TR xxxxx (draft) V0.0.1 (2000-02)

Technical Report

Transmission and Multiplexing (TM); Spectral Management on Metallic Access Networks; Part 1: Definitions and Signal Library

Work Item Reference	DTS/TM-06016
Permanent Document	**TM6(99)07**
Filename	990p07r0.*
Date	16 feb 2000

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Reference

DTS/TM-06016

Keywords

unbundling, local loop, MDF Access, spectral management, xDSL, transmission

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Foreword

Introduction

1. Scope

The present document gives guidance on a common language for Spectral Management specifications. It provides a first set of definitions on Spectral management quantities, including
(a) a description of the technical purpose of Spectral Management,
(b) a common reference model to identify LT-ports, NT-ports, upstream, downstream, etc.
(c) a minimum set of characteristics necessary to describe signals within the context of Spectral Management, and
(d) an initial informative library of electrical signals that may flow into the ports of a metallic access network.

The present document is applicable to simplify & harmonize the description of ***network specific*** spectral management documents. The objective is to be a clear reference for these documents, without making any specific choice on the technology mix that may use the access network. Network-specific documents, that rule the selected penetration limits and technology mix for spectral management purposes, can be kept compact by refering to the definitions in this document.

The informative library of signal definitions is organized in clusters of signal categories. Each category defines, independent from other categories, a full set of signal limits between DC and 30 MHz. These categories are dominantly based on transmission equipment standards from ETSI, ANSI and ITU (existing or in progress), and on the technical understanding of additional requirements to protect future technology. When these definitions are incomplete or not appropriated, ***network specific*** spectral management documents may use additional definitions.

2. References

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The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- *References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.*
- *For a specific reference, subsequent revisions do not apply.*
- *For a non-specific reference, subsequent revisions do apply.*
- *A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.*

[1] EN 301 234 (V2.1 onwards): "Example 1".

[2] EG 201 568 (V1.3.5): "Example 2".

[3] ETS 300 499 (1996): "Example 3".

[4] ETS 300 999: "Example 4".

3. Definition of terminology, symbols and abbreviations

3.1. Terminology

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

Network owner: The company owning the telecommunication access network. (Mostly incumbent telecommunication network operators.)

Network operator: The company that make use of the access network of the Network owner, to transport telecommunication services.

Transmission technique: Electrical technique used for the transportation of information over electrical wiring.

Transmission equipment: Equipment connected to the access network that uses a transmission technique to transport information.

Line Termination Port (LT-port) : Port between network transmission equipment and the twisted pair access network, that is labelled by the network owner as “LT-port”. Such a port is commonly located near the telecommunication exchange.

Network Termination Port (NT-port): Port between network transmission equipment and the twisted pair access network, that is labelled by the network owner as “NT-port”. Such a port is commonly located at the customer premises.

Upstream transmission: Transmission direction from an NT-port to an LT-port, usually from the customer premises, via the access network, to the telecommunication exchange.

Downstream transmission: Transmission direction from an LT-port to an NT-port, usually from the telecommunication exchange via the access network, to the customer premises.

Degree of penetration: Number and mixture of connected transmission techniques to the ports of a binder or cable bundle, that inject signals into the access network.

3.2. Symbols

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

<symbol>	*<Explanation>*
<2nd symbol>	*<2nd Explanation>*

3.3. Abbreviations

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

ADSL	Asymmetrical Digital Subscriber Line
ATU-C	ADSL Transceiver Unit, Central office end
ATU-R	ADSL Transceiver Unit, Remote terminal end
AMI	Alternate Mark Inversion
ANSI	American National Standards Institute
BRA	Basic Rate Access
CSS	Customer-side signal source
CAP	Carrier Amplitude Modulation
CCITT	Commité Consultatif International du Téléphone et de la Télégraphie
CDSL	Customer Digital Subscriber Line
DC	Direct Current
EMC	Electro Magnetical Compatibility
ESS	Exchange-side signal source
ETSI	European Telecommunications Standards Institute
FDD	Frequency Division Duplexing
HDSL	High bitrate Digital Subscriber Line
ISDN	Integrated Services Digital Network
ITU	International Telecommu nication Union
LCL	Longitudinal Conversion Loss
LT-port	Line Termination port
LVD	Low Voltage Directive
MDF	Main Distribution Frame
NBSP	Narrow band signal power
NT-port	Network Termination port

NTE	Network Terminal Equipment
NTI	Network Terminal Interface
OLO	Other Licensed Operator
ONP	Open Network Provision
PCM	Pulse Code Modulation
PSD	Power Spectral Density
POTS	Plain Old Telephony Services
PSTN	Public Switched Telephone Network
R&TTE	Radio and Telecommunications Terminal Equipment
SDSL	Symmetrical Digital Subscriber Line
TBR	Technical Basis for Regulation
UNI	User Network Interface
U-ADSL	Universal Asymmetrical Digital Subscriber Line
VDSL	Very high bit rate Digital Subscriber Line
xDSL	(all systems) Digital Subscriber Line

4. The technical purpose of Spectral Management

Connecting a signal to a wire pair of a (metallic) access network cable, causes that parts of that signal couple to other wire pairs in the same cable bundle or binder group. Connecting more systems to the same cable will increase the total crosstalk noise level in each wire-pair, and disturbs systems that were already installed.

Existing access network cables are designed to facilitate a low crosstalk coupling at low frequencies (telephony band), but the frequency of signals in cables increases substantially due to the introduction of broadband transmission systems. The consequense will be a substantially increase of the total crosstalk noise power in each wire pair.

Existing transmission systems are designed to cope (to some extend) with this type of impairment, but impairment puts anyhow a limit on the capacity of what can be transported through that cable. Capacity means here the maximum bitrate that can be transported over a single wire-pair at given cable length, or the maximum length that can be reached at given bitrate. Above some impairment level, the reliability of installed systems becomes poor, and they will even fail when the imparment level is increased further.

Usually, systems are designed to function optimally when they are only impaired by identical systems (self-crosstalk) that use other wire-pairs in the same cable. In practice, it is quite common to mix different transmission technologies in one cable. This may cause some degradation of transmission capacity, compared to the above mentioned idealised situation.

- If this degradation is minor, the technology mix is referred to as *compatible*.
- If this degradation is acceptable, the technology mix is referred to as *near-compatible*.
- If this degradation is not-acceptable, the technology mix is referred to as *incompatible*.

To prevent that only a few systems make an inefficient use of the access network, at the cost of al the others, measures have to be taken. This is referred to as "Spectral Management".

4.1. Controlling spectral pollution

The objective for *spectral management* is to control the maximum spectral pollution, to enable an efficient use of the access network for all connected systems. This can be achieved by focussing on the use of near-compatibe systems in the *same cable* or cable bundle.
Spectral management is an issue for both the network owner and the network operator (in some cases they are within the same organisation).

- The best that an *access network owner* can do to help the network operator(s) on its network, is to bound the spectral pollution in its network. This can be achieved by putting limits on signals (levels, spectra), diversity (technology mix) and penetration (number of systems). These limits may be dependent on the loop length.

Defining relevant limits at the boundaries (or ports) of the access network is the most appropriate approach. This approach is not restricted to situations where more than one licence operator make use of the same binders or cable bundles; it is also essential when one operator mixes different broadband technologies into one binder or cable bundle.

- The best that *network operators* can do is making estimates of the maximum impairment level in a wire-pair, and define adequate deployment rules. Deployment rules define the maximum reach or bitrate for a given transmission technology, with 'sufficient' noise margin (according to the network operator). Since the crosstalk coupling between the wirepairs in binders or cable bundles is only known by a very rough approximation, the maximum impairment level is also only known by a very rough estimate. In other words: the definition of adequate limits is an essential requirement for successful deployment rules, but it can never *guarantee* that deployment rules can be adequate under all conditions. It is an inconvenience which each network operator has to face.

This document provides an informative library of signal categories, to simplify spectral management specifications that bound the spectral pollution of a network. Guidelines for deployment rules are beyond the scope of this document. A spectral management specification of a possible length dependency of the signal limits is also beyond the scope of this document.

4.2. Individual components of crosstalk in a multi-wirepair cable

Defining adequate rules for controlling spectral pollution requires a technical understanding of how individual disturbers contribute to the total impairment. The crosstalk coupling functions and the attenuation characteristics of an existing access network are fixed and from an electrical point of view the network can be considered as a closed entity. Controlling the spectral pollution is therefore restricted to controlling what signals may, and may not, flow into the access network cables.

Figure 1 illustrates the impact of these cable characteristics on the transmission. Transceiver TR1.LT sends information to TR1.NT.

- Receiver TR1.NT receives the downstream signal from transmitter TR1.LT, that has been attenuated by the insertion loss of the wire-pair.

- In addition, TR1.NT receives crosstalk noise through the NEXT coupling function (near end crosstalk), from the upstream signal transmitted by TR2.NT.

- In addition, TR1.NT receives crosstalk noise through the FEXT coupling function (far end crosstalk), from the downstream signal transmitted by TR2.LT.

This crosstalk noise deteriorates the signal to noise ratio of the received signal, and therefore the performance of the transmission between TR1.LT and TR1.NT.

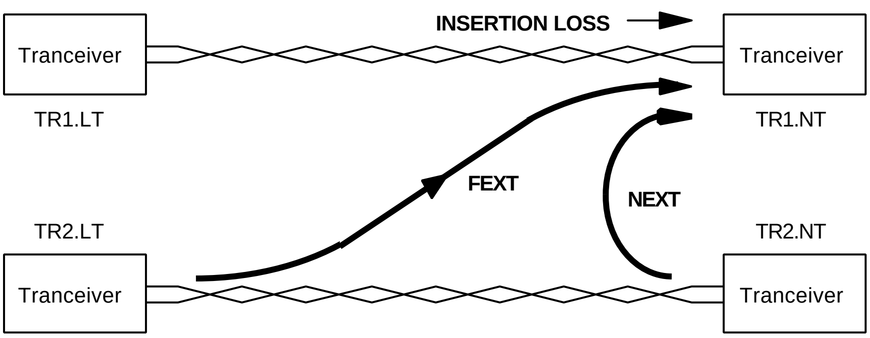


Figure 1. Various crosstalk paths .

Crosstalk and attenuation characteristics are frequency dependent. Because of the differences in crosstalk coupling at the near and the far end, the relation between frequency allocation and sending direction is of major importance for the management of the crosstalk noise.

The crosstalk coupling to the far end of the transmitter (FEXT) is relatively low due to the attenuation. The crosstalk on the near end (NEXT) will be relatively high. So if the transmitter and the receiver at one end of the line would use the same frequency band, the transmitter outputs should be limited in order not to disturb the adjacent receivers. The result would be that the achievable wire-pair length would be limited because crosstalk limits the maximum allowed sending level. By using different frequency bands for transmitters and receivers at one end of the binder or cable bundle, this effect can be eliminated and the achievable length will increase.

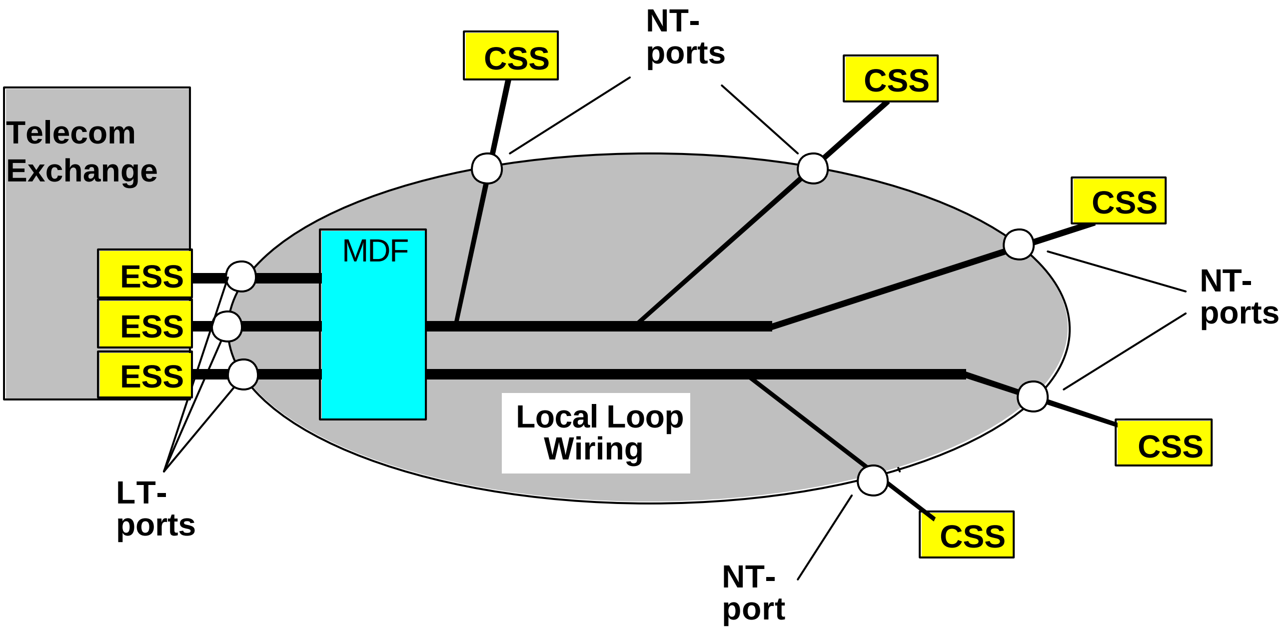
NOTE Some systems, such as FDD-based ADSL, take advantage from allocating different frequency bands for transmitting signals in upstream and downstream direction. By using spectra that are only partly overlapped (echo-cancelled systems), or not overlapped at all (FDD-systems), the NEXT between these systems can be reduced significantly. Ideally, if there is no spectral overlap between up and downstream signals, and the binder or cable bundle is only filled with these systems, the transmission performance becomes FEXT-limited only since all NEXT has been eliminated.

