



**Environmental Engineering (EE);
Measurement Methods and Limits for Power Consumption in
Broadband Telecommunication Networks Equipment**

Reference

DES/EE-00015

Keywords

broadband, power supply

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Important notice

Individual copies of the present document can be downloaded from:

<http://www.etsi.org>

The present document may be made available in more than one electronic version or in print. In any case of existing or perceived difference in contents between such versions, the reference version is the Portable Document Format (PDF). In case of dispute, the reference shall be the printing on ETSI printers of the PDF version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at

<http://portal.etsi.org/tb/status/status.asp>

If you find errors in the present document, please send your comment to one of the following services:

http://portal.etsi.org/chaicor/ETSI_support.asp

Copyright Notification

No part may be reproduced except as authorized by written permission.
The copyright and the foregoing restriction extend to reproduction in all media.

© European Telecommunications Standards Institute 2011.
All rights reserved.

DECT™, **PLUGTESTS™**, **UMTS™** and the ETSI logo are Trade Marks of ETSI registered for the benefit of its Members.
3GPP™ and **LTE™** are Trade Marks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.
GSM® and the GSM logo are Trade Marks registered and owned by the GSM Association.

Contents

Intellectual Property Rights	4
Foreword.....	4
Introduction	4
1 Scope	5
2 References	5
2.1 Normative references	5
2.2 Informative references.....	6
3 Definitions and abbreviations.....	6
3.1 Definitions	6
3.2 Abbreviations	7
4 Definition of power consumption.....	7
4.1 Definition of power consumption per port of broadband network equipment	7
4.2 Power consumption taking into account the low-power states.....	8
5 Measurement methods.....	8
5.1 General requirements	8
5.1.1 Measurement conditions	8
5.1.2 Measurement instruments requirements	9
5.1.3 Considered equipment	9
5.1.4 Not considered equipment	9
5.1.5 Measurement reference points	10
5.1.6 Traffic profile.....	10
5.2 Measurement method for DSLAM/MSAN equipment	10
5.2.1 Equipment configuration	10
5.2.2 Reference measurement method	12
5.3 Measurement method for OLT equipment	13
5.3.1 Equipment configuration	13
5.3.2 Reference measurement method	13
5.4 Alternative measurement method.....	14
5.5 Reporting of the measurements	15
Annex A (informative): Power consumption limits	16
A.1 DSLAM power limits.....	16
A.2 MSAN POTS power limits.....	17
A.3 OLT power limits	18
Annex B (informative): Example hourly traffic distribution profiles	19
Annex C (informative): NPC definition and calculation examples	20
Annex D (informative): Measurement power consumption for DSLAM/MSAN and OLT equipment for different number of active ports.....	21
Annex E (informative): Bibliography.....	22
History	23

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: "*Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards*", which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<http://ipr.etsi.org>).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

This final draft ETSI Standard (ES) has been produced by ETSI Technical Committee Environmental Engineering (EE), and is now submitted for the ETSI standards Membership Approval Procedure.

Introduction

The present document defines the energy consumption limits and measurement methods for fixed broadband telecommunication network equipment.

1 Scope

The present document defines the power consumption limits, the methodology and the test conditions to measure the power consumption of broadband fixed telecommunication networks equipment. Some proposal power consumption limits are provided as informative data.

The document does not cover all possible configuration of equipment but only homogenous configuration

The types of broadband access technologies covered by the present document are the ones widely deployed at the date of publication. Currently, the present document considers DSLAM DSL, MSAN, GPON OLT, Point to Point OLT equipment. Other access technologies may be included in further versions of the present document.

In addition to the full power state, power-saving states as defined in DSL standards [i.1] and [i.2] are also covered.

The present document focuses on Network Equipment. The end-user equipment will be handled in another document.

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.

- [1] ETSI TS 101 388: "Access Terminals Transmission and Multiplexing (ATTM); Access transmission systems on metallic access cables; Asymmetric Digital Subscriber Line (ADSL) - European specific requirements [ITU-T Recommendation G.992.1 modified]".
- [2] ETSI EN 300 132-2: "Environmental Engineering (EE); Power supply interface at the input to telecommunications and datacom (ICT) equipment; Part 2: Operated by -48 V direct current (dc)".
- [3] ETSI TS 101 271 (V1.1.1): "Access Terminals Transmission and Multiplexing (ATTM); Access transmission system on metallic pairs; Very High Speed digital subscriber line system (VDSL2); [ITU-T Recommendation G.993.2 modified]".
- [4] IEC 60038 (Ed. 7.0): "IEC standard voltages".
- [5] ETSI ES 201 970: "Access and Terminals (AT); Public Switched Telephone Network (PSTN); Harmonized specification of physical and electrical characteristics at a 2-wire analogue presented Network Termination Point (NTP)".
- [6] ITU-T Recommendation G.984: "Gigabit-capable Passive Optical Networks (GPON)".
- [7] ITU-T Recommendation G.984.2: "Gigabit-capable Passive Optical Networks (G-PON): Physical Media Dependent (PMD) layer specification".
- [8] IEEE 802.3: "IEEE Standard for Information technology-Specific requirements -- Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications".

