[i.5] 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.6] 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.7] ETSI TS 102 533: "Environmental Engineering (EE) Measurement Methods and limits for Energy Consumption in Broadband Telecommunication Networks Equipment".

[i.8] Code Of Conduct on Energy Consumption of Broadband Communication Equipment European Commission Directorate-General, Joint Research Centre; Final v2: 17 July 2007.

[i.9] CENELEC EN 60950-1: "Information Technology Equipment - Safety Part 1 General requirements (IEC 60950-1 2005 Modified)".

[i.10] CENELEC EN 60950-21: "Information Technology Equipment - Safety. Part 21 Remote Power Feeding (IEC 60950-21:2002)".

[i.11] BT contribution 08CC-020, "Remote Node Powering", ITU SG-15, Campbell, CA, 15-19 Sept. 2008.

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3 Abbreviations

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

CO	Central Office
CPE	Customer Premises Equipment
DP	Distribution Point
NTE	Network Termination Equipment
ONU	Optical Network Unit
PD	Powered Device
PoE	Power over Ethernet
POTS	Plain Old Telephony Service
POTSA	POTS - Analogue presentation
POTSD	POTS - derived
PSE	Power Sourcing Equipment
RFT	Remote Feeding Telecommunication
RGW	Residential GateWay
SELV	Safety or Separation Extra Low Voltage
SG	Service Gateway

TNV Telecommunication Network Voltage

4 Reverse Power Feed for Remote Nodes

4.1 Reverse Power Feed Background

The basic architecture of a reverse power feed system is shown below in figure 1.

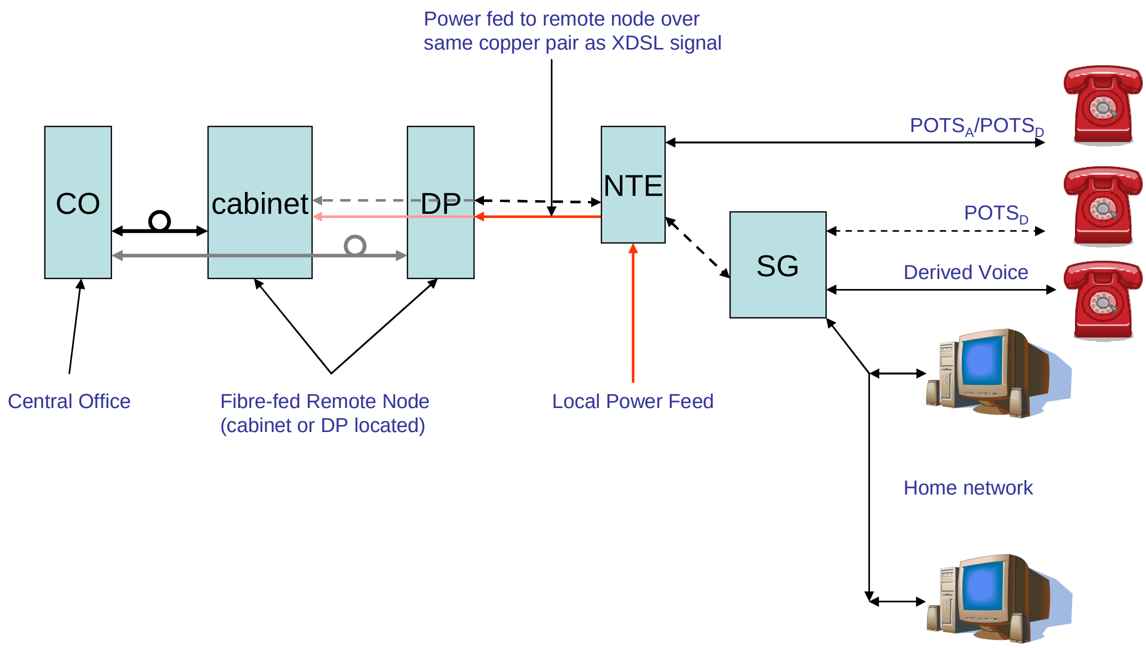

Figure 1: Generic Reverse Power Feed Architecture

Figure 1 shows power being injected at the NTE from a local power source (located within the home/building) which traverses the local loop to power a fibre-fed remote node which can be located at either the DP or 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 both with an analogue presentation (POTSA) at the NTE and also as a derived POTS service (POTSD). 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 whom/what is responsible for the powering of common circuitry contained within the node. It is easy to envisage that an individual user could be responsible for the powering of the remote line terminating/driver electronics corresponding to their particular circuit (see note). However, it is not so easy to determine who/what is responsible for powering of say the ONU that terminates the fibre link.

NOTE: In practice even this may not be easy to implement since DSL chipsets may be of an octal channel design and therefore all eight channels will be required to be powered in order to operate a single channel.