NOTE Consider the example of FEXT-limited ADSL: the NEXT at the NT due to neighbouring HDSL systems can limit the ADSL downstream performance. By restricting the deployment distance of HDSL, the NEXT disturbance at the NT of longer ADSL lines will be attenuated by the extra cable length, increasing the ADSL capacity (or reach for a given capacity). It follows that the deployment range limit of HDSL systems has an impact on the deployment range limit of ADSL. This example shows that it may be desirable to make the specifications for the signal limits dependent on the loop length.

5. Reference model of the local loop wiring

Figure 2 shows the reference model of the *local loop wiring* of an access network, from a spectral management point of view. It illustrates that local loop cable sections are asymmetrical in nature, because equipment near the local exchange side may differ from equipent near the customer side.

The reference model shows that the local loop wiring of an access network includes cables, but may also include a Main Distribution Frame (MDF), street cabinets, and other distribution elements.



LT-port: Line Termination Port
NT-port: Network Termination Port
CSS: Customer-side signal source
ESS: Exchange-side signal source
MDF: Main Distribution Frame

Figure 2. Reference model of the local loop wiring of an access network. This model enables the definition of upstream and downstream directions. Furthermore, a distinction between NT-ports may be made on the basis of the loop length, when specifying signal limits on the ports.

5.1. The interfaces of the reference model: Ports

Signals, generated by transmission equipment connected to the local loop wiring, flow into the wire-pairs of that access network. These signals enter the local loop wiring via the so-called “ports”. Their location identify the interface (or connection point) between transmission equipment and the local loop wiring. Two kinds of ports are defined in this reference model:

- ***LT-port***: The Line Termination port is generally used for the telecommunication exchange connection.
- ***NT-port***: The Network Termination port is generally used for the Telecommunication terminal equipment (TTE) at the customer premises.

NOTE "Connected to the local loop wiring", does not necessary mean "intended for transmission through that local loop". In-home transmission equipment, that make use of existing telephony wires, are also "connected to the local loop wiring". They will also (unintentional) inject signals into the access network via the NT-ports

5.2. Ports for upstream and downstream

Asymmetrical DSL systems, such as ADSL, generate different signals in different transmission directions. Therefore the signal limits for these systems are in this document subdivided into downstream and upstream limits throughout this document.

- ***Downstream*** signal limits are mandatory for signals that are injected into the ports of the local loop wiring that are identified by the network owner as “LT-port”. These ports are usually located at the central office side of the local loop wiring.
- ***Upstream*** signal limits are mandatory for signals that are injected into he ports of the local loop wiring that are identified by the network owner as “NT-port”. These ports are usually located at the customer premises.

The network owner identifies for each port if this is an LT- or NT-port, and what signal limits are mandatory for these ports.

NOTE It is not recommended to reverse the transmission direction, which causes the injection of upstream signals into LT-ports and downstream signals into the NT-ports. This may occur when the MDF of another licenced operator is not co-located with the MDF of the network owner (at the local exchange). In such a case, a binder or cable bundle *separated* from the standard access cables, is required to connect the two MDF’s. Such a binder or cable bundle will be fully dedicated to this purpose, having an NT-port at the local exchange of the network owner.

NOTE Signal limits need not be the same for all NT-ports or LT-ports. It is conceivable that the signal limits depend on e.g. the loop length. A specification of this possible length dependence is beyond the scope of this document.

6. Minimum set of characteristics for signal descriptions

To classify signals for spectral management purposes, the following parameters are relevant:

- Unbalance about earth
- Total signal voltage (or power)
- Peak amplitude
- Narrow-band signal voltage (or power)
- Feeding Power (if relevant)

In some cases, additional parameters are required, such as feeding requirements (in case of remote powering) and ringing signals.

7. Cluster 1 Signals (voice band)

This cluster summarizes signals that are generated by analogue transmission equipment (including POTS), voice band modems, analogue leased lines, telex signals encoded as voiceband signals and music lines.

ED NOTE: Is there a need for two "POTS signal" categories: a "base" category and an "enhanced" category?. This enables a destinction between equipment installed before <month/year> and after <month/year>. Contributions on different spectral requirements (up to 30 MHz) are invited.

7.1. "POTS" Signals (voice band lines 300 - 3400Hz)

This category covers signals from telephony transmission equipment (e.g. telephones, voice band modems, Faxes, analogue leased lines etc.) on a single wire pair. Unless other specified, the requirements on DTMF-signals (Dual Tone Multi-Frequency), as defined in [1], are equal to the voice signal.

A signal can be classified as a "POTS signal" if it is complient with all subclauses below.

7.1.1. Unbalance about earth

To be complient with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum limits, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal conversion loss (LCL) measurement at the source of that signal, observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.1.
The observed LCL shall be higher than the lower limits given in figure 3. The LCL values of the associated break frequencies of this figure are given in table 1. The values for the components of the terminating impedance of the LCL measurements are given in table 2.

Reference [1]: ***[ETSI-TBR 21: clause 4.4.3 and 4.7.4.1]***
Reference [4]: ***[ETSI-ETS 300 450: clause 4.4.2]***
Reference [5]: ***[ETSI-ETS 300 453: clause 4.4.2]***
Reference [20]: ***[ETSI-TS 101 270-1: clause 8.3.3]***

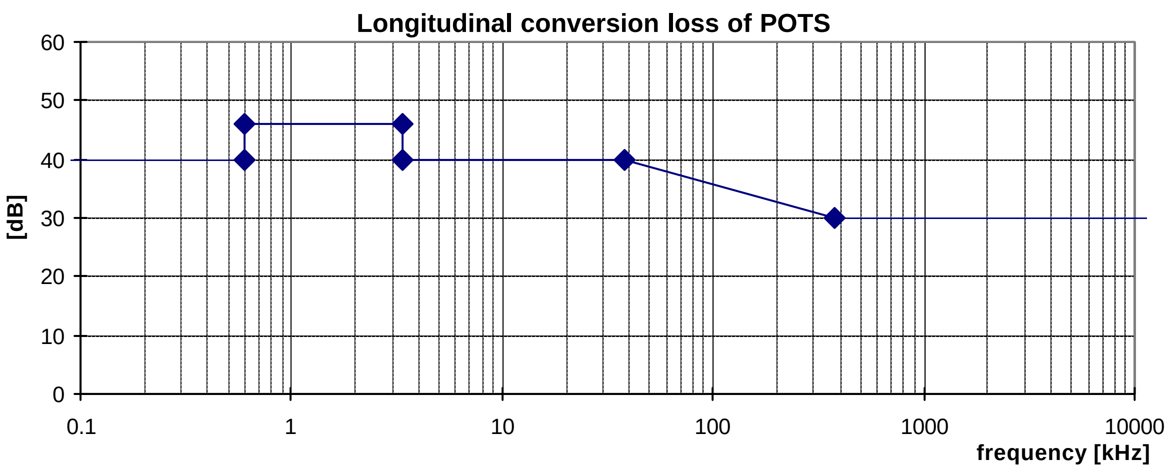


Figure 3: Minimum longitudinal conversion loss for a POTS-system

Frequency range	Minimum value	Impedance
50 Hz to 600 Hz	40 dB	600 Ω
600 Hz to 3400 Hz	46 dB	600 Ω
3400 Hz to 3800 Hz	40 dB	600 Ω
3800 Hz to 38 kHz	40 dB	135 Ω
38 kHz to 380 kHz	40 to 30 dB	135 Ω
380 kHz to 30 MHz	30 dB	135 Ω

Table 1: Frequencies and LCL values of the breakpoints of the LCL mask in figure 3.

	Value	Frequency range	Tolerance
Resistance R1	300 ohm	50 Hz –3800 Hz	
Resistance R2	300 ohm	50 Hz –3800 Hz	
Resistance R1	135/2 ohm	3800 Hz – 30 MHz	R1/R2=1± 0,1 %
Resistance R2	135/2 ohm	3800 Hz – 30 MHz	R1/R2=1± 0,1 %
TE powering by Feeding bridge according to ETSI-TBR 21 4.4.3			

Table 2: Values for the components for the terminating impedance for measuring the LCL.

ED NOTE: This is an extension of the frequency range of the current recommendation / standard, with the goal of protection of VDSL transmission.

7.1.2. Total signal voltage

To be complient with this signal category, the mean signal voltage over a reference impedance Z_R (see figure 5) shall not exceed a level of -9,7 dBV, measured within a frequency band from at least 200 Hz to 3.8 kHz, and over a one-minute period. This requirement does not apply to DTMF signals.

*Reference [1]: **[ETSI-TBR21: clause 4.7.3.1]**, (tested according to annex A, sub clause A.4.7.3.1)*

To be complient with this signal category, the level of any tone in the DTMF high frequency group shall not be greater than -9,0 dBV + 2,0 dB = -7,0 dBV. The level of any tone in the low frequency group shall not be greater than -11,0 dBV + 2,5 dB = -8,5 dBV. This is to be measured when the TE interface is terminated with the specified reference impedance Z_R (see figure 5).

*Reference [1]: **[ETSI-TBR2: clause 4.8.2.2.1]** (tested according to annex A, sub clause A.4.8.2.2)*

7.1.3. Peak amplitude

To be complient with this signal category, the peak to peak signal voltage over a reference impedance Z_R (see figure 5) shall not exceed a level of 5,0 volts, measured within a frequency band from at least 200 Hz to 3.8 kHz, and over a one-minute period.

*Reference [1]: **[ETSI-TBR21: clause 4.7.3.2]** (tested according to annex A, sub clause A.4.7.3.2)*

7.1.4. Narrow-band signal voltage

To be complient with this signal category, the narrow-band signal voltage (NBSV) shall not exceed the limits given in table 3, at any point in the frequency range 100 Hz to 30 MHz. This table specifies the break points of these limits, in which Z_R refers to the specified reference impedance Z_R (see figure 5). Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. Figure 4 illustrates the NBSV in a bandwidth-normalized way.

The NBSV is the average voltage ***U*** of a sending signal into a (complex) load impedance ***Z***, within a bandwidth ***B***. The measurement method of the NBSV is described in sub-clause 12.4.