- [9] Broadband Forum TR-100: "ADSL2/ADSL2plus; Performance Test Plan".
- [10] Broadband Forum TR-114: "VDSL2 Performance Test Plan".

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] ITU-T Recommendation G.992.3 (2005): "Asymmetric digital subscriber line transceivers 2 (ADSL2)".
- [i.2] ITU-T Recommendation G.992.5 (2005): "Asymmetric Digital Subscriber Line (ADSL) transceivers - Extended bandwidth ADSL2 (ADSL2plus)".
- [i.3] ITU-T Recommendation G.993.2 (2006): "Very high speed digital subscriber line 2 (VDSL2)".
- [i.4] ETSI TR 102 530: "Environmental Engineering (EE); The reduction of energy consumption in telecommunications equipment and related infrastructure".
- [i.5] Broadband Forum TR-202: "ADSL2/ADSL2plus Low-Power Mode Guidelines".
- [i.6] Code of Conduct on Energy Consumption of Broadband Equipment, European Commission Directorate-General, Joint Research Centre.

3 Definitions and abbreviations

3.1 Definitions

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

active line: line in operational mode and carrying traffic as specified for that mode of operation (ADSL2plus or VDSL2)

broadband telecommunication network equipment: equipment of broadband technology that is part of a telecommunication network

broadband terminal equipment: equipment of broadband technology that is connected beyond the Network Termination Point of a telecommunication network

full-power state: state in which the maximal allowed data transmission is possible

NOTE: The maximum is defined by the physical properties of the line and the settings of the operator (e.g. L0 for ADSL2/2plus).

low-power state: state in which a limited power reduction capability and a limited data transmission is allowed

NOTE: It is entered automatically from the full power state after the data transmission during a certain time is lower than the limit. If more than the limited data has to be transmitted from either side a state change to the full power state is entered automatically. The low power state may comprise multiple sub-states with history dependant state transition rules (e.g. L2 for ADSL2/2plus).

power consumption: power used by a device to achieve an intended application performance

stand-by state: state in which the largest power reduction capability and no transmission of data is possible

NOTE: From this state a direct state change to the full-transmission state is possible, if data has to be transmitted from either side (e.g. L3 for ADSL2/2plus).

telecommunication network: network operated under a license granted by a national telecommunications authority, which provides telecommunications between Network Termination Points (NTPs) (i.e. excluding terminal equipment beyond the NTPs)

3.2 Abbreviations

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

AC	Alternative Current
ADSL	Asymmetric Digital Subscriber Line
ADSL2plus	Second generation ADSL with extended bandwidth
CPE	Customer Premises Equipment
DBA	Dynamic Bandwidth Allocation
DC	Directive Current
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexer
DSM	Dynamic Spectrum Management
GPON	Gigabit Passive Optical Network
IP	Internet Protocol
MAC	Media Access Control
MELT	Metallic Loop Test
MIMO	Multiple Input Multiple Output
MPLS	Multiprotocol Label Switching
MSAN	Multi Service Access Node
NPC	Normalized Power Consumption
OLT	Optical Line Termination
ONU	Optical Network Unit
POTS	Plain Old Telephone Service
PSTN	Public Switched Telephone Network
QoS	Quality of Service
VAC	Ventilation Air Conditioning
VDSL	Very high speed Digital Subscriber Line
VDSL2	second generation VDSL
VLAN	Virtual Local Area Network

4 Definition of power consumption

4.1 Definition of power consumption per port of broadband network equipment

The power consumption of broadband telecommunication network equipment is defined as:

$$P_{\text{BBport}} = P_{\text{BBeq}} / N_{\text{ports}}$$

Where:

P_{BBeq} is the power consumption (in W) of a fully equipped broadband network equipment, measured at the electric power input interface, placed at the premises of the operator or the equipment supplier, which connects multiple broadband subscribers to a backbone. P_{BBeq} is measured in determined environmental conditions defined in clause 5.1.1.

P_{BBport} is the power consumption per port in W of the broadband network equipment for which the limits are defined in the present document.

N_{ports} is the maximum number of subscriber lines access ports served by the broadband network equipment under test.

4.2 Power consumption taking into account the low-power states

The low-power states are intended to reduce the power consumption during periods of no or minimal traffic needs (e.g. low data-rate applications or control signalling only). When these low-power states are used, the achievable power consumption reduction can be estimated by using profiles based on user traffic assumptions, some example of user hourly traffic as illustrated in annex B.

NOTE 1: Example of power-saving states usage.

A number of power-saving states are defined in the DSL standards (L2, L3, ITU-T Recommendations G.992.3 [i.1] and G.992.5 [i.2]). These power-saving states are implemented, both in the Network equipment (i.e. the subject of the present document) and the CPE/end-user equipment deployed at the premises of the user of the broadband line; this will enable the operator to use these to further limit the power consumption of the equipment. Further study is required to optimize the way in which the low-power states are controlled. In particular, to determine the levels of interference that might arise due to the fluctuating crosstalk caused by frequent multi-state power transitions.

It is important to notice that it is only possible for GPON to use stand-by state if all ONU are in stand-by state and not individually as possible for Point-to-Point transmission.