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. Also, there may be occasions where say a GPON feed requests a response from the ONU (for ranging or management purposes) when no users are currently connected and providing electrical power.

Such situations result in the requirement for battery back-up devices and these may be located in the SG, remote node itself or the cabinet providing that spare copper-pairs remain connected to the fibre-fed remote node. Figure 2 shows battery backup devices have been located in the NTE and fibre-fed remote node. It is envisaged that in order to provide high-reliability services (including lifeline POTS support) then a combination of battery back-up devices will be distributed throughout the network.

4.2 Power Backup Situations

4.2.1 Case 1 Battery Backup at the NTE

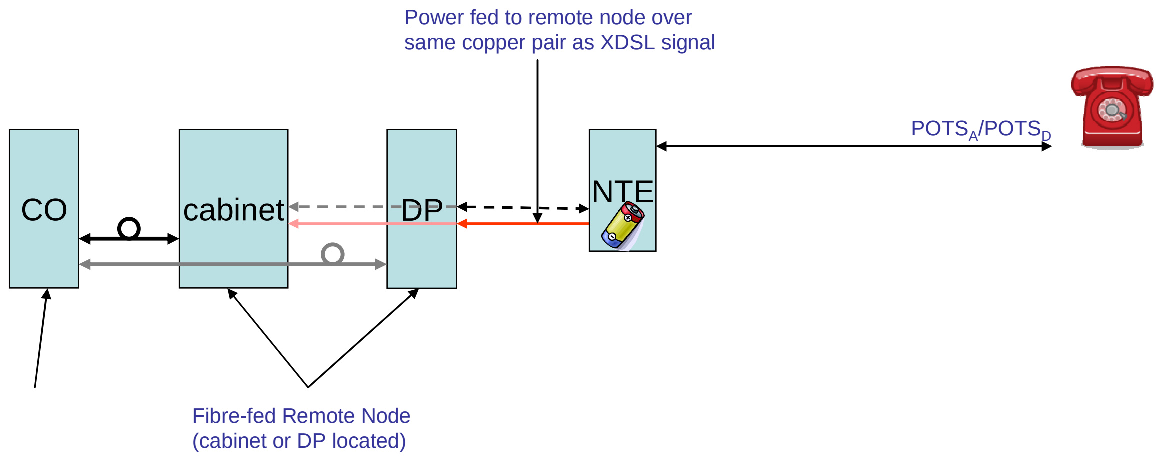

Figure 2: Battery Backup at NTE

Figure 2 shows the case where battery backup is placed at the NTE. The aim being that if there is a local power failure then lifeline POTSA (or maybe POTSD) plus OAM support at the remote node can be provided by the battery backup.

4.2.2 Case 2 Battery Backup at the DP and NTE

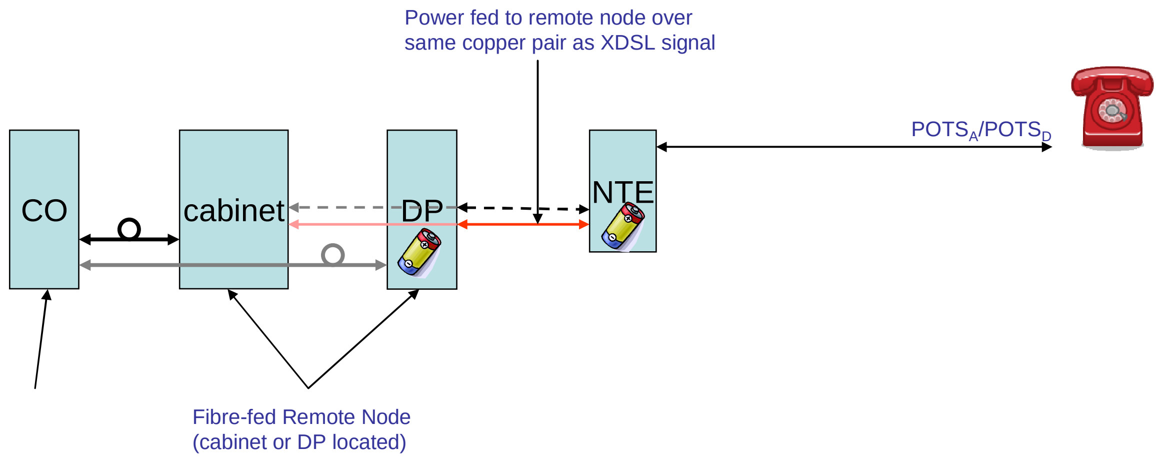

Figure 3: Battery Backup at the DP and NTE

Figure 3 shows the addition of another battery backup located at the DP. This gives the advantage in that equipment located at the DP can remain powered even though no subscribers are connected and thus retaining OAM support.