*Reference [1]: **[ETSI-TBR21: (30 Hz - 4.3kHz, clause 4.7.3.3), (4.3 kHz - 200kHz, clause 4.7.3.4)]** the requirements above 200kHz are extended from [1]. This extension is essential to guarantee compatibility with broadband xDSL systems.*

frequency f	impedance Z	Sending level U	Bandwidth B	Spectral Voltage U/ÖB
30 Hz	Z_R	-33.7 dBV	10 Hz	–43.7 dBV/√Hz
100 Hz	Z_R	-10.7 dBV	10 Hz	–20.7 dBV/√Hz
200 Hz	Z_R	-6.7 dBV	10 Hz	–16.7 dBV/√Hz
3.8 kHz	Z_R	-6.7 dBV	10 Hz	–16.7 dBV/√Hz
3.9 kHz	Z_R	-10.7 dBV	10 Hz	–20.7 dBV/√Hz
4.0 kHz	Z_R	-16.7 dBV	10 Hz	–26.7 dBV/√Hz
4.3 kHz	Z_R	-44.7 dBV	10 Hz	–54.7 dBV/√Hz
4.3 kHz	Z_R	-40 dBV	300 Hz	–65 dBV/√Hz
5.1 kHz	Z_R	-44 dBV	300 Hz	–69 dBV/√Hz
8.9 kHz	Z_R	-44 dBV	300 Hz	–69 dBV/√Hz
11.0 kHz	Z_R	-58.5 dBV	300 Hz	–73.5 dBV/√Hz
11.0 kHz	Z_R	-58.5 dBV	1 kHz	–88.5 dBV/√Hz
200 kHz	Z_R	-58.5 dBV	1 kHz	–88.5 dBV/√Hz
200 kHz	135 Ω	-60 dBV	1 kHz	–90 dBV/√Hz
500 kHz	135 Ω	-90 dBV	1 kHz	–120dBV/√Hz
500 kHz	135 Ω	-60 dBV	1 MHz	–120dBV/√Hz
30 MHz	135 Ω	-60 dBV	1 MHz	–120dBV/√Hz

***Table 3** Break points of the narrow-band voltage limits. A voltage of 1 V, equals 0 dBV, and causes a power of 2.2 dBm in 600 W and 8.7 dBm in 135 W.*

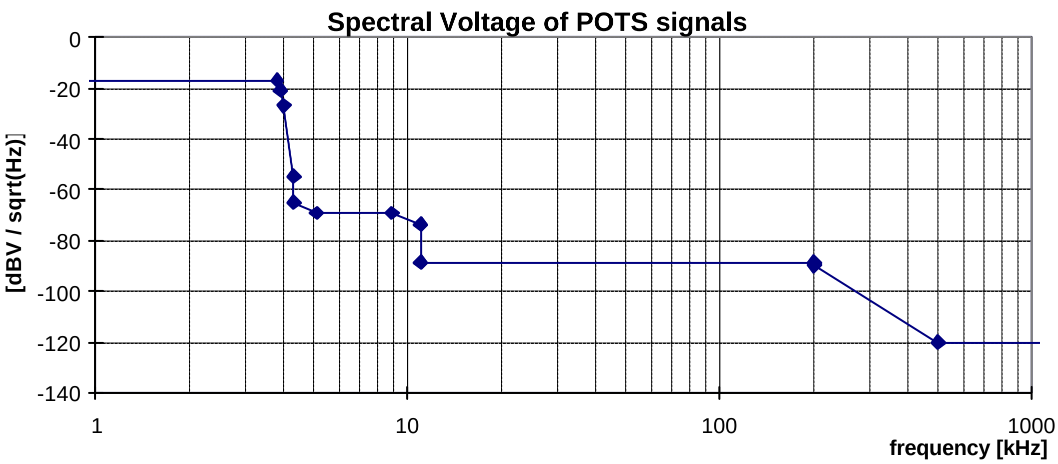


***Figure 4**: Spectral Voltage, for POTS signals, as specified in table 3.*

ED NOTE: This is an extension of the frequency range of the current recommendation / standard, with the goal of protection of VDSL transmission

During tone signalling the limits given in table 3 do not apply to DTMF signals and are replaced by the following limits:

- In the range 4,3 kHz to 20 kHz, the individual level of any single frequency component shall not exceed -35,7 dBV, when terminated with Z_R.

- In the range 20 kHz to 200 kHz, the individual level of any single frequency component shall not exceed -40,7 dBV, when terminated with Z_R.
- In the range 200 kHz to 30 MHz, the individual level of any single frequency component shall not exceed **<value for further study>** when terminated with 135Ω.

Reference [1]: ***[ETSI-TBR21: clause 4.7.3.4]***

7.1.5. Feeding Power (from the LT-port)

To be complient with this signal category, the DC feeding voltage and feeding current, used for the POTS service shall not exceed the maximum values in table 4.

Reference [2]: ***[ETSI- EG 201 188: clause 6.2.1 and 6.3.1]***
Reference [3]: ***[ETSI- TRS 300 001: clause 1.5]***

	Maximum Voltage:	**Maximum Current :**
European Harmonised	78 V	55 mA
Country 1		
Country 2		

Table 4 *Maximum feeding requirements for the POTS service*

7.1.6. Reference impedance Z_R

The reference impedance Z_R, that is used to enable the specification of various signal levels, is the European harmonised complex impedance. This harmonised complex impedance (see figure 5) equals 270Ω in series with a parallel combination of 750Ω and 150 nF.

Reference [1]: ***[ETSI-TBR21: clause A.2.1]***

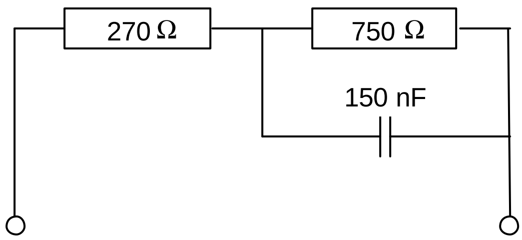


Figure 5*: Reference impedance Z_R*

7.1.7. Ringing signal

To be complient with this signal category, the AC ringing voltage shall not exceed the maximum values in table 5. The AC ringing signal may be or may be not superimposed on the DC feeding voltage.

Reference [2]: ***[ETSI- EG 201 188: clause 12.1]***
Reference [3]: ***[ETSI- TRS 300 001: clause 1.7.2]***

	Frequency	Maximum Voltage
European Harmonised	25 ± 2 Hz	100 V_{rms}
Country 1	50 Hz	100 V_{rms}
Country 2		

Table 5 *Maximum ringing signal (POTS service)*

7.1.8. Metering signals

To be complient with this signal category, 50 Hz common mode metering pulses (if added to POTS lines), shall be within the limits of table 6.

NOTE: Most access networks are using a different type of metering signals.

Reference [3]: ***[ETSI ETS 300 001: clause 1.7.8]***

Frequency	Voltage	Pulse width
48 to 52 Hz	maximum 100 V_{eff}	70 to 200 ms

Table 6 *Maximum metering signal.*

ED NOTE: The text above, on metering signal pulses, is currently dedicated to the Dutch situation, but needs a significant update to cover the European situation.

At this moment it is unclear of these are all relevant parameters for spectral management. Additional parameters dealing with on-hook / off-hook disturbance are worth considering for inclusion.

This issue is for further study.

8. Cluster 2 Signals (semi broad band)

This cluster summarizes signals that are generated by digital transmission equipment up to 160 kb/s, including ISDN-BRA and 64 and 128 kb/s leased lines.

8.1. "ISDN.2B1Q" Signals

This category covers signals generated by ISDN transmission equipment on a single wire-pair, based on 2B1Q line coding. This sub clause is based on the ETSI reports on ISDN equipment [8].

A signal can be classified as an "ISDN.2B1Q signal" if it is complient with all subclauses below.

8.1.1. Unbalance about earth

To be complient with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum limits, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal conversion loss (LCL) measurement at the source of that signal, observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.1.

The observed LCL shall be higher than the lower limits given in figure 6. The LCL values of the associated break frequencies of this figure are given in table 7. The values for the components of the terminating impedance of the LCL measurements are given in table 8.

Reference [8]: ***[ETSI TS 102 080: clause A.13.3.1]*** *extended tot 30 MHz according to [20].*
Reference[20]: ***[ETSI TS 101 270-1: clause 8.3.3]***

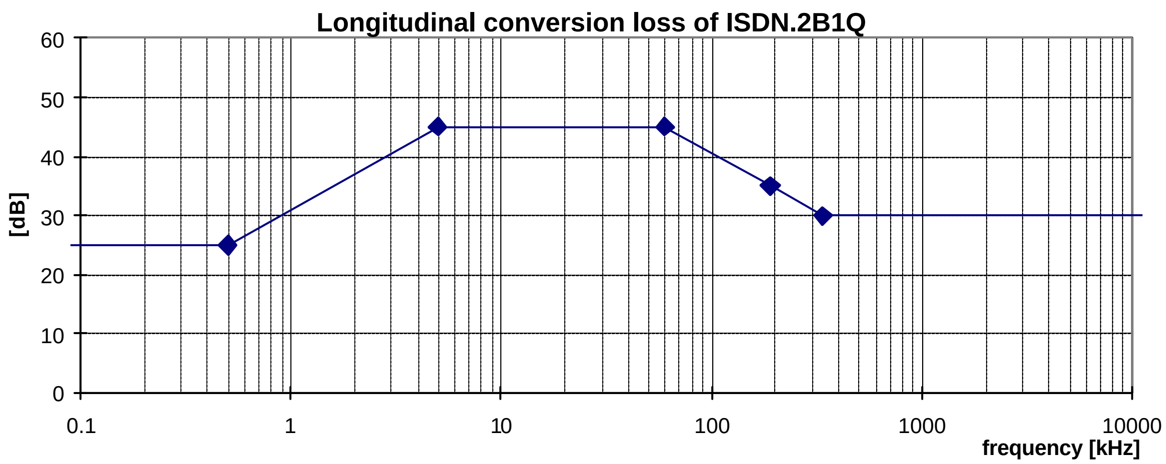


Figure 6: Minimum longitudinal conversion loss for a ISDN.2B1Q system

Frequency range	LCL
<0,5 kHz	25 dB
5 kHz	45 dB
60 kHz	45 dB
190 kHz	35 dB
337 kHz	30 dB
30 MHz	30 dB

Table 7: Frequencies and LCL values of the breakpoints of the LCL mask in figure ***6****.*

	Value	Tolerance
Resistance R1	135/2 ohm	R1/R2=1± 0,1 %
Resistance R2	135/2 ohm	R1/R2=1± 0,1 %
Capacitance	0.33 µF	

Table 8: Values for the components for the terminating impedance for measuring the LCL.

8.1.2. Total signal power

To be complient with this signal category, the mean signal power into a resistive load of 135Ω shall not exceed a level of 13.5 dBm (± 0.5 dBm), measured within a frequency band from at least 100 Hz to 80 kHz.

Reference [8]: ***[ETSI TS 102 080: clause A.12.3]***

8.1.3. Peak amplitude

To be complient with this signal category, the nominal voltage peak of the largest signal pulse into a resistive load of 135Ω shall not exceed a level of 2,5 V (± 5%), measured within a frequency band from at least 100 Hz to 80 kHz.

Reference [8]: ***[ETSI TS 102 080: clause A.12.1]***

8.1.4. Narrow-band signal power

To be complient with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 9, at any point in the frequency range 100 Hz to 30 MHz. This table specifies the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. Figure 7 illustrates the NBSP in a bandwidth-normalized way.

The NBSP is the average power ***P*** of a sending signal into a load resitance ***R***, within a bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.4.

NOTE The NBSP specification in table 9 is reconstructed from the commonly used PSD specification in [8] (similar to figure 7), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.
The nature of the original PSD specification in [8] is in fact a NBSP specification, since the use of a 10 kHz bandwidth (above 10 kHz) and a 1 Mhz bandwidth (above 300 kHz) is mandatory in [8]. The additional use of a sliding window PSD specification in [8], in order to make sure that different systems do not fill the entire allowable bandwidth with noise up to the PSD limit, illustrates the NBSP nature of the PSD specification in [8] in more detail.