NOTE 2: Additional power saving solutions. A number of additional power saving solutions are available. Some of these are listed below. However the list is not complete and both the developers and users of broadband network equipment are encouraged to investigate and introduce new power saving solutions:

- Politeness algorithms.
- Dynamic Spectrum Management.
- Boards optimized for remote applications (reduced line power).
- Dynamic power saving for unused components such as line card, chipset, port, etc.

5 Measurement methods

This clause describes the methods to measure the power consumption of broadband network equipment and also gives the conditions under which these measurements shall be performed.

5.1 General requirements

5.1.1 Measurement conditions

The power measurements shall be performed in a laboratory environment under the following conditions:

- Room Temperature: $25\text{ °C} \pm 2\text{ °C}$.
- Room Relative Humidity: 30 % to 75 %.
- Operating voltage:
 - DC Powered Equipment: According to EN 300 132-2 [2], $-54,5\text{ V} \pm 1,5\text{ V}$ for nominal voltage of -48 V DC powered equipment. Equipment using voltage other than -48 V DC shall be tested at $\pm 1\%$ of the nominal voltage.
 - AC Powered Equipment: According to IEC 60038 [4], $230\text{ V} \pm 1\%$ for nominal voltage of 230 V AC and frequency $50\text{ Hz} \pm 1\%$.

- Minimum Measurement Duration: Equipment shall be allowed to stabilize to get stable power measurement. If power varies over the measurement interval time, an average of measurement shall be calculated:
 - For DSLAM equipment, wait 1 minute to settle bitswap after entering L0 mode. After entering L2 mode, wait one more minute after achieving the final trimmed power level.
 - For OLT equipment, wait till OLT and the connected ONUs have finished ranging and dynamic bandwidth allocation (DBA). The DBA will ensure that any unused bandwidth on a specific GPON port is allocated to the ONUs connected to it.

5.1.2 Measurement instruments requirements

All measurement instruments used should be calibrated by counterpart national metrology institute and within calibration due date, and the measurement tolerance must be within ± 1 %:

- Power Source: Power sources used to provide power to the equipment under test shall be capable of providing a minimum of 1,5 times the power rating of the equipment under test.
- Power Measurement Instrument: Power measurement instrument (such as voltmeter and amperometer or power analyzer) shall have a resolution of 0,5 % or better. AC power measurement instrument shall have the following minimum characteristics:
 - 1) A minimum digitizing sample rate of 40 kHz.
 - 2) Input circuitry with a minimum bandwidth of 80 kHz.
 - 3) It shall be capable of accurate readings of waveforms having. Crest Factor up to at least 5.

5.1.3 Considered equipment

The following items are considered part of the broadband network equipment and therefore their power consumption shall be taken into account to get the total power consumption (P_{BBeq}) of the broadband network equipment:

- Network Termination board, providing one or more links to the Core or Backhaul Network.
- NOTE: The actual number of links should reflect the normal resilience practice for that type of equipment. Furthermore, all uplink ports should carry test traffic averaged or approximatively averaged.
- Line Termination board, providing a number of DSL, POTS, GPON or Point to Point Ethernet ports connected to the end-user through the metallic lines or optical fibre.
 - Backplane (or other) to interconnect the different blocks of the broadband network equipment.
 - Inside Rack Cooling system (e.g. fans drawer inside cabinet based broadband systems).
 - Normal operational power supply unit.

5.1.4 Not considered equipment

The following items are not considered part of the broadband network equipment and therefore their power consumption shall not be added to the power consumption of the broadband network equipment:

- External rectifier (AC - DC converter).
- Room or outdoor Cabinet Ventilation and Air Conditioning Unit (VAC Unit).
- Auxiliary or redundant power unit.
- Battery.
- For DSLAM equipment, Additional External signal processing (Dynamic Spectrum Management (DSM) and Multiple Input Multiple Output (MIMO) techniques if not implemented as part of the Line Termination board).

For those boards which have more than the bare DSL functionality but have additional functions (e.g. MELT, vectoring, test access and channel bonding, etc.), these boards are to be used in normal DSL mode of operation with such additional functions disabled. Optionally a measurement with these functions enabled can be described/requested. In case such additional functions cannot be fully disabled, manufacturer will declare what is the extra power budget due to the added functionality. Such extra budget will not be considered in P_{BBport} .

5.1.5 Measurement reference points

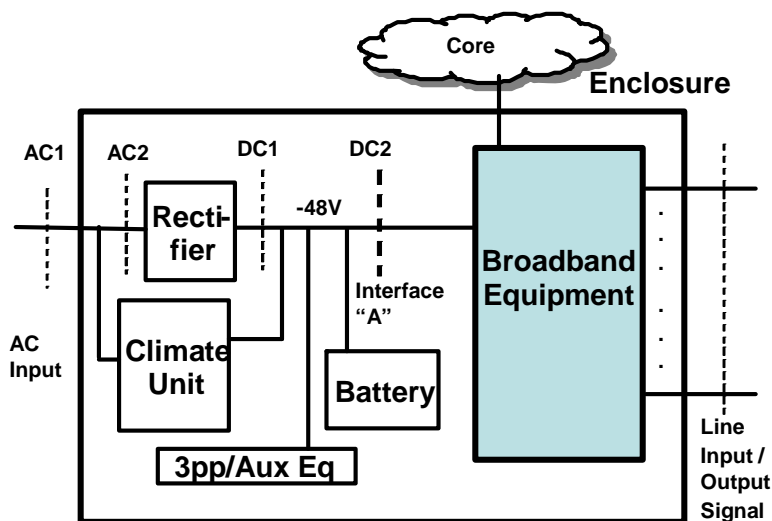


Figure 1: Broadband Node site reference model

The power consumption requirements of the present document apply at Interface "A" [2] as shown in figure 1 (i.e. at the point DC2 for the configuration in figure 1).