4.2.3 Case 3 Battery Backup at the DP Only

Figure 4 shows the battery backup being located only at the DP. This arrangement takes away the responsibility for backup from the subscriber - but probably means in practice that a larger capacity backup device is required when compared to Case 2.

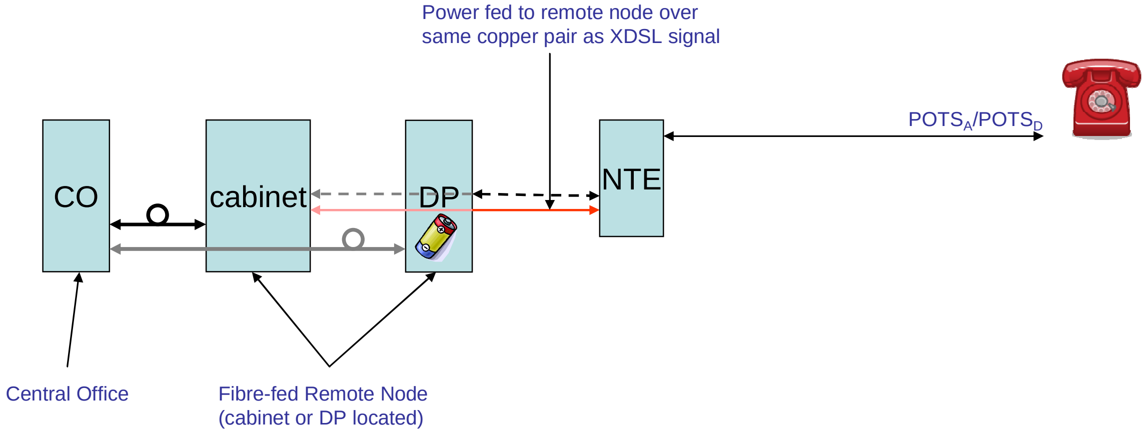

Figure 4: Battery Back-up at the DP

4.2.4 Case 4 Battery Backup at the DP and Cabinet

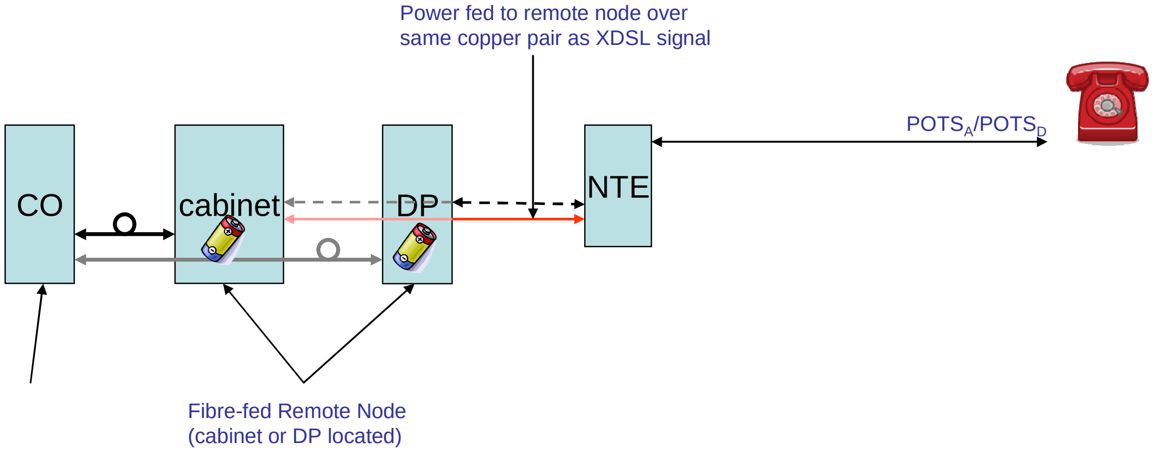

Figure 5: Battery Backup at the DP and Cabinet

Figure 5 shows the battery backup being located at the cabinet and the DP. This arrangement allows a smaller battery to be located at the DP. The battery at the cabinet could be reverse power charged from the DPs.