References [8]: ***[ETSI TS 102 080: clause A.12.4]***

Frequency f	Impedance R	Sending level P	Bandwidth B	Spectral Power P/B
0.1 kHz 10 kHz	135Ω 135Ω	-0 dBm -0 dBm	1 kHz 1 kHz	-30 dBm/Hz -30 dBm/Hz
10 kHz 50 kHz 500 kHz 1.4 MHz 5 MHz 30 MHz	135Ω 135Ω 135Ω 135Ω 135Ω 135Ω	10 dBm 10 dBm -30 dBm -30 dBm -60 dBm -60 dBm	10 kHz 10 kHz 10 kHz 10 kHz 10 kHz 10 kHz	-30 dBm/Hz -30 dBm/Hz -80 dBm/Hz -80 dBm/Hz -120 dBm/Hz -120 dBm/Hz
300 kHz 500 kHz 1.4 MHz 3.637 MHz 30 MHz	135Ω 135Ω 135Ω 135Ω 135Ω	-19 dBm -30 dBm -30 dBm -60 dBm -60 dBm	1 MHz 1 MHz 1 MHz 1 MHz 1 MHz	-79 dBm/Hz -90 dBm/Hz -90 dBm/Hz -120 dBm/Hz -120 dBm/Hz

***Table 9**: Break points of the narrow-band power limits. When measured at 1MHz bandwidth, the center frequency is 500 kHz above the lowest frequency that is specified in this table (sliding window approach)*

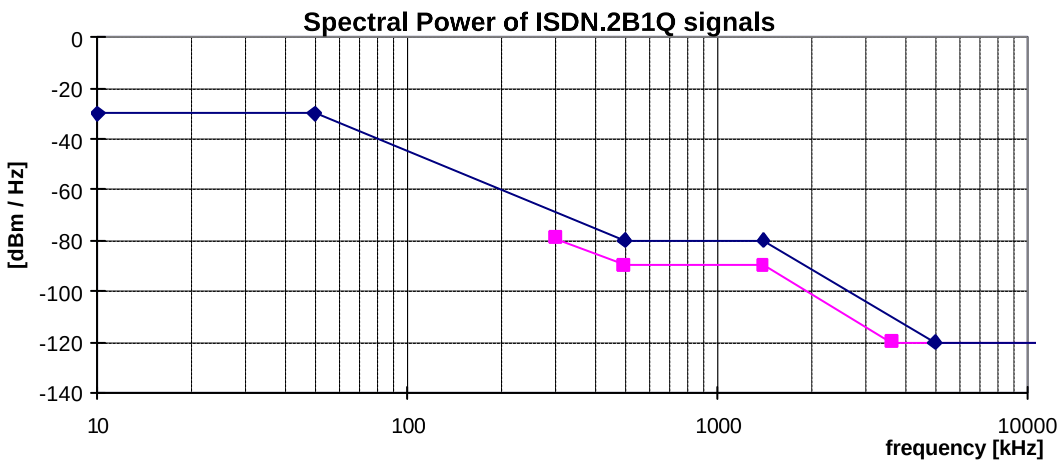


***Figure 7**: Spectral Power, for ISDN.2B1Q signals, as specified in table 9.*

8.1.5. Feeding Power (from the LT-port)

To be complient with this signal category, the DC feeding voltage and feeding current, used for the ISDN service shall not exceed the maximum values in table 10. The value for power includes a possible overload or short circuit condition at the user-network interface.

*Reference [8]: **[ETSI TS 102 080: clause 10.5 and 10.6.1.1]***

Voltage	Current	Power NT-port
Maximum 99 V	40 mA	maximum 1100 mW

***Table 10** Maximum feeding requirements for the ISDN service*

9. Cluster 3 Signals (symmetrical broad band)

This cluster summarizes symmetrical signals that are generated by digital transmission equipment up to 2 Mb/s, including HDSL and SDSL. If such a system requires more than one wire-pair for carrying that bitrate, the signal description holds for each individual wire-pair.

These signals are commonly used to carry services like high quality leased lines, with symmetrical bit rates (in up- and downstream directions).

9.1. “HDSL.2B1Q/3” Signals (392 kbaud /s leased lines)

This category covers signals, generated by HDSL transmission equipment on three wire-pairs, based on 2B1Q line coding. This sub clause is based on the ETSI reports on HDSL equipment [9,10,11]. These are essentially 392 kbaud/s systems (per wire-pair).

A signal (per wire-pair) can be classified as an "HDSL.2B1Q/3 signal" if it is complient with all subclauses below.

Unless otherwise indicated, the following signal specifications apply with a resistive load impedance of 135Ω, and does not apply to the DC remote power feeding (if any).

9.1.1. Unbalance about earth

To be complient with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum limits, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal conversion loss (LCL) measurement at the source of that signal, observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.1.

The observed LCL shall be higher than the lower limits given in figure 8. The LCL values of the associated break frequencies of this figure are given in table 11. The values for the components of the terminating impedance of the LCL measurements are given in table 12.

*Reference [11]: **[ETSI TS 101 135: clause 5.8.5.1]** extended tot 30 MHz according to Reference[20].*
*Reference [20]: **[ETSI TS 101 270-1: clause 8.3.3]***

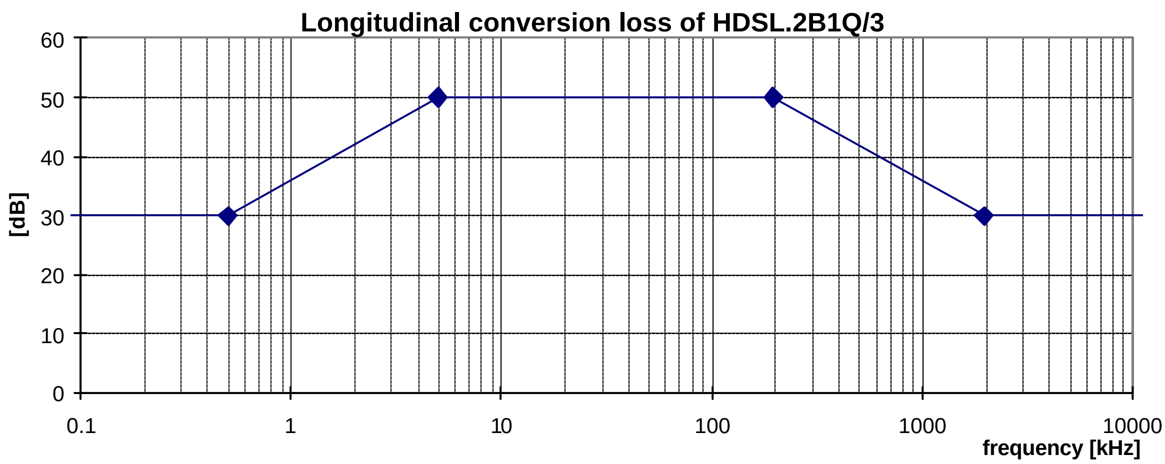


Figure 8: Minimum longitudinal conversion loss for a HDSL.2B1Q/3 system (392 kbaud/wirepair)

Frequency	LCL
<0.5 kHz	30 dB
5 kHz	50 dB
196 kHz	50 dB
1960 kHz	30 dB
30000 kHz	30 dB

Table 11: Frequencies and LCL values of the breakpoints of the LCL mask in figure ***8****.*

	Value	**Tolerance**
Resistance R1	135/2 ohm	R1/R2=1± 0,1 %
Resistance R2	135/2 ohm	R1/R2=1± 0,1 %
Capacitance	0.33 µF	

Table 12: Values for the components for the terminating impedance for measuring the LCL.

9.1.2. Total signal power

To be complient with this signal category, the mean signal power into a resistive load of 135 Ω shall not exceed a level of 14 dBm, measured within a frequency band from at least 100 Hz to 784 kHz.

*Reference [*11*]:* ***[ETSI TS 101 135: clause 5.8.4.4]***

9.1.3. Peak amplitude

To be complient with this signal category, the nominal voltage peak of the largest signal pulse into a resistive load of 135Ω shall not exceed a level of 2,64 V (± 7%), measured within a frequency band from at least 100 Hz to 784 kHz.

*Reference [*11*]:* ***ETSI TS 101 135: clause 5.8.4.1]***

9.1.4. Narrow-band signal power

To be complient with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 13, at any point in the frequency range 100 Hz to 30 MHz. This table specifies the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. Figure 9 illustrates the NBSP in a bandwidth-normalized way.

The NBSP is the average power ***P*** of a sending signal into a load resitance ***R***, within a bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.4.

NOTE The NBSP specification in table 13 is reconstructed from the commonly used PSD specification in [11] (similar to figure 9), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.

*Reference: [*11*]:* ***[ETSI TS 101 135: clause 5.8.4.3]****. These numbers are reconstructed from PSD requirements in [*11*]*

Frequency f	Impedance R	Sending level P	Bandwidth B	Spectral Power P/B
0.1 kHz	135Ω	-7 dBm	1 kHz	-37 dBm/Hz
10 kHz	135Ω	-7 dBm	1 kHz	-37 dBm/Hz
10 kHz	135Ω	3 dBm	10 kHz	-37 dBm/Hz
196 kHz	135Ω	3 dBm	10 kHz	-37 dBm/Hz
1.96 MHz	135Ω	-77 dBm	10 kHz	-117 dBm/Hz
1.96 MHz	135Ω	-57 dBm	1 MHz	-117 dBm/Hz
30 MHz	135Ω	-57 dBm	1 MHz	-117 dBm/Hz

Table 13 *Break points of the narrow-band power limits. These limits are frequency independent between 100 Hz to 196 kHz, and decrease with 24 dB/octave (80 dB/decade) above 196 kHz.*

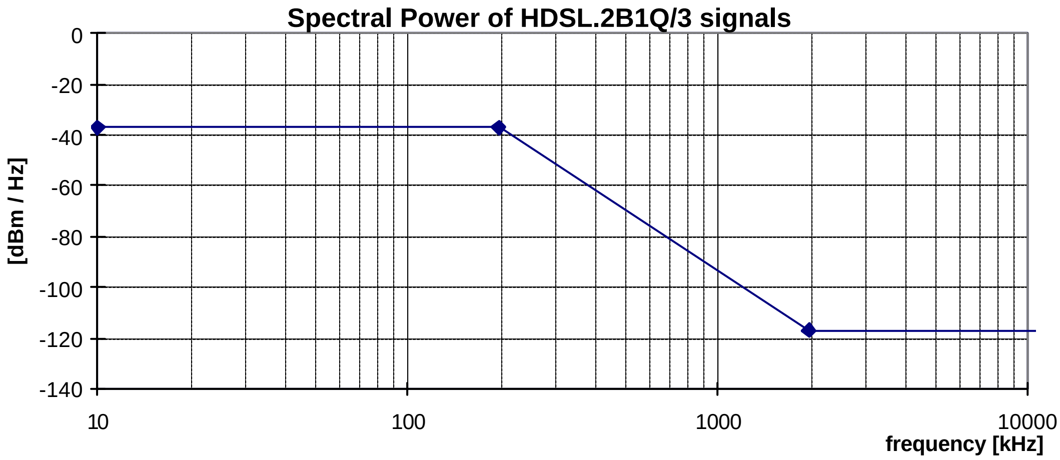


Figure 9*: Spectral Power, for HDSL.2B1Q/3 signals, as specified in table 13.*

9.1.5. Feeding Power (from the LT-port)

To be complient with this signal category, the DC feeding voltage and feeding current, used for the HDSL service shall not exceed the maximum values in table 14. The value for power includes a possible overload or short circuit condition at the user-network interface.

Reference [11]: ***[ETSI TS 101 135: clause 9.2]***

Voltage SUM (DC feeding + AC signal)	Current
maximum 120 V	50 mA

Table 14 *Maximum feeding requirements for the leased line service over HDSL*

9.2. "HDSL.2B1Q/2" Signals (584 kbaud/s leased lines)

This category covers signals, generated by HDSL transmission equipment on two wire-pairs, based on 2B1Q line coding. This sub clause is based on the ETSI reports on HDSL equipment [9,10,11]. These are essentially 584 kbaud/s systems (per wire-pair).

A signal (per wire-pair) can be classified as an "HDSL.2B1Q/2 signal" if it is complient with all subclauses below.

Unless otherwise indicated, the following signal specifications apply with a resistive load impedance of 135Ω, and does not apply to the DC remote power feeding (if any).

9.2.1. Unbalance about earth

To be complient with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum limits, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal conversion loss (LCL) measurement at the source of that signal, observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.1.

The observed LCL shall be higher than the lower limits given in figure 10. The LCL values of the associated break frequencies of this figure are given in table 15. The values for the components of the terminating impedance of the LCL measurements are given in table 16.