5.1.6 Traffic profile

Definition of Ethernet traffic:

- Bridge mode.
- Random variable packet size distribution from 64 octets to 1 518 octets (bytes).
- Traffic rates limited to 80% of net activation rate (takes overhead into account).

Traffic shall flow in both directions, but due in case of Upstream and Downstream possible asymmetry, loop-back mode is not allowed except for Point-to-Point OLT.

5.2 Measurement method for DSLAM/MSAN equipment

In the present document only homogenous configuration are measured. Mixed configuration (e.g. DSLAM with a mix of ADSL2/2plus, VDSL2 and optical interfaces) are not considered.

5.2.1 Equipment configuration

Active lines shall be carrying traffic over an ETSI loop 1, as defined in TS 101 388 [1] and TS 101 271 [3], without any additional noise. The loop length is dependent on the DSL technology (see ITU-T Recommendations G.992.3 [i.1], G.992.5 [i.2] and G.993.2 [i.3]) activated on the line. The test set-up is as shown in figure 2.

Equipment conditions:

- ADSL2plus configuration:
 - Loop length/type: see table 1.
 - Full power state is configured as follows:
 - Common line settings: as defined in BBF TR-100, table 7-1 [9].
 - General test profile: F-1/0 as defined in BBF TR-100, table 7-2 [9].
 - Specific test Profile: A2P_RA_F_30000k as defined in BBF TR-100, table 7-3 [9].
 - DPBO shall be off.
 - Low power state is configured as following:
 - PMMODE: L2 state enabled (Low power state).
 - L0-TIME: as defined in BBF TR-100, table B.2-25 [9].
 - L2-TIME: as defined in BBF TR-100, table B.2-25 [9].
 - L2-ATPR: 1 dB.
 - L2-ATPRT: in the range -1 dB to -31 dB. Manufacturer shall declare the minimum L2-ATPRT value necessary to respect the requirements of table A.1.

NOTE 1: L2-ATPRT parameter defines the total maximum aggregate transmit power reduction that is allowed in L2 state. As such matching L2 power consumption targets with L2 value close to -1 dB is better (higher efficient) than matching the same targets but with L2 value close to -31 dB.

- L2-MinDatarate: ≥ 128 kbps.

NOTE 2: For real network implementation a reference for the setting can be found in BroadBand Forum documents TR-202 [i.5], for example L2 ATPRT ≤ 10 dB.

- VDSL2 configuration:
 - Loop-length/type: see table 1.
 - Common line settings: as defined in BBF TR-114, table 11 [10].
 - General line settings: I-8/2 as defined in BBF TR-114, table 12 [10].
 - Specific test Profile: RA_I_150_150 as defined in BBF TR-114, table 13 [10].
 - Both DPBO and UPBO shall be off.

Table 1: Loop-lengths for various DSL technologies

Technology	Loop length	Reference loop	Reference document
ADSL2plus	2 500 m	TS 101 388 [1] loop#1	BBF TR-100, table A.2-19 [9]
VDSL2 profile 8a, 8b, 8d	1 200 m	ETSI PE04	BBF TR-114, table 57 [10]
VDSL2 profile 8c	1 200 m	ETSI TP100	BBF TR-114, table 85 [10]
VDSL2 profile 12a, 12b	450 m	ETSI PE04	BBF TR-114, table 59 [10]
VDSL2 profile 17a	450 m	ETSI PE04	BBF TR-114, table 61 [10]
VDSL2 profile 30a	150 m	ETSI PE04	
NOTE:	The above DSL technologies and profiles are defined for the power consumption measurement. Representative loop lengths for the corresponding DSL technologies and profiles are also defined in this table. The worst case VDSL2 configurations are the configurations for profile 8b, 17a and 30a. Other loop types and loop lengths may be used if resulting in the same insertion loss at 300 kHz for ADSL2plus and 1 MHz for VDSL2.		

- MSAN configuration:
 - Broadband(DSL) circuit power consumption are as measured for the DSLAM configuration.
 - Only narrowband(voice) circuit is present in measured configuration, with POTS interfaces so configured as follows:
 - Loop current is from min 20 mA to max 40 mA according to ES 201 970, [5] (see table A.2).
 - Loop length is 3 km of 0,4 mm gauge or a loop resistance of 510 ohm, and CPE resistance is assumed to be zero.
 - Refer to table A.2 for port status.
 - Total power consumption of MSAN port (consisting of Voice and Broadband) is the sum of power consumption of the narrowband and broadband circuits.