4.2.5 Case 5 Battery Backup at the DP and Cabinet with Forwards Powering from the CO

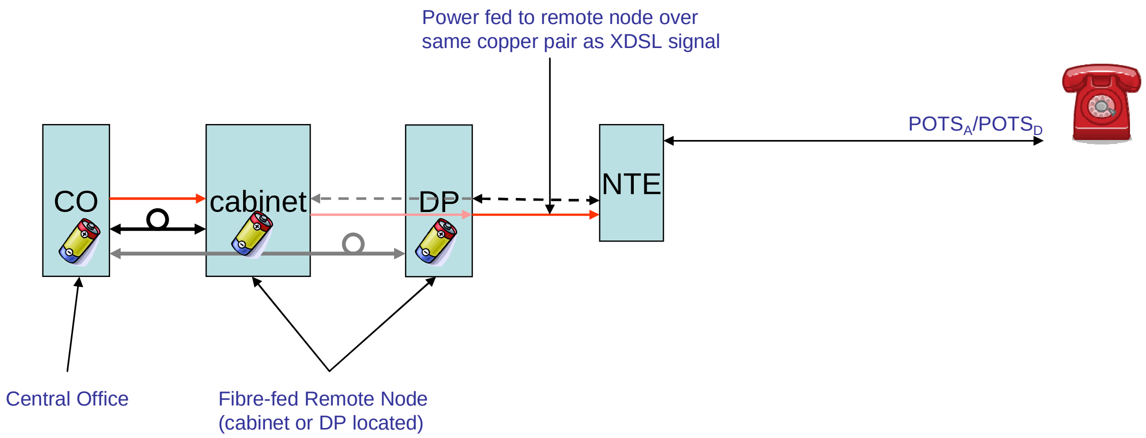

Figure 6: Forwards Powering from the CO

Figure 6 shows another option where the battery located at the cabinet is forwards power trickle charged from the CO. This instance relies upon there being copper cable still existing between the CO and the cabinet.

4.3 Options for Reverse Power and Forwards Power Feed

4.3.1 Reverse Power Feed to the DP

Reverse power feed to the DP is now considered in more detail. Figure 7 shows the sample lengths of 9 million drop-wires in the UK [i.2] (note the rise above 100 m is caused by all drop-wires above 100m being summed into a common bin). It can be clearly seen from figure 7 that the average length of a drop-wire (in the UK) is approximately 30 m.

Over such lengths, it is not necessary to operate at high voltages in order to reduce copper losses to an acceptable level and therefore it is possible to operate at SELV levels (60 V dc) in order to achieve a reasonably efficient reverse powering scheme.

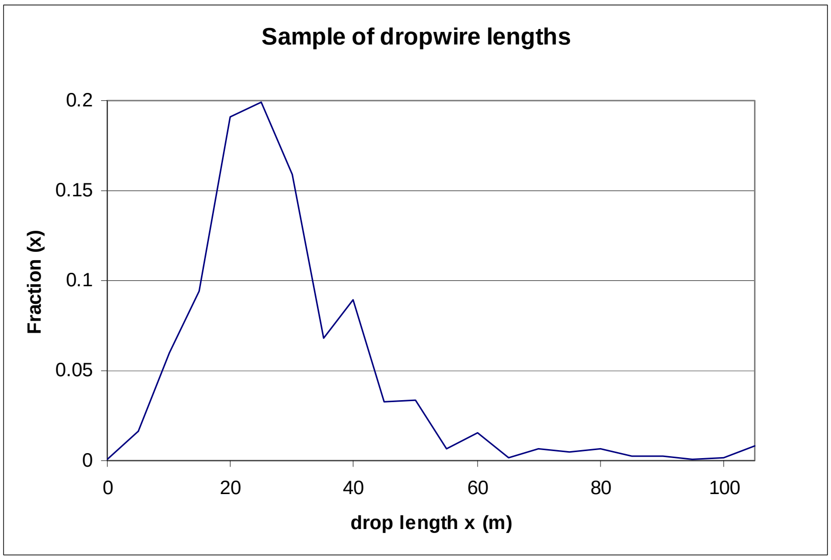

Figure 7: Sample UK Dropwire Lengths [i.2]

As a starting basis for such a powering scheme it would be possible to adopt/modify existing technology in the form of IEEE 802.3-2005 [i.1] (commonly known as IEEE 802.3af - Power over Ethernet) technology (PoE). This specification uses a line voltage of 36 V DC to 57 V DC (nominal voltage supply range for 48V powered equipment) over two of the four pairs of Cat 3/Cat 5e cable, with a current range of 10 mA to 400 mA subject to a maximum load power of 14,40 W. After cable losses, a maximum power of approximately 12,95 W is available to the remote device although another 10 % to 25 % of this can be lost due to inefficiency of the switched mode power supplies used.

PoE technology normally operates over 2 or 4 pairs of the Cat 3/Cat5e cable and therefore alternative coupling arrangements will have to be made in order to operate over a single pair. However, a large percentage of homes in the UK are fed with two-pair cable and therefore it would be possible to retain the same differential data transmission over each pair with transformer coupling with each pair acting in common-mode as one side of the DC supply. However, even if two pairs are used, it may be necessary to increase the existing PoE current limit beyond 400mA in order to be able to remotely power DSLAM equipment located at the DP when consideration is made regarding the power requirements of existing DSLAM technologies.

Note that a future standard, commonly known as PoE+ is being drafted by the IEEE 802.3at task force to extend the PoE using two pairs of Cat5e cable to be able to provide 24 W of power. Beyond this, proprietary solutions using up to 720 mA of current per line pair to provide 36 W of remote power feed on a single pair have also been devised [i.3].