*Reference [11]: **[ETSI TS 101 135: clause 5.8.5.1]** extended tot 30 MHz according to Reference[20]:*
*Reference [20]: **[ETSI TS 101 270-1: clause 8.3.3]***

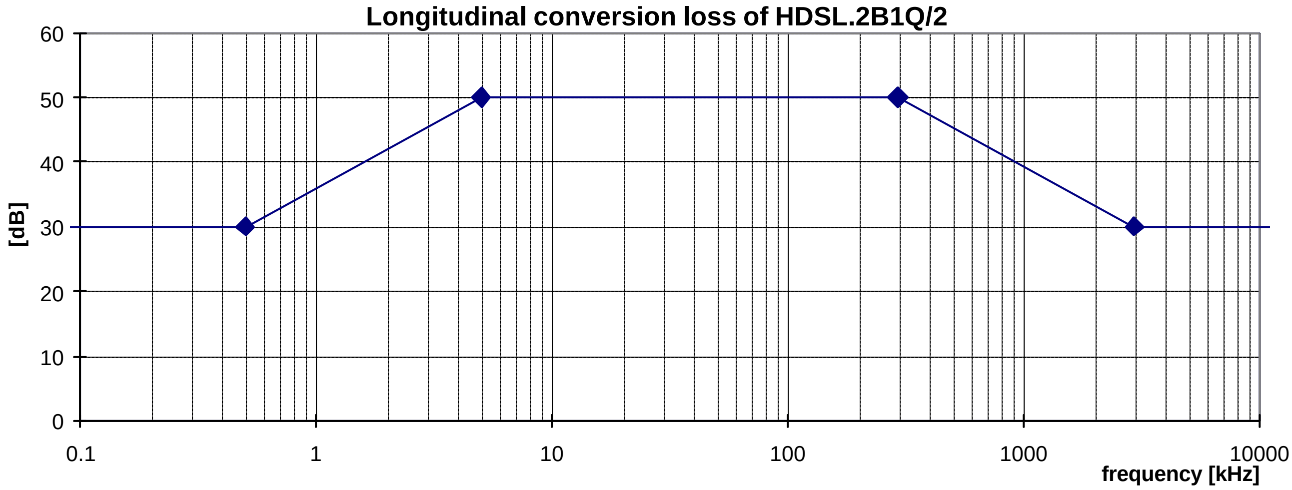


Figure 10: Minimum longitudinal conversion loss for a HDSL.2B1Q/2 system (584 kbaud/wirepair)

Frequency	LCL
<0.5 kHz	30 dB
5 kHz	50 dB
292 kHz	50 dB
2920 kHz	30 dB
30000 kHz	30 dB

*Table 15: Frequencies and LCL values of the breakpoints of the LCL mask in figure **10**.*

	Value	**Tolerance**
Resistance R1	135/2 ohm	R1/R2=1± 0,1 %
Resistance R2	135/2 ohm	R1/R2=1± 0,1 %
Capacitance	0.33 µF	

Table 16: Values for the components for the terminating impedance for measuring the LCL.

9.2.2. Total signal power

To be complient with this signal category, the mean signal power into a resistive load of 135 Ω shall not exceed a level of 14 dBm, measured within a frequency band from at least 100 Hz to 1168 kHz.

Reference [11]: ***[ETSI TS 101 135: clause 5.8.4.4]***

9.2.3. Peak amplitude

To be complient with this signal category, the nominal voltage peak of the largest signal pulse into a resistive load of 135Ω shall not exceed a level of 2,64 V (± 7%), measured within a frequency band from at least 100 Hz to 1168 kHz.

Reference [11]: ***[ETSI TS 101 135: clause 5.8.4.1]***

9.2.4. Narrow-band signal power

To be complient with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 17, at any point in the frequency range 100 Hz to 30 MHz. This table specifies the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. Figure 11 illustrates the NBSP in a bandwidth-normalized way.

The NBSP is the average power ***P*** of a sending signal into a load resitance ***R***, within a bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.4.

NOTE The NBSP specification in table 17 is reconstructed from the commonly used PSD specification in [11] (similar to figure 11), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.

Reference: [11]: ***[ETSI TS 101 135: clause 5.8.4.3]****. These numbers are reconstructed from PSD requirements in [11]*

frequency f	Impedance R	Sending level P	Bandwidth B	Spectral Power P/B
0.1 kHz	135Ω	-9 dBm	1 kHz	-39 dBm/Hz
10 kHz	135Ω	-9 dBm	1 kHz	-39 dBm/Hz
10 kHz	135Ω	1 dBm	10 kHz	-39 dBm/Hz
292 kHz	135Ω	1 dBm	10 kHz	-39 dBm/Hz
2.92 MHz	135Ω	-79 dBm	10 kHz	-119 dBm/Hz
2.92 MHz	135Ω	-59 dBm	1 MHz	-119 dBm/Hz
30 MHz	135Ω	-59 dBm	1 MHz	-119 dBm/Hz

Table 17: Break points of the narrow-band power limits. These limits are frequency independent between 100 Hz to 292 kHz, and decrease with 24 dB/octave (80 dB/decade) above 292 kHz.

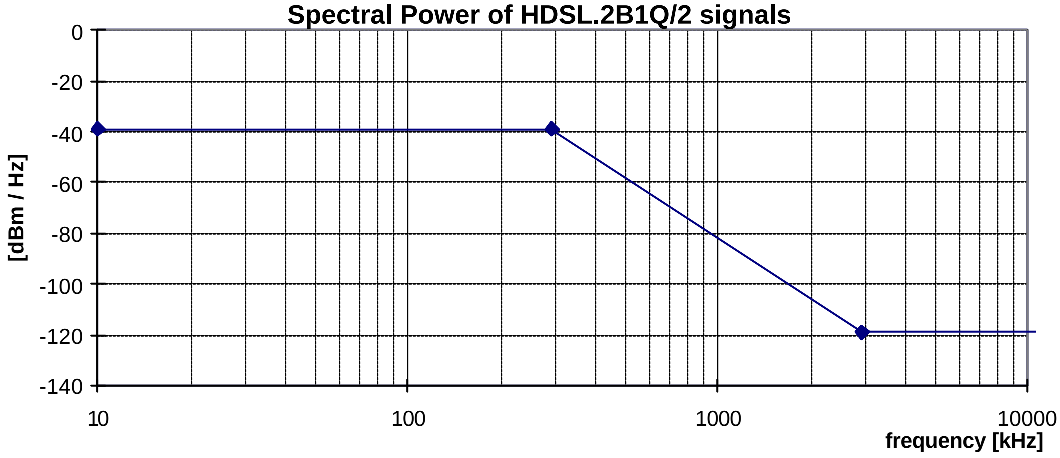


Figure 11: *Spectral Power, for HDSL.2B1Q/2 signals, as specified in table* ***17****.*

9.2.5. Feeding Power (from the LT-port)

To be complient with this signal category, the DC feeding voltage and feeding current, used for the HDSL service shall not exceed the maximum values in table 18. The value for power includes a possible overload or short circuit condition at the user-network interface.

*Reference [*11*]:* ***[ETSI TS 101 135: clause 9.2]***

Voltage SUM (DC feeding + AC signal)	**Current**
maximum 120 V	50 mA

Table 18 *Maximum feeding requirements for the leased line service over HDSL*

9.3. "HDSL.CAP/2" Signals

This category covers signals, generated by HDSL transmission equipment on two wire-pairs, based on CAP modulation. This sub clause is based on the ETSI reports on HDSL equipment [9,10,11].

A signal (per wire-pair) can be classified as an "HDSL.CAP/2 signal" if it is complient with all subclauses below.

Unless otherwise indicated, the following signal specifications apply with a resistive load impedance of 135Ω, and does not apply to the DC remote power feeding (if any).

9.3.1. Unbalance about earth

To be complient with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum limits, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal conversion loss (LCL) measurement at the source of that signal, observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.1.

The observed LCL shall be higher than the lower limits given in figure 12. The LCL values of the associated break frequencies of this figure are given in table 19. The values for the components of the terminating impedance of the LCL measurements are given in table 20.

*Reference [11]**: [ETSI TS 101 135: clause B.5.8.5.1]** extended tot 30 MHz according to Reference[20]:*
*Reference [20]: **[ETSI TS 101 270-1: clause 8.3.3]***

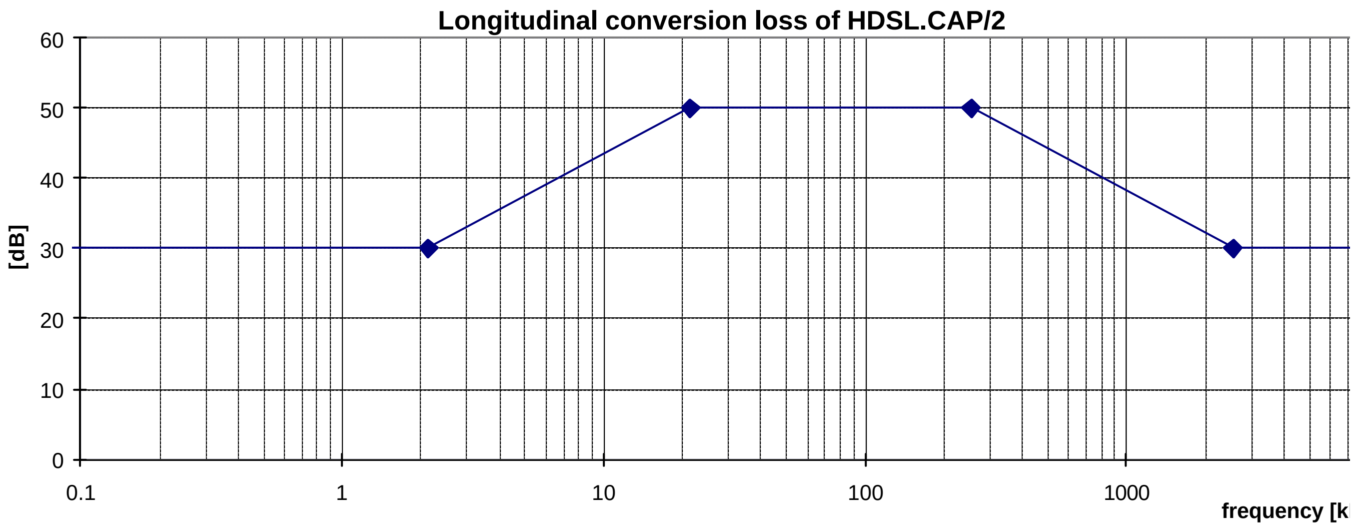


Figure 12: Minimum longitudinal conversion loss.

Frequency	LCL
<2.15 kHz	30 dB
21.5 kHz	50 dB
255 kHz	50 dB
2550 kHz	30 dB
30000 kHz	30 dB

*Table 19: Frequencies and LCL values of the breakpoints of the LCL mask in figure **12**.*

	Value	Tolerance
Resistance R1	135/2 ohm	R1/R2=1± 0,1 %
Resistance R2	135/2 ohm	R1/R2=1± 0,1 %
Capacitance	0.33 µF	

Table 20: Values for the components for the terminating impedance for measuring the LCL.

9.3.2. Total signal power

To be complient with this signal category, the mean signal power into a resistive load of 135Ω shall not exceed a level of 14 dBm, measured within a frequency band from at least 100 Hz to 1 MHz.

*Reference [*11*]: **[ETSI TS 101 135: clause B.5.8.4.1]***

9.3.3. Peak amplitude

To be complient with this signal category, the nominal voltage peak of the largest signal pulse into a resistive load of 135Ω shall not exceed a level of 6.5V (13V peak-peak), measured within a frequency band from at least 100 Hz to 1 MHz.

(no ETSI reference)

9.3.4. Narrow-band signal power (NBSP)

To be complient with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 21, at any point in the frequency range 100 Hz to 30 MHz. This table specifies the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. Figure 13 illustrates the NBSP in a bandwidth-normalized way.

The NBSP is the average power ***P*** of a sending signal into a load resitance ***R***, within a bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.4.

NOTE The NBSP specification in table 21 is reconstructed from the commonly used PSD specification in [11] (similar to figure 13), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.
The NBSP specification of this signal category has been split into two overlapping limits. Both upper limits shall be met simultaneously. The 10 kHz bandwidth values represent the "maximum PSD values" from [11], while the 100 kHz bandwidth values represent the "nominal PSD values". The 100 kHz bandwidth specification has been added here to smooth spectral ripple ("±1.5dB") from the "maximum PSD" into the "nominal PSD".