5.2.2 Reference measurement method

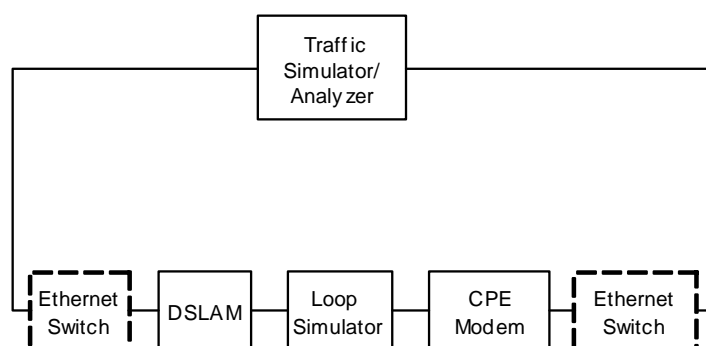


Figure 2: Test Setup for power measurement for DSLAM

Figure 2 shows the basic test setup, which is to be used during the power measurements. Both the network side (optionally through an Ethernet switch) and the end-user side (direct or also through an Ethernet switch) are connected to an Ethernet Traffic Simulator/Analyzer.

For the reference measurement method, the broadband network loop simulator should be a cable with length in line with the requirements shown in table 1 or an artificial line simulator giving the same insertion loss of the physical cable.

The specification of this artificial line simulator is currently under study.

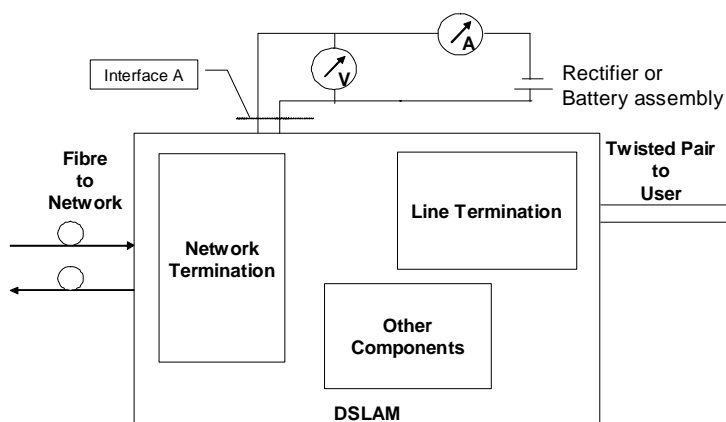


Figure 3: Power Consumption measurement at System level

In figure 3, the actual DSLAM power measurement method is shown. The DSLAM comprises the line termination boards, the Network termination boards and some other components like the cooling system. The Network termination board has fibre connections to the traffic simulator/analyzer (as shown in figures 2 and 3) and the line termination boards have twisted pairs connected to loop/line simulators.

The power consumption (P_{BBeq}) of the system under different power states (Full power state, Low power state and Standby State) is measured at the interface "A" of the DSLAM using power measurement instruments. The system can be powered either through a battery assembly or rectifier set at the nominal voltage as described in clause 5.1.1. For AC powered equipment, Real Power, Apparent Power and Power Factor should be accurately measured.

5.3 Measurement method for OLT equipment

5.3.1 Equipment configuration

OLT equipment shall be fully equipped with maximum configuration as defined below. The ports are activated and carry traffic. The test set-up is as shown in figure 4.

- GPON OLT configuration:
 - Compliance with ITU-T Recommendation G.984 [6].
 - Downstream data-rate is 2,488 Gbps and upstream data-rate is 1,244 Gbps.
 - Configured with ClassB+ (ITU-T Recommendation G.984.2 [7]) optical modules.
 - Each port of Line termination board is directly connected to one ONU with a 15 dB attenuator, but without splitter. The ONU will typically provide sufficient capacity to fully load the GPON interface with the OLT. It should be verified that the selected ONU is configured such that the upstream bandwidth can be filled by the ONU and that the downstream bandwidth coming from OLT can be fully processed.
 - Typical features: standard Layer-2 (Ethernet) aggregation functionalities, MAC address management, VLAN management, Multicast. For equipment with network layer functionalities, other features including static and dynamic routing protocols, MPLS, IP QoS.
- Point to Point OLT configuration:
 - Point to point OLT is directly connected to Customer Premises Equipment without cascading switch.
 - The optical budget for the interfaces shall be in line with IEEE 802.3 [8], clause 58 for the 100Base-LX10 and 100Base-BX10 interfaces and IEEE 802.3 [8], clause 59 for the 1000Base-LX10 and 1000Base-BX10 interfaces.
 - Typical features: Layer-2 (Ethernet) protocol management and network layer functionalities including static and dynamic routing protocols, MPLS, IP QoS.

5.3.2 Reference measurement method

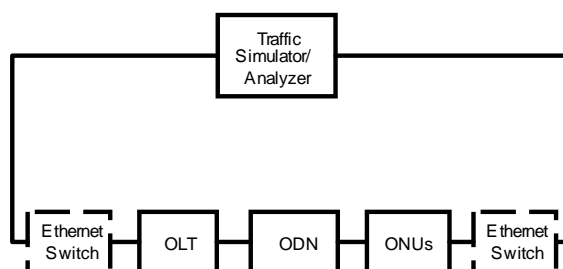


Figure 4: Test Setup for power measurement for OLT

Figure 4 shows the basic test setup, which is to be used during the power measurements. Both the network side (optionally through an Ethernet switch) and the end-user side (direct or also through an Ethernet switch) are connected to an Ethernet Traffic Simulator/Analyzer.