4.4 Reverse Power Feed Architecture

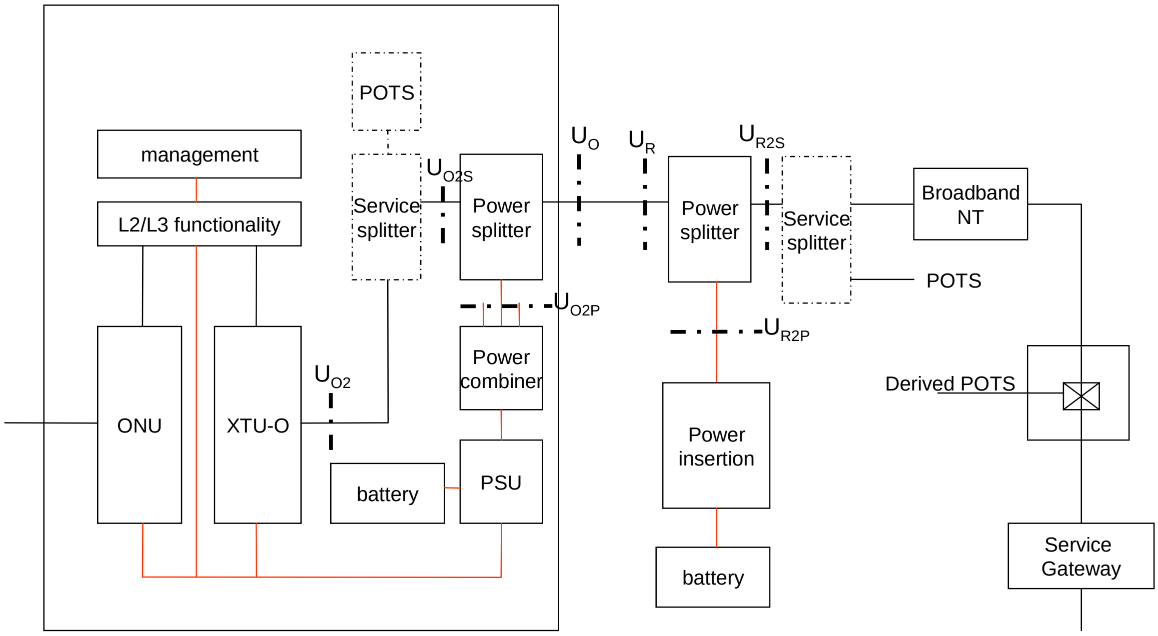

Figure 8

Figure 8 shows a reverse power feed reference model.

The reference model shown in figure 8 depicts a similar architecture to that given in the definition of the A4 interface from [i.4]. Here the ONU or remote DSL unit is located distant from the CO (FTTx) in a cabinet, underground or pole-top location, The FTTx equipment is common to N customers (x=Building, Curb, Pole-top, Node etc.) and is typically powered via a 48 V dc interface [i.5] via a power gathering/combining interface from the various copper pairs connected to the N customers connected to the remote node. A power splitter separates the signal (S) and power (P). Note that a battery backup device is shown in figure 8 to enable the ONU to be able to communicate to the PON feeder network even when there are no customers actively connected to the remote node.

At the CPE, the copper local loop is powered by a direct current source (also shown with battery back-up) and again connects to the home phone pair network (defined by the standard [i.6]). The power interface at this point is UR2P which is equivalent to the A4 interface as described by [i.4].

4.4 Reverse Power Feed Options

There should be compatibility with other architectures such as forwards powering of remote equipment from the CO or the provision of local mains powering.

There may be options to provide power back-up capability at the remote node and/or the in the customer premises i.e. the two battery locations depicted in figure 8.

It should be possible to combine these power-feed options, for example when there is not enough power to operate a remote node by reverse powering from a single customer alone. Under such circumstances it should be possible to augment this power with forwards power from the CO or local mains derived power.

When mains powering is the preferred option it should be possible to provide power back-up using reverse powering.

4.5 U_{R2P} Electrical Interface

4.5.1 Current standards in force

The present document covering the safety of information technology equipment with particular reference to remote power feeding is EN 60950-21 [i.10]. Remote Power feeding equipment using voltages higher than SELV should comply with the requirements of the present document.

4.5.2 Telecommunications cables

The most common type of telecommunications cable in use today employs solid copper conductors with a diameter of between 0,4 mm and 0,9 mm. In modern cable the conductors are insulated using polyethylene which has either a cellular, foam skin or solid construction. Older cables that are in service would have paper or PVC insulation.

The polyethylene insulated cable with solid insulation is better able to support higher feeding voltages than the cellular insulation cable especially if there is moisture ingress in the cable. Oxidation or corrosion of conductors or connection strips can also be found on circuits carrying higher than the normal ~50 V commonly used for the PSTN service.