*Reference [*11*]: **[ETSI TS 101 135: clause B.5.8.4.2]**. (reconstructed from the PSD requirements in [*11*])*

frequency f	Impedance R	Sending level P	Bandwidth B	Spectral Power P/B
0.10 kHz 3.98 kHz	135Ω 135Ω	-25.5 dBm -25.5 dBm	1 kHz 1 kHz	-55.5 dBm/Hz -55.5 dBm/Hz
3.98 kHz 21.50 kHz 39.02 kHz 237.58 kHz 255.10 kHz 272.62 kHz 297.00 kHz 1.188 MHz	135Ω 135Ω 135Ω 135Ω 135Ω 135Ω 135Ω 135Ω	-15.5 dBm -1.5 dBm +1.5 dBm +1.5 dBm -1.5 dBm -17 dBm -30 dBm -60 dBm	10 kHz 10 kHz 10 kHz 10 kHz 10 kHz 10 kHz 10 kHz 10 kHz	-55.5 dBm/Hz -41.5 dBm/Hz -38.5 dBm/Hz -38.5 dBm/Hz -41.5 dBm/Hz -57 dBm/Hz -70 dBm/Hz -120 dBm/Hz
1.188 MHz 30 MHz	135Ω 135Ω	-60 dBm -60 dBm	1 MHz 1 MHz	-120 dBm/Hz -120 dBm/Hz
10 kHz 400 kHz	135Ω 135Ω	+10 dBm +10 dBm	100 kHz 100 kHz	-40 dBm/Hz -40 dBm/Hz

Table 21*:Frequencies of the break points and the corresponding peak and average values of the narrow-band signal power.*

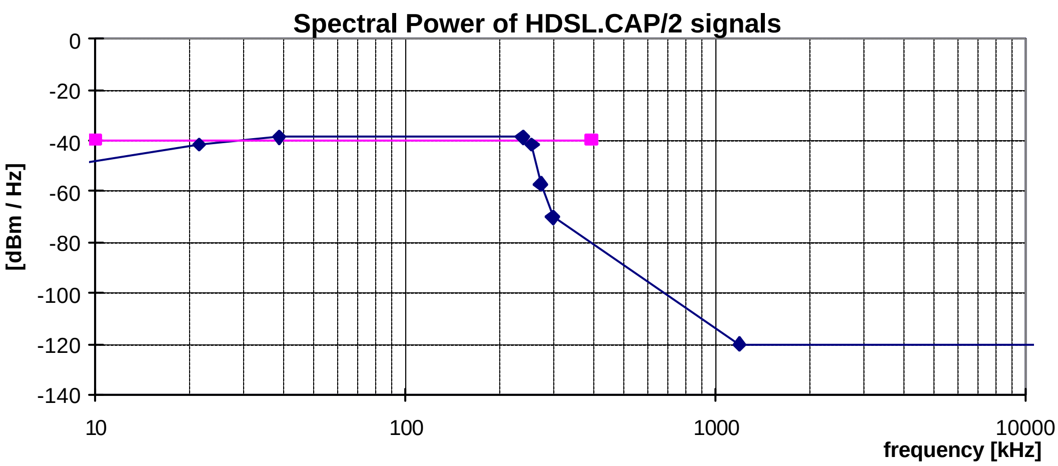


Figure 13*: Spectral Power, for HDSL.CAP/2 signals, as specified in table* ***21****.*

9.3.5. Feeding Power (from the LT-port)

To be complient with this signal category, the DC feeding voltage and feeding current, used for the HDSL service shall not exceed the maximum values in table 22. The value for power includes a possible overload or short circuit condition at the user-network interface.

*Reference [*11*]:* ***[ETSI TS101135: clause 9.2]***

Voltage SUM (DC feeding + AC signal)	**Current**
maximum 120 V	50 mA

Table 22 *Maximum feeding requirements for the leased line service over HDSL*

9.4. "SDSL" Signals

This category covers Symmetrical DSL transmission equipment on a single wire-pair. **This standard is still in progress, and therefore not yet defined here.**

Reference [22]: ***[ETSI WG TM6(98)9, Rev. 1, living list]***

9.5. "MSDSL.CAP/1::Fx" Signals (Variable bit-rate leased lines)

This category covers signals, generated by multi-rate HDSL transmission equipment on one (or two) wire-pairs, based on CAP modulation. This sub clause is partly based on the ETSI reports on HDSL equipment [9,10,11].

A signal (per wire-pair) can be classified as an "MSDSL.CAP/1::Fx signal" if it is complient with all subclauses below. The label "MSDSL.CAP/1::Fx" identifies a generic signal definition only.

In this naming convention, is the phrase "Fx" a placeholder for a number that is used as parameter in the signal definition. Replacing "Fx" by a number, changes the generic signal description into a specific description. This parameter is used in the sub clauses below, to complete the signal definition.
The parameter value F_x is indicative for the maximum baudrate [kbaud/s] that can be transported within these signal limits. A higher parameter value, identifies a signal that occupies a wider spectrum.
Table 23 gives several examples on how the naming convention relates to the actual parameter value F_X. It also illustrates some (informative) bitrates that can be transported within these signal limits, when using the associated (informative) modulation parameters. These are examples only, other system implementations may use the same signal limits in a different way.

Signal category	F_X [kHz]		Constellation size	Bit/symbol	Baud Rate [kbaud/s]	Bit Rate [kb/s]
MSDSL.CAP/1::72	72 kHz		8	2	72	144
MSDSL.CAP/1::91	91 kHz		16	3	90.7	272
MSDSL.CAP/1::133	133 kHz		16	3	133.3	400
MSDSL.CAP/1::176	176 kHz		16	3	176	528
MSDSL.CAP/1::261	261 kHz		16	3	261.3	784
MSDSL.CAP/1::261	261 kHz		32	4	260	1040
MSDSL.CAP/1::311	311 kHz		64	5	310.4	1552
MSDSL.CAP/1::344	344 kHz		128	6	344	2064
MSDSL.CAP/1::387	387 kHz		128	6	386.7	2320

Table 23. Example on how the naming convention relates to the actual parameter value F_x. that is used in the sub caluses below to specify the signal limits of this signal category. The bitrates and modulation parameters are informative only, and implementation dependent.

Unless otherwise indicated, the following signal specifications apply with a resistive load impedance of 135Ω, and does not apply to the DC remote power feeding (if any).

ED NOTE. The naming convention "MSDSL" may be confusing, since it suggests that it is derived from SDSL, while the text clearly states that it is derived from HDSL. I suggest to use an other name, such as "MHDSL". Suggestions invited.

9.5.1. Unbalance about earth

To be complient with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum limits, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal conversion loss (LCL) measurement at the source of that signal, observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.1.

The observed LCL shall be higher than the lower limits given in figure 14. The LCL values of the associated break frequencies of this figure are given in table 24. The values for the components of the terminating impedance of the LCL measurements are given in table 25.

(no ETSI reference)

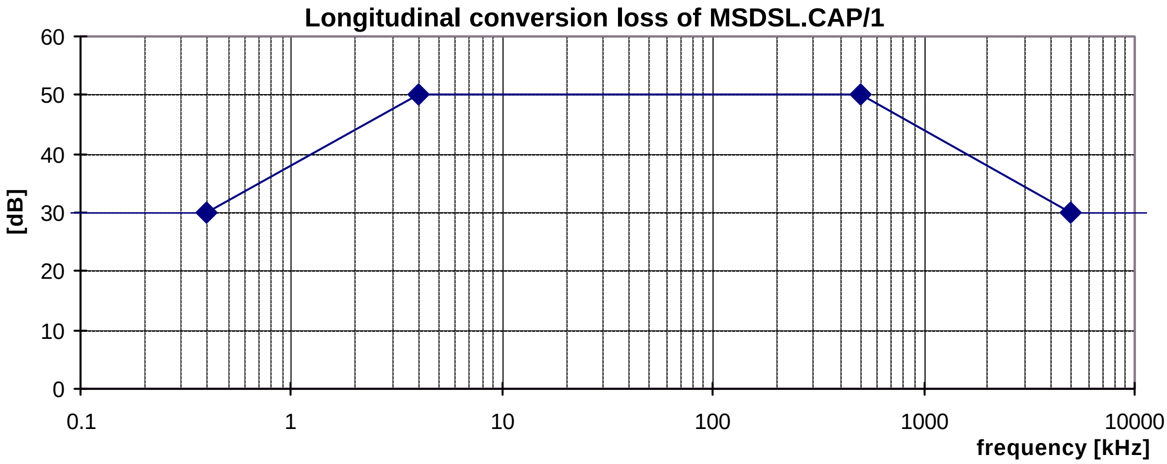


Figure 14: Minimum longitudinal conversion loss for a MSDSL.CAP/1::Fx system.

Frequency	**LCL**
<0.4 kHz	30 dB
4 kHz	50 dB
500 kHz	50 dB
5000 kHz	30 dB
30000 kHz	30 dB

*Table 24: Frequencies and LCL values of the breakpoints of the LCL mask in figure **14**.*

	Value	**Tolerance**
Resistance R1	135/2 ohm	R1/R2=1± 0,1 %
Resistance R2	135/2 ohm	R1/R2=1± 0,1 %
Capacitance	0.33 µF	

Table 25: Values for the components for the terminating impedance for measuring the LCL.

9.5.2. Total signal power

To be complient with this signal category, the mean signal power into a resistive load of 135Ω shall not exceed a level of 14 dBm, measured within a frequency band from at least 100 Hz to 1 MHz

(no ETSI reference)

9.5.3. Peak amplitude

To be complient with this signal category, the nominal voltage peak of the largest signal pulse into a resistive load of 135Ω shall not exceed a level of 6.5V (13V peak-peak), measured within a frequency band from at least 100 Hz to 1 MHz.

(no ETSI reference)

9.5.4. Narrow-band signal power (NBSP)

To be complient with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 26, at any point in the frequency range 100 Hz to 30 MHz. This table specifies the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. Figure 15 illustrates the NBSP in a bandwidth-normalized way.

The NBSP is the average power ***P*** of a sending signal into a load resitance ***R***, within a bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.4.

(no ETSI reference)

frequency f	Impedance R	Sending level P	Bandwidth B	Spectral Power P/B
0.1 kHz 4 kHz	135Ω 135Ω	-50 dBm -39 dBm	100 Hz 100 Hz	-70 dBm/Hz -59 dBm/Hz
4 kHz 10 kHz	135Ω 135Ω	-29 dBm -12 dBm	1 kHz 1 kHz	-59 dBm/Hz -42 dBm/Hz
10 kHz 40 kHz $F_L+(a \times F_X)$ $F_L + (1+a/2) \times F_X$ $F_L + (1+a) \times F_X$ 500 kHz 2 MHz	135Ω 135Ω 135Ω 135Ω 135Ω 135Ω 135Ω	-12 dBm -9 dBm -9 dBm -12 dBm -29 dBm -46 dBm -90 dBm	1 kHz 1 kHz 1 kHz 1 kHz 1 kHz 1 kHz 1 kHz	-42 dBm/Hz -39 dBm/Hz -39 dBm/Hz -42 dBm/Hz -59 dBm/Hz -76 dBm/Hz -120 dBm/Hz
2 MHz 30 MHz	135Ω 135Ω	-80 dBm -80 dBm	10 kHz 10 kHz	-120 dBm/Hz -120 dBm/Hz

Table 26*: frequencies of the break points and the corresponding peak and average values of the narrow-band signal power. The parameters are defined as follows: a=0.15,* $\boldsymbol{F_L}$*=10 kHz,* F_X*= defined by the signal category (see table 23).*

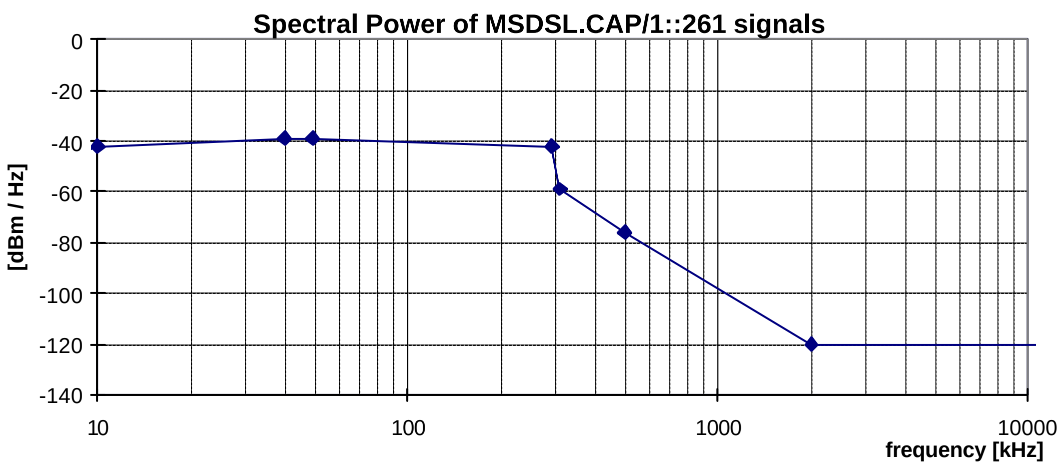


Figure 15*: Spectral Power, for MSDSL.CAP/1::261 signals (*F_X*=261 kHz), as specified in table* ***26****. Note that these curves are dependent of the value of parameter Fx, and that this figure shows an example only.*

10. Cluster 4 Signals (asymmetrical broad band)

This cluster summarizes asymmetrical signals that are generated by digital transmission equipment up to 8 Mb/s, including ADSL. Asymmetrically means a bit rate in the downstream direction and a significantly lower bitrate (e.g. 25%) in the upstream direction.