For the reference measurement method the broadband network equipment shall be fully equipped. All ports of the OLT shall be directly connected to one ONU through Class B+ optical module and a 15 dB attenuator but without splitter or cascading switch. The equipment is configured properly such that traffic generated by the Traffic Simulator can flow properly through the equipment to the ONU and vice versa. The Traffic Analyzer will show that the traffic is indeed passing through the setup.

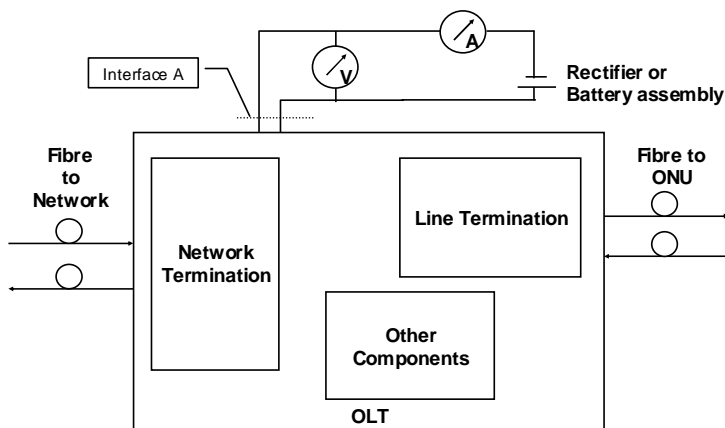


Figure 5: Power Consumption measurement at System level

In figure 5, the actual equipment power measurement method is shown. The equipment comprises the line termination boards, the Network termination boards and some other components like the cooling system. The Network termination board has fibre connections to the traffic simulator/analyzer (as shown in figures 4 and 5) and the line termination boards have fibres connected to ONU.

The power consumption (P_{BBeq}) of the system is measured at the interface "A" of the equipment using power measurement instruments. The system can be powered either through a battery assembly or rectifier set at the nominal voltage as described in clause 5.1.1. For AC powered equipment, Real Power, Apparent Power and Power Factor should be accurately measured.

5.4 Alternative measurement method

This alternative technique reduces the number of line simulators and CPE or ONU required but requires extrapolation to give the correct per line result. A minimal configuration shall include at least one fully equipped Line Termination board connected to end-user equipments and configured to pass traffic.

This alternative measurement method comprises two phases:

- The power consumption (P_{empty}) of the equipment is first measured without any Line Termination board based on figure 3 and figure 5 setup.
- In a second phase, for DSLAM, one Line Termination board is added to the system with all lines connected to a CPE through line or loop simulators. For OLT, one Line Termination board is added to the system with all lines connected to ONU through fibre. All parameters are set based on values shown in clauses 5.2.1 and 5.3.1. The power consumption ($P_{1\ line\ card}$) of the equipment with the added Line Termination board is measured once again and the difference ($P_{1\ line\ card} - P_{empty}$) gives the power consumption ($P_{line\ card}$) of a fully equipped Line Termination board.

NOTE: During both measurements (P_{empty} and $P_{1\ line\ card}$), it is important that the functional blocks, expected to have a power consumption varying with the number of users connected, are forced in a full load condition. Functional blocks which are known to increase power consumption under heavy load are the cooling system and the Network Termination board.

The total power consumption is given by the formula:

$$P_{BBeq} = P_{empty} + n \times P_{line\ card}$$

Where n is the maximum number of Line Termination boards per equipment.

5.5 Reporting of the measurements

The following details shall be included in the power measurement report:

- System configuration:
 - List of hardware items used in the system under test, showing both the vendor type number and serial number.
 - List of software/firmware modules used in the system.
 - The number of active line boards and ports.
 - The status and number of all end-user interfaces, including line length, line configuration and actual data rate.
- Measurement instruments:
 - List of measurement instruments used to measure the power consumption, including calibration information.
 - List of the CPE (DSL modem or ONU) used for the measurement.
- Measurement conditions:
 - Room temperature.
 - Relative humidity.
 - Actual operating voltage.
- Measurement results:
 - Power consumption: P_{BBeq} , P_{BBport} .

NOTE 1: P_{empty} , $P_{1\ line\ card}$, $P_{line\ card}$ should also be reported if the alternative measurement method defined in clause 5.4 is used.

NOTE 2: For DSLAM equipment, power consumptions should be included for different power states (full power state, low power state, standby state).

NOTE 3: For AC powered equipment, Real Power, Apparent Power and Power Factor should be reported.

Annex A (informative): Power consumption limits

The limits here proposed are informative only. Other possible limits applicable with the test method described in the present document are contained in the Code of Conduct on Energy Consumption of Broadband Equipment [i.6].

The energy efficiency performance of broadband telecommunication network equipment should be classified according to different power consumption values. Tier 1 to 3 are defined for different power consumption limits in tables A.1 to A.3. Tier 1 is basically applicable to the most recent equipment available in 2010. Tier 2/Tier 3 are expected to be achieved through improved energy efficiency technologies. The higher the tier, the better the energy efficiency.