Manufacturers of telecommunications cables are reluctant to specify cables up to the higher RFT voltage levels. Typical information on the dielectric strength testing is given as withstanding between 1 kV and 5 kV for 3 s for wire to wire and up to 6 kV for 3 s wire to earth.

Operators using remote power feeding would need to be aware of the limitation of the insulation of the cable and other access network plant (e.g. over voltage protection) in the network.

4.5.3 Safety of personnel

While EN 60950 tends to focus on physiological damage as a direct result of an electric current passing through the human body, there are other health and safety issues that may need to be considered for personnel working on access network plant that carries high voltages. As the specification states the current that passes through the human body from these RFT circuits will not in itself cause physiological damage but the person will still receive a definite electric shock and the spontaneous reaction to that shock may result in injury e.g. hand injury if it is pulled back quickly and hitting some nearby object or the reaction may cause a person to lose balance and fall.

However there are other signals present in the telecommunications access network that can also deliver electric shocks on contact with conductive parts of the circuit e.g. ringing on PSTN or Telex signalling using ±80 V (probably now historic). Therefore personnel working on the telecommunications access network should have training to expect that circuits may give a non hazardous electric shock and should have any protective equipment necessary to ensure their safety.

4.6 ONU Power Consumption

The power consumption is based on the target value per line of TS 102 533 [i.7] measured at the UR2P interface. The power consumption for one ONU port has to be compliant with BBCoC values [i.8]. It should be calculated including the power loss in the copper line.

Starting from 01/01/2008, VDSL2 line power should be lower than 2,5 W for ONU 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.5]. If standby modes are available, this will reduce the end-user power consumption and improve back-up autonomy.

Ultimately, the target power consumption for the ONU or remote DSL equipment per line should be <1,0 W (including power loss in the copper line). Power consumption should be scaleable with regards to the number of active lines and also proportional to the amount of data being transmitted over the copper link. Figure 9 (taken from Reference [i.11]) shows the expected future trend of remote DSLAM power consumption.

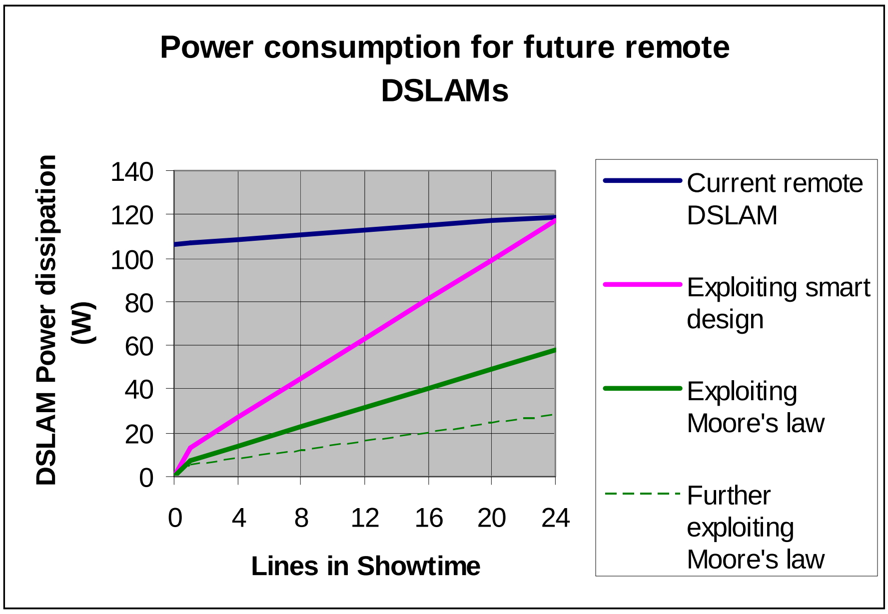

Figure 9: Power Consumption for Future Remote DSLAMS

4.7 Reverse Power Feed Specification

The following clauses describe two scenarios each with its own electrical standard for reverse powering. For short lines (up to 200 m) then the standard described in clause 10.1 should be followed. This is essentially a voltage limited standard (60 V) which is also current limited (300 mA). For longer lines (with associated larger copper losses), a lower current limit is necessary (60 mA) which necessitates a higher maximum injection voltage (200 V). Such a system is described in clause 10.2.

4.7.1 Distribution Point Reverse Powering

The maximum voltage that may be applied to the UR2S interface is 50 V with current limited to 40 mA.

The maximum voltage/currents limit that will apply at the UR interface is:

60 V@300 mA limit (RFT-V Circuit voltage limited (EN 60950-21 [i.10], clause 6.2)

The maximum voltage/current that is injected into the network before a suitable sink has been recognised is 50 V@40 mA. This is to ensure that if a reverse power feed capable CPE device is inadvertently connected to an un-terminated line, the voltage/current applied to that line is no higher than that which is expected to be present on the line.