NOTE Asymmetrical DSL systems generate different signals in different transmission directions. Reversal of their transmission direction, which means the injection of upstream signals into LT-ports and downstream signals into the NT-ports, will cause a substantial reduction of the maximum reach. Such a reduction is even significant for all asymmetrical DSL systems when only one such system is reversed. Therefore the classification of asymmetrical DSL systems is consequently splitted into upstream and downstream specifications.

10.1. "ADSL.EC over POTS" Signals

This category covers signals, generated by ADSL transmission equipment. These signals may share the same wire pair with POTS signals. The additive "EC" identifies "echo cancelled, since the upstream and downstream signal spectra may overlap each other in frequency.

This clause is based on ETSI, ANSI and ITU reports on ADSL equipment [13,14,16]. A signal can be classified as an "ADSL.EC over POTS" signal if it is complient with all subclauses below.

10.1.1. Unbalance about earth (upstream and downstream)

To be complient with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum limits, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal conversion loss (LCL) measurement at the source of that signal, observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.1.

The observed LCL shall be higher than the lower limits given in figure 16. The LCL values of the associated break frequencies of this figure are given in table 27. The values for the components of the terminating impedance of the LCL measurements are given in table 28. The modem shall meet this requirement both, switched on and off.

*Reference [15]: **[ANSI-T1.413 issue 2: clause 12.3.1]** extended tot 30 MHz according to Reference [20]:*
*Reference [20]: **[ETSI-TS 101 270-1: clause 8.3.3]** and E.3.2.*

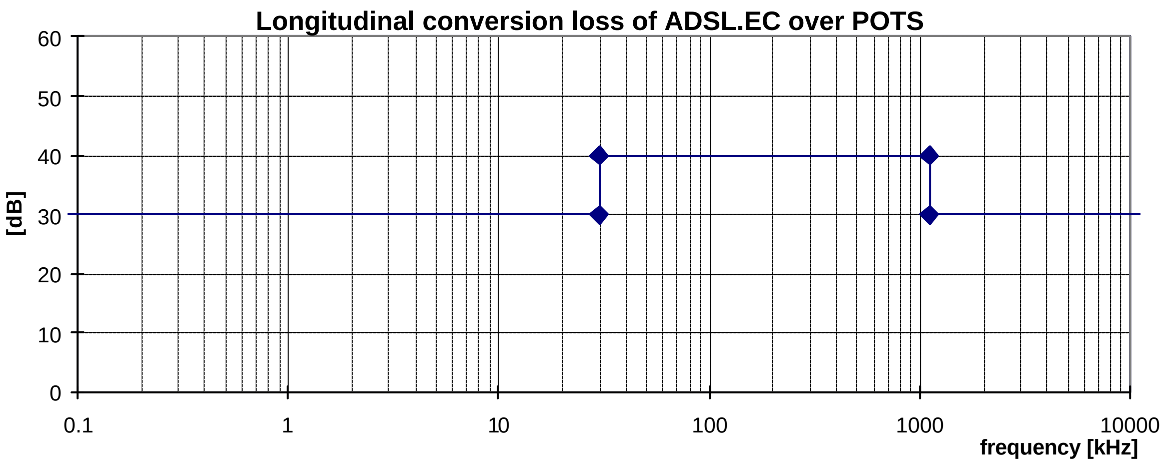


Figure 16: Minimum longitudinal conversion loss.

Frequency	LCL
< 30 kHz	30 dB
30 kHz	40 dB
1104 kHz	40 dB
>1104 kHz	30 dB

*Table 27: Frequencies and LCL values of the breakpoints of the LCL mask in figure **16**.*

	Value	Tolerance
Resistance R1	50 ohm	± 0.03 %
Resistance R2	50 ohm	± 0.03 %
Capacitance	Replace by short	

Table 28: Values for the components for the terminating impedance for measuring the LCL.

10.1.2. Total signal power (downstream only)

To be complient with this signal category, the mean downstream signal power into a resistive load of 100 Ω shall not exceed a level of 20.4 dBm, measured within a frequency band from at least 4 kHz to 3 MHz.

If measurements of the upstream power indicates that downstream power back-off is necessary, as described for the downstream PSD, than the maximum total transmit power shall be reduced accordingly.

Reference [15]: ***[ANSI-T1.413, issue 2: clause 6.15.1 and 6.15.3]***
Reference [16]: ***[ITU-G992.1: clause A.1.2.3.1]***

10.1.3. Total signal power (upstream only)

To be complient with this signal category, the mean upstream signal power into a resistive load of 100Ω shall not exceed a level of 12.5 dBm, measured within a frequency band from at least 4 kHz to 3 MHz.

Reference [15]: ***[ANSI-T1.413, issue 2: clause 7.15.1 and 7.15.3]***
Reference [16]: ***[ITU-G992.1: clause A.2.4.3.1]***

10.1.4. Peak amplitude (upstream and downstream)

To be complient with this signal category, the nominal voltage peak of the largest signal pulse into a resistive load of 100Ω shall not exceed a level of 7.5V (14V peak-peak), measured within a frequency band from at least 100 Hz to 1 MHz.

(no ETSI reference)

10.1.5. Narrow-band signal power (downstream only)

To be complient with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 29, at any point in the frequency range 100 Hz to 30 MHz. This table specifies the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. Figure 17 illustrates the NBSP in a bandwidth-normalized way.

The NBSP is the average power ***P*** of a sending signal into a load resitance ***R***, within a bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.4.

NOTE The NBSP specification in table 29 is reconstructed from the commonly used PSD specifications in [13,14,16] (similar to figure 17), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.
The NBSP specification of this signal category has been split into two overlapping limits. Both upper limits shall hold simultaneously. The 10 kHz bandwidth values represent the "maximum PSD values" from [13,14,16], and includes the pass band ripple. The 100 kHz bandwidth values represent the "average PSD values" in the passband to smooth out the spectrall ripple of 3.5 dB. The 1 MHz bandwidth specification is equivalent to the "sliding window" specification in [13,14,16].

*Reference [15]: **[ANSI-T1.413, issue 2: clause 6.14]** reconstructed from PSD requirements*
*Reference [16]: **[ITU-G992.1: clause A.1.2]** reconstructed from PSD requirements*

frequency f	Impedance R	Sending level P	Bandwidth B	Spectral Power P/B
0,1 kHz	600Ω	-77.5 dBm	100 Hz	-97.5 dBm/Hz
1 kHz	600Ω	-77.5 dBm	100 Hz	-97.5 dBm/Hz
1 kHz	600Ω	-67.5 dBm	1 kHz	-97.5 dBm/Hz
4 kHz	600Ω	-67.5 dBm	1 kHz	-97.5 dBm/Hz
4 kHz	100Ω	-52.5 dBm	10 kHz	-92.5 dBm/Hz
25.875 kHz	100Ω	+3.5 dBm	10 kHz	-36.5 dBm/Hz
1104 kHz	100Ω	+3.5 dBm	10 kHz	-36.5 dBm/Hz
3093 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
11040 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
30000 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
25 kHz	100Ω	P_{BO} - 50 dBm	100 kHz	P_{BO} dBm/Hz
1104 kHz	100Ω	P_{BO} - 50 dBm	100 kHz	P_{BO} dBm/Hz
3093 kHz	100Ω	-40 dBm	100 kHz	-90 dBm/Hz
3093 kHz	100Ω	-30 dBm	1 MHz	-90 dBm/Hz
4545 kHz	100Ω	-50 dBm	1 MHz	-110 dBm/Hz
30000 kHz	100Ω	-50 dBm	1 MHz	-110 dBm/Hz

*Table 29: Break points of the narrow-band power limits. The values for parameter P_{BO} are defined in table **30**, and are dependend from the received upstream power (Power back-off).*

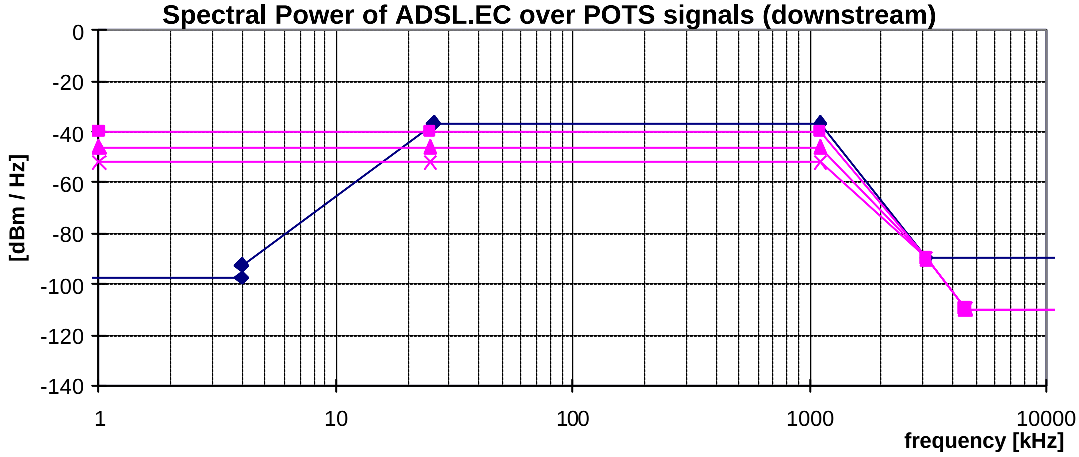


***Figure 17**: Spectral Power, for ADSL.EC over POTS signals, as specified in table **29**. The maximum spectral power varies with the value of parameter P_{BO}, as defined in table 30. Only the curves for the values P_{BO}=-40 dBm/Hz, P_{BO}=-46 dBm/Hz, and P_{BO}=-52 dBm/Hz are shown here.*

Power back-off. To be complient with this signal category, the maximum downstream signal power shall be reduced when the received upstream power is below specified levels. If the total received upstream power from 28.031 to 79.781

kHz (ADSL sub-carriers 7-18) is greater than 3 dBm into 100 ohm then parameter P_{BO} shall not exceed the values shown in table 30. The received upstream power measurement shall be performed with an accuracy of ±1 dB or better.

Upstream received power (dBm)	<3	<4	<5	<6	<7	<8	<9
Parameter P_{BO}	-40	-42	-44	-46	-48	-50	-52

Table 30: ***Definition of parameter P_{BO}, as used in table*** *29* ***(Power Back-off, or Power Cut-Back).***

Reference [15]: ***[ANSI-T1.413, issue 2: clause 9.4.6]***
Reference [16]: ***[ITU-G992.1: clause A.3.1]***

10.1.6. Narrow-band signal power (upstream only)

To be complient with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 31, at any point in the frequency range 100 Hz to 30 MHz. This table specifies the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. Figure 18 illustrates the NBSP in a bandwidth-normalized way.

The NBSP is the average power ***P*** of a sending signal into a load resitance ***R***, within a bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.4.

NOTE The NBSP specification in table 29 is reconstructed from the commonly used PSD specifications in [13,14,16] (similar to figure 18), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.
The NBSP specification of this signal category has been split into two overlapping limits. Both upper limits shall hold simultaneously. The 10 kHz bandwidth values represent the "maximum PSD values" from [13,14,16], and includes the pass band ripple. The 100 kHz bandwidth values represent the "average PSD values" in the passband to smooth out the spectrall ripple of 3.5 dB. The 1 MHz bandwidth specification is equivalent to the "sliding window" specification in [13,14,16].

Reference [15]: ***[ANSI-T1.413, issue 2: clause 7.14]*** *reconstructed from PSD requirements*
Reference [16]: ***[ITU-G992.1: clause A.2.4]*** *reconstructed from PSD requirements*

frequency f	Impedance R	Sending level P	Bandwidth B	Spectral Power P/B
0,1 kHz	600Ω	-77.5 dBm	100 Hz	-97.5 dBm/Hz
1 kHz	600Ω	-77.5 dBm	100 Hz	-97.5 dBm/Hz
1 kHz	600Ω	-67.5 dBm	1 kHz	-97.5 dBm/Hz
4 kHz	600Ω	-67.5 dBm	1 kHz	-97.5 dBm/Hz
4 kHz	100Ω	-52.5 dBm	10 kHz	-92.5 dBm/Hz
25.875 kHz	100Ω	+5.5 dBm	10 kHz	-34.5 dBm/Hz
138 kHz	100Ω	+5.5 dBm	10 kHz	-34.5 dBm/Hz
307 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
11040 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
30000 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
25 kHz	100Ω	+3.5 dBm	100 kHz	-38 dBm/Hz
138 kHz	100Ω	+3.5 dBm	100 kHz	-38 dBm/Hz
307 kHz	100Ω	-40 dBm	100 kHz	-90 dBm/Hz
1221 kHz	100Ω	-40 dBm	100 kHz	-90 dBm/Hz
1221 kHz	100Ω	-30 dBm	1 MHz	-90 dBm/Hz
1630 kHz	100Ω	-50 dBm	1 MHz	-110 dBm/Hz
11040 kHz	100Ω	-50 dBm	1 MHz	-110 dBm/Hz
30000 kHz	100Ω	-50 dBm	1 MHz	-110 dBm/Hz

Table 31: Break points of the narrow-band power limits.