The additional allowance for the uplink interface is:

- 4,5 W per equipment for each Point to Point 1 000 Mbit/s interface (electrical or optical).
- 9 W per equipment for each Point to Point 10 Gbit/s interface.
- 6 W per equipment for each Point to Multipoint (GPON) interface.

In case of AC powered equipment, the power limits stated may be increased by 10 %.

In case of remote powered systems, the power limits stated may be increased by 15 %.

A.1 DSLAM power limits

The values in table A.1 are for fully equipped DSLAMs with more than 100 ports. For small network equipment (up to 100 ports), where the consumption of the common parts is shared among a limited number of ports, the power consumption per port might be slightly higher than the values given in table A.1. An additional 0,3 W per line is added to the below figures with a minimum of 10 W for a complete (small) DSLAM.

Table A.1: DSLAM power consumption limits per port (notes 1 and 2)

	P_{BBline} (W)		
	Tier 1	Tier 2	Tier 3
Full power state			
ADSL2plus (19,8 dBm)	1,3	1,2	1,1
VDSL2(profile 8a)	1,9	1,7	1,55
VDSL2(profile 8b)	2,0	1,8	1,6
VDSL2(profile 8c)	1,7	1,5	1,4
VDSL2(profile 8d,12a,12b,17a)	1,8	1,6	1,5
VDSL2(profile 30a)	2,5	2,0	1,7
Low power state			
ADSL2plus	1,1	0,8	0,7
VDSL2 (note 3)	-	-	-
Standby State			
ADSL2plus	0,4	0,4	0,3
VDSL2	0,8	0,6	0,5
NOTE 1: For multi-profile boards the power consumption limits do not apply to boards profile not optimized under Energy Efficiency point of view. Equipment maker should specify what the optimized profile for the given board under test is at which the power consumption target limit apply. For instance a board optimized for VDSL2 8b can support other profiles (e.g. 8a, 17a, 30a) but might having suboptimal performances also in terms of power consumption at such additional profiles.			
NOTE 2: The values are in line with European Code of Conduct on Energy Consumption of Broadband Equipment (EU CoC BB) [i.6] version 4, but the table have been extended also considering all today's available profiles, although some are not specified in the version 4 of EU CoC BB [i.6].			
NOTE 3: Low-power states are currently not defined in ITU-T Recommendation G.993.2 [i.3] (VDSL2). The target limits will be completed once they are defined in standard.			

A.2 MSAN POTS power limits

Table A.2: MSAN POTS power consumption limits per port (note 1)

Per-port MSAN POTS power consumption limits in Watt	Tier 1				Tier 2				Tier 3			
	Port State line feed (W)				Port State line feed (W)				Port State line feed (W)			
Port State	40 mA	32 mA	25 mA	20 mA	40 mA	32 mA	25 mA	20 mA	40 mA	32 mA	25 mA	20 mA
Not provisioned for POTS (note 2)	0,7	0,7	0,7	0,7	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Provisioned for POTS - on-hook (note 3)	0,7	0,7	0,7	0,7	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Provisioned for POTS - off-hook	3,2	2,8	2,5	2,3	3,0	2,3	2,0	1,9	2,6	1,9	1,6	1,5

NOTE 1: These figures are additive to those existing in the clause A.1 for DSLAM power limits to form the per port limit for combo operation.
NOTE 2: This assumes that the port is equipped to supply POTS but has not been configured for use by an end customer.
NOTE 3: This excludes any on-hook charging current, which may be drawn by the CPE (up to 3 mA in some countries).

A.3 OLT power limits

The below values are for fully equipped with maximum configuration OLTs.

Table A.3: OLT power consumption limits per port

Equipment	P_{BBline} (W)		
	Tier 1	Tier 2	Tier 3
OLT (GPON, fully equipped with maximum configuration implementing standard Layer-2 (Ethernet) aggregation functionalities, including Multicast)	15	11	8
OLT (GPON, fully equipped with maximum configuration implementing also functionalities at the IP layer such as routing, MPLS, IP QoS)	16,5	12	9
OLT (Point to Point at 10 Gbit/s, up to 12 ports, fully equipped with maximum configuration)	38	38	28
OLT (Point to Point at 10 Gbit/s, from 12 to 42 ports, fully equipped with maximum configuration)	28	28	20
OLT (Point to Point at 10 Gbit/s, with more than 42 ports, fully equipped with maximum configuration)	18	18	13
OLT (Point to Point up to 1 000 Mbit/s, up to 100 ports, fully equipped with maximum configuration)	5	4,5	4
OLT (Point to Point up to 1 000 Mbit/s, from 100 and 300 ports, fully equipped with maximum configuration)	4	2,8	2,7
OLT (Point to Point up to 1 000 Mbit/s, with more than 300 ports, fully equipped with maximum configuration)	3	2	1,9
Additional per port allowance for Point to Point up to 1 000 Mbit/s OLT, with independent traffic process component (not embedded in Lanswitch) on each line cards, implementing layer-3 functionalities of Edge Router (at least IP/MPLS routing and interface and policy based hierarchical QoS (H-QoS)), providing extendable capability to evolve adding new functionalities currently under discussion, and variable traffic processing functions and/or market specific customization requirements	0	0,4	0,3

Annex B (informative): Example hourly traffic distribution profiles

The 24-hour time distribution over the states is based on the estimated typical traffic behaviour for a variety of user types. These traffic profiles are just examples and they might or might not be representative for an actual network.