The 60 V SELV limit is useful for consideration of a self-install reverse power feeding solution and as mentioned in Clause 5.1 it is compatible with PoE powering solution silicon.

Figure 10 shows the situation for the 60 V case where a range of approximately 70 m is possible before the power dissipation in the line reaches 1 W. It should be noted that this graph extends to a range of 200 m, however, the expected that the bulk of practical reverse powering operation is expected to be at ranges of less than 40 m (as depicted in figure 7).

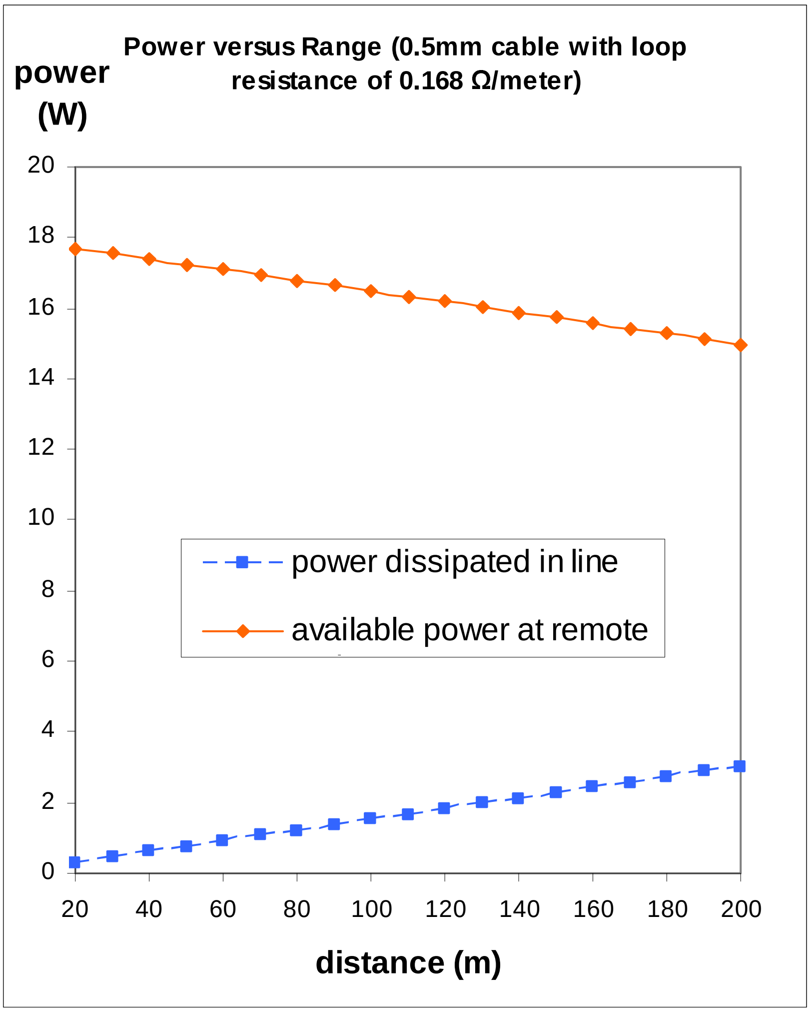

Figure 10: Range versus Power for Reverse Power Feed (60 V@300 mA)

4.7.2 Cabinet Reverse Powering

The maximum voltage that may be applied to the UR2S interface is 50 V with current limited to 40 mA.

The maximum voltage/currents limit that will apply at the UR interface is:

200V@60 mA limit (RFT-C Circuit current limited (EN 60950-21 [i.10], clause 6.1).

The maximum voltage/current that is injected into the network before a suitable sink has been recognised is 50 V@40 mA. This is to ensure that if a reverse power feed capable CPE device is inadvertently connected to an un-terminated line, the voltage/current applied to that line is no higher than that which is expected to be present on the line.

Figure 11 shows the situation for the 140 V case where a range of approximately 1 600 m is possible before the power dissipation in the line reaches 1 W.

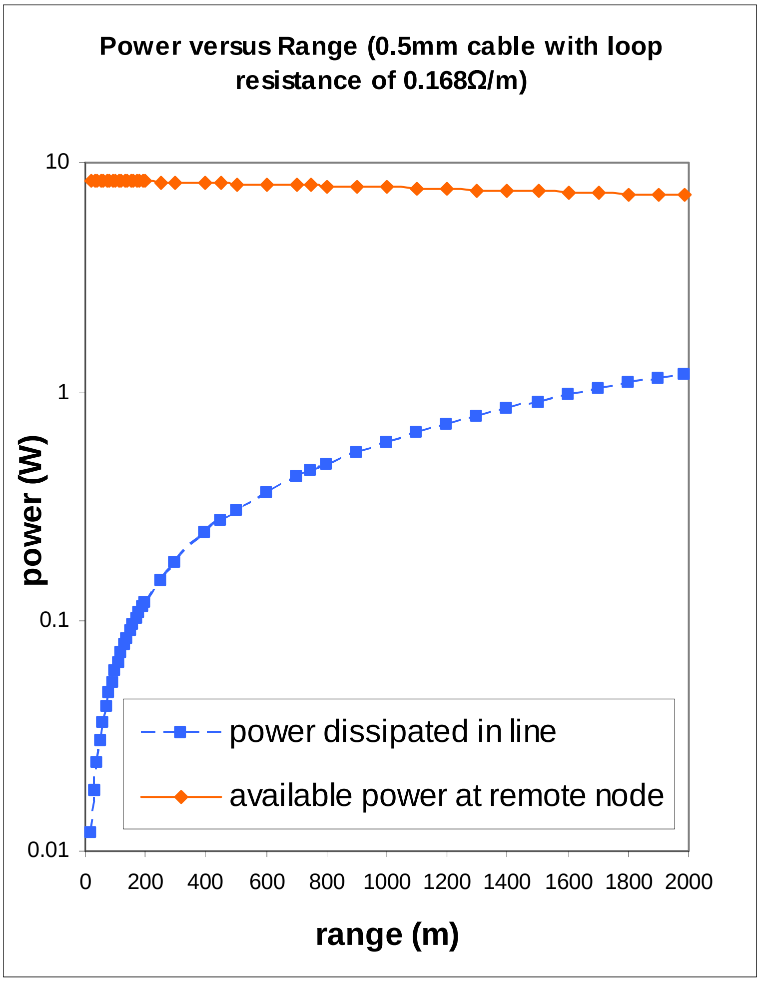

Figure 11: Range versus Power for Reverse Power Feed (140 V@60 mA)

4.8 Reverse Power Feed and Pots

Lifeline Support

Lifeline POTS can be supplied via 2 main methods:

1) Traditional POTS via SLICs in the fibre-fed remote (64 kbit/s channelized service).

2) VoIP based derived POTS using the DSL link.

NOTE: Under power-outage conditions the DSL can revert to a low-power mode that has sufficient capacity to transport a 64 kbit/s POTS channel.

However this method relies upon the NTE/SG also having an operational battery back-up system (the serviceability of which is reliant upon the subscriber and therefore method 1) above is the more preferred POTS supply method for lifeline services.

This clause to include:

- Options available to support reverse power feed both with/without POTS (for further study).
- Options to handle POTS signalling in the presence of reverse power feed (for further study).

4.9 Reverse Power Feed States

This clause to include:

- Definition of powering states of the power feed system, and power feed states that remote nodes will be required to support. (for further study).

- Define the requirements for a state transition specification for each scenario considered. (for further study).

4.10 Concatenated Reverse Power Feed Architectures

This clause to include:

- Consideration of scenarios where a mixture of forward, reverse, and local power feed methods may be utilised, taking account of the physical locations where the operator has easy access to the plant and external power supply sources. (for further study).

NOTE: Reverse power feed scenarios are not going to only exist between CPE and distribution point powering but also be involved with various forward powering schemes from both the local exchange or the remotely powered cabinet. It is important to understand the combinations of forward and reverse powering that may exist and what impacts these will have upon lifeline support and general operational availability of remote nodes.
Reverse powering may be used to augment forward powering in some circumstances when, for example, there are insufficient spare copper pairs for a complete forward powering solution.

4.11 Power Sharing/Billing Model

This clause to include:

- Consideration of various power sharing policies that could be applied to regulate the amount of power taken from each active customer's CPE. (for further study).

NOTE: The policies may require power demand to be fairly shared amongst this group, or if the customer is financially compensated for the power taken then power metering may be required.

Consideration of the other following issues:

- What information is required to support billing - e.g. energy provided?

- If so how is received power to be measured on a line-by-line basis?

- Should power provided be measured at the CPE or at the remote node?

- How is differentiation performed between essential power extraction for operation and power extracted to perform auxiliary tasks such as battery charging?

4.12 External Requirements on the Reverse Power Feed

This clause to include consideration of the following issues:

- What POTS features need to be considered when considering reverse power feed e.g. caller ID, line reversal, loop disconnect, ringing (in-band/out-of-band) etc. (for further study).

- Impact upon remote line testing (for further study).

- Monitoring/control of powering status by network management system (for further study).

- ONU dying gasp - activated when all powering options are failing before all power gone (for further study).

- Alarm generation (for further study).

- Requirements of PON feeder system (for further study).

History

Document history		
V1.1.1	November 2009	Publication