NOTE: Further study is required to understand the effects of fluctuating crosstalk caused by systems transitioning between the L2/L3 and L0 states. This will potentially cause degradation in the performance of rate adaptive ADSL systems and therefore operators may decide to constrain the number of state transitions, which would result in a system spending longer in higher power modes.

Table B.1: Example DSLAM operational states L0-L2-L3 and 24-hour traffic model

User Type	L0 Time/Day (i.e. Full power state-time/day)	L2 Time/Day (i.e. Low power state-time/day)	L3 Time/Day (i.e. Standby state/day)
Private DSL	1 hour	1 hour	22 hours
Private triple play/SOHO	6 hours	2 hours	16 hours
Average	3,5 hours	1,5 hours	19 hours

Other traffic model, reported in table B.2, shows an alternative model with different time distribution.

Table B.2: Example DSLAM operational states L0-L2-L3 and 24-hour traffic model

User Type	L0 Time/Day (i.e. Full power state-time/day)	L2 Time/Day (i.e. Low power state- time/day)	L3 Time/Day (i.e. Standby state/day)
Private DSL	2 hours	22 hours	0
Private triple play/SOHO	8 hours	16 hours	0
Average	5 hours	19 hours	0

Annex C (informative): NPC definition and calculation examples

In addition to the power consumption P_{BBport} that is defined for the equipment, an indication of global network power performance "Normalized Power Consumption" (NPC) might be given. The definition of the NPC can be found in TR 102 530 [i.4].

For DSLAM equipment, the NPC is an indicator of the amount of power required to transport 1 Mbps of data over a predefined reference lengths in table 1, it is based on the bitrate and reach at full-power state as defined in the measurement method (see clause 5.2).

For OLT equipment, the NPC is an indicator of the amount of power required to transport 1 Mbps. Since the power consumption of OLT is not directly related with optical fibre length, no reference optical fibre length is defined.

$$\text{NPC} = 1\,000 \times P_{\text{BBport}} / \text{bitrate}$$

NPC is expressed in mW/Mbps. Bitrate is the downstream net data rate expressed in Mbps.

This NPC enables comparison of same technologies from different equipments and/or vendors, as well as of similar technologies such as evolutions or extensions (e.g. VDSL2 Vectoring) regarding the efficiency of transporting information (in terms of power). It is calculated at relevant reference loop lengths for each technology, and as such it should be clear that using NPC to directly compare technologies which use different reference loops or different access technologies should not be promoted. These reference loops are derived from the typical or targeted working conditions of these technologies and are given in the clause on measurement methods (clause 5.2.2).

NOTE: Using the NPC to compare the different working states (e.g. L0 with L2 or L3) is not recommended as the intention of some of these working states is to save energy at times of no or low-rate transmission, i.e. when there is no need to transmit high data rates.

NPC values are not actual requirements but informative only, and are calculated based on actual test data. Table C.1 gives some examples for NPC calculation.

Table C.1: NPC examples calculated according to P_{BBport} values in tables A.1 and A.3

	Data rate (Mbps)	Distance (km)	NPC (mW/Mbps)		
			Tier 1	Tier 2	Tier 3
ADSL2plus (19,8 dBm)	10	2,5	130	120	110
VDSL2 (profile 8b)	17	1,2	117,6	106	94
VDSL2 (profile 12a)	34	0,45	53	47	44
VDSL2 (profile 17a)	38	0,45	47,4	42	39,5
VDSL2 (profile 30a)	65	0,15	38,5	30,8	26,2
OLT (GPON)	2 488	Optical budget: Class B+	6,0	4,4	3,2
OLT (Point to Point up to 1 000 Mbps)	1 000	Optical budget class as in clause 5.3.1	5	4,5	4

Annex D (informative): Measurement power consumption for DSLAM/MSAN and OLT equipment for different number of active ports

In most cases of network deployment, the broadband access network equipment will not be fully configured (e.g. some ports are not activated for fully equipped subrack). To verify the dynamic power management capability, it is necessary to measure the power consumption of network equipment under different configurations.

The power consumption should be measured with a power measurement instrument at Interface A according to clause 5.2 for a defined fully equipped DSLAM or MSAN with maximum configuration and to clause 5.3 for the OLT equipment. The ports are activated and carry traffic. The system can be powered either through a battery assembly or rectifier set at the nominal voltage as described in clause 5.1.1.

The power consumption measurements should be measured for the following percentages of activated ports:

- 40 % of the number of ports of a line termination boards of a DSLAM, MSAN or OLT;
- 80 % of the number of ports of a line termination boards of a DSLAM, MSAN or OLT;
- 100 % of the number of ports of a line termination boards of a DSLAM, MSAN or OLT.

Annex E (informative): Bibliography

ITU-T Recommendation G.Supplement 45 (2009): "GPON power conservation".

History

Document history		
V1.1.1	September 2010	Membership Approval Procedure MV 20101114: 2010-09-15 to 2010-11-15
V1.2.1	August 2011	Membership Approval Procedure MV 20111010: 2011-08-11 to 2011-10-10