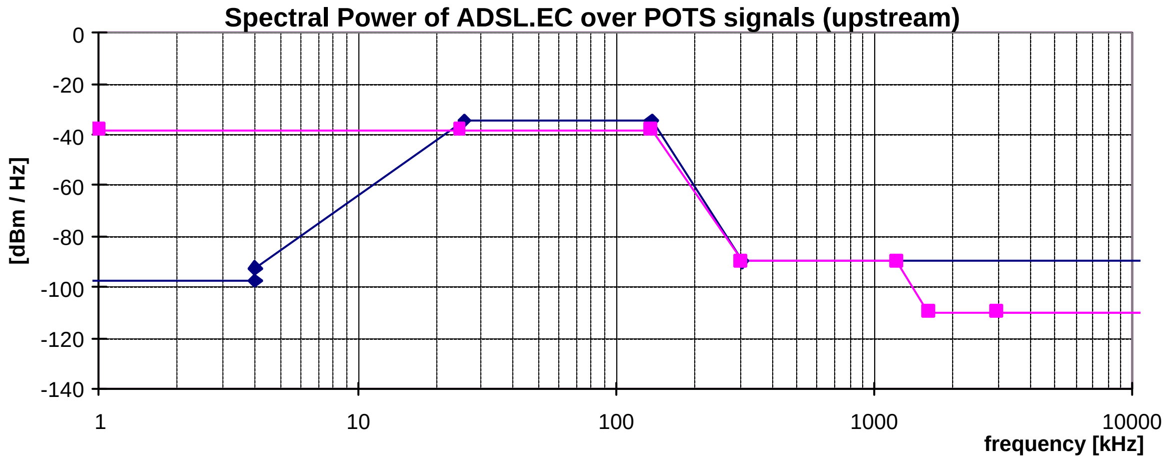


***Figure 18**: Spectral Power, for ADSL.EC over POTS signals, as specified in table **31**.*

10.2. "ADSL.EC over ISDN" Signals

This category covers signals, generated by ADSL transmission equipment. These signals may share the same wire pair with ISDN signals. The additive "EC" identifies "echo cancelled, since the upstream and downstream signal spectra may overlap each other in frequency.

This clause is based on ETSI and ITU reports on ADSL equipment [13,16]. A signal can be classified as an "ADSL.EC over ISDN" signal if it is complient with all subclauses below.

10.2.1. Unbalance about earth (upstream and downstream)

To be complient with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum limits, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal conversion loss (LCL) measurement at the source of that signal, observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.1.

The observed LCL shall be higher than the lower limits given in figure 19. The LCL values of the associated break frequencies of this figure are given in table 32. The values for the components of the terminating impedance of the LCL measurements are given in table 33. The modem shall meet this requirement both, switched on and off.

Reference [15]: ***[ANSI-T1.413, issue 2: clause 12.3.1]*** *extended tot 30 MHz according to Reference [20]*
Reference [20]: ***[ETSI-TS 101 270-1: clause 8.3.3 and E.3.2]***

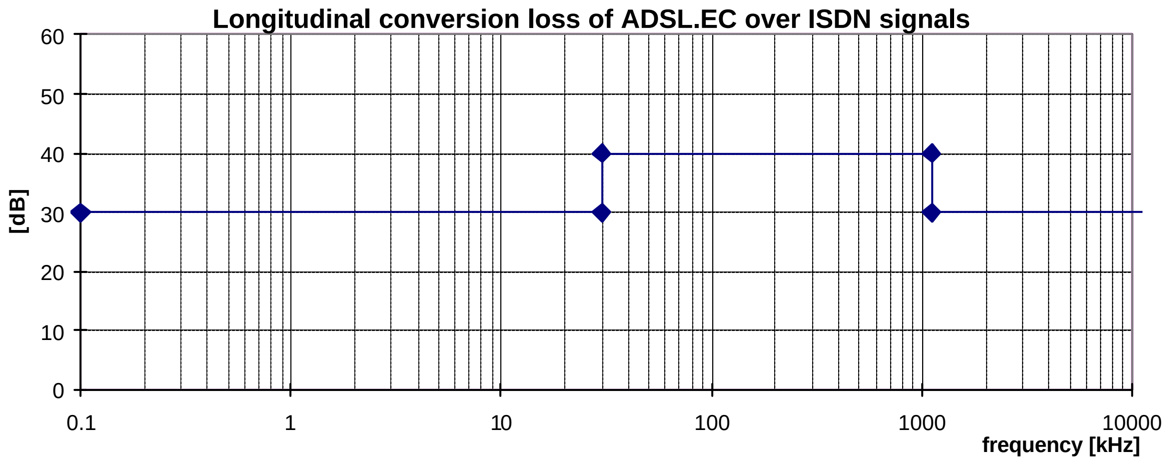


Figure 19: Minimum longitudinal conversion loss.

Frequency	LCL
< 30 kHz	30 dB
30 kHz	40 dB
1104 kHz	40 dB
>1104 kHz	30 dB

Table 32*: Frequencies and LCL values of the breakpoints of the LCL-mask in figure 19.*

	Value	Tolerance
Resistance R1	50 ohm	± 0.03 %
Resistance R2	50 ohm	± 0.03 %
Capacitance	Replace by short	

Table 33: Values for the components of the termination for measuring the LCL.

10.2.2. Total signal power (downstream only)

To be complient with this signal category, the mean downstream signal power into a resistive load of 100 Ω shall not exceed a level of 19.83 dBm, measured within a frequency band from at least 4 kHz to 3 MHz.

If measurements of the upstream power indicates that downstream power back-off is necessary, as described for the downstream PSD, than the maximum total transmit power shall be reduced accordingly.

Reference [13]: ***[ETSI TS 101 388: clause 5.2]***

10.2.3. Total signal power (upstream only)

To be complient with this signal category, the mean upstream signal power into a resistive load of 100 Ω shall not exceed a level of 13.26 dBm, measured within a frequency band from at least 4 kHz to 3 MHz.

Reference [13]: ***[ETSI TS 101 388: clause 6.3]***

10.2.4. Peak amplitude (upstream and downstream)

To be complient with this signal category, the nominal voltage peak of the largest signal pulse into a resistive load of 100Ω shall not exceed a level of 7.5V (14V peak-peak), measured within a frequency band from at least 100 Hz to 1 MHz.

(no ETSI reference)

10.2.5. Narrow-band signal power (downstream only)

To be complient with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 34, at any point in the frequency range 100 Hz to 30 MHz. This table specifies the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. Figure 20 illustrates the NBSP in a bandwidth-normalized way.

The NBSP is the average power ***P*** of a sending signal into a load resitance ***R***, within a bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.4.

NOTE The NBSP specification in table 34 is reconstructed from the commonly used PSD specifications in [13, 16] (similar to figure 20), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.
The NBSP specification of this signal category has been split into two overlapping limits. Both upper limits shall hold simultaneously. The 10 kHz bandwidth values represent the "maximum PSD values" from [13, 16], and includes the pass band ripple. The 100 kHz bandwidth values represent the "average PSD values" in the passband to smooth out the spectrall ripple of 3.5 dB. The 1 MHz bandwidth specification is equivalent to the "sliding window" specification in [13, 16].

Reference [13]: ***[ETSI TS 101 388: clause 5.4]*** *reconstructed from PSD requirements*
Reference [16]: ***[ITU-G992.1: clause B.1.3]*** *reconstructed from PSD requirements*

frequency f	Impedance R	Sending level P	Bandwidth B	Spectral Power P/B
0,1 kHz	100Ω	-70 dBm	100 Hz	-90 dBm/Hz
1 kHz	100Ω	-70 dBm	100 Hz	-90 dBm/Hz
1 kHz	100Ω	-60 dBm	1 kHz	-90 dBm/Hz
4 kHz	100Ω	-60 dBm	1 kHz	-90 dBm/Hz
4 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
50 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
80 kHz	100Ω	-41.8 dBm	10 kHz	-81.8 dBm/Hz
120 kHz	100Ω	+3.5 dBm	10 kHz	-36.5 dBm/Hz
1104 kHz	100Ω	+3.5 dBm	10 kHz	-36.5 dBm/Hz
3093 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
11040 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
30000 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
120 kHz	100Ω	P_{BO} - 50 dBm	100 kHz	P_{BO} dBm/Hz
1104 kHz	100Ω	P_{BO} - 50 dBm	100 kHz	P_{BO} dBm/Hz
3093 kHz	100Ω	-40 dBm	100 kHz	-90 dBm/Hz
3093 kHz	100Ω	-30 dBm	1 MHz	-90 dBm/Hz
4545 kHz	100Ω	-50 dBm	1 MHz	-110 dBm/Hz
30000 kHz	100Ω	-50 dBm	1 MHz	-110 dBm/Hz

*Table 34: Break points of the narrow-band power limits. The values for parameter P_{BO} are defined in table **35**, and are dependend from the received upstream power (Power back-off).*

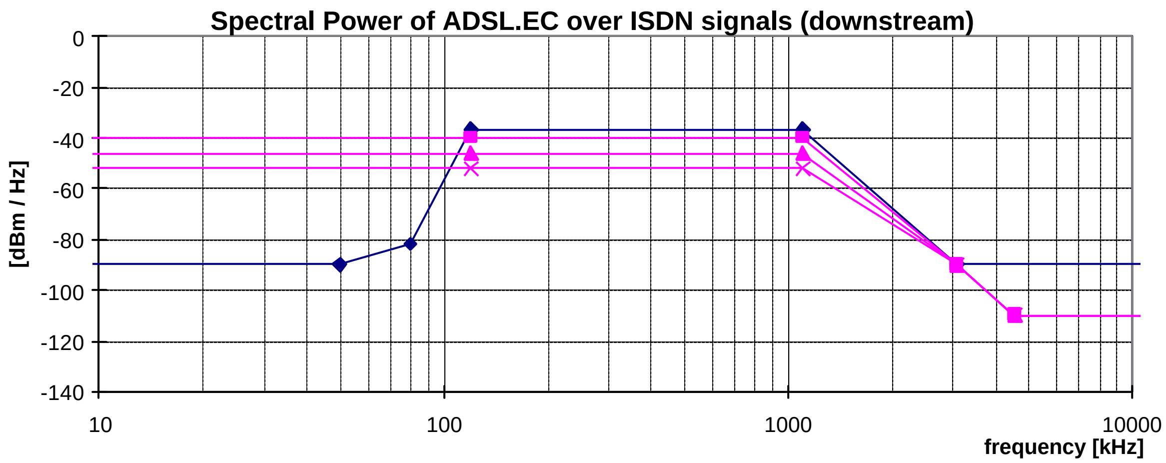


***Figure 20**: Spectral Power, for ADSL.EC over ISDN signals, as specified in table **34**. The maximum spectral power varies with the value of parameter P_{BO}, as defined in table **35**. Only the curves for the values P_{BO}=-40 dBm/Hz, P_{BO}=-46 dBm/Hz, and P_{BO}=-52 dBm/Hz are shown here.*

Power back-off. To be complient with this signal category, the maximum downstream signal power shall be reduced when the received upstream power is below specified levels. If the total received upstream power from 170.34 to 222.09 kHz (ADSL sub-carriers 40-51) is greater than 0 dBm into 100 ohm then parameter P_{BO} shall not exceed the values shown in table 35. The received upstream power measurement shall be performed with an accuracy of ±1 dB or better.

Upstream received power (dBm)	<0	<1.5	<3	<4.5	<6	<7.5	<9
Parameter P_{BO}	-40	-42	-44	-46	-48	-50	-52

*Table 35: **Definition of parameter P_{BO}, as used in table 34 (Power Back-off, or Power Cut-Back).***

.

*Reference [13]: **[ETSI TS 101 388: clause 7.17]** (Uses subcarrier 40-51, values that have been adopted here)*
*Reference [16]: **[ITU-G992.1: clause B.3.3]** (Uses subcarrier 36-51, values that have been ignored here)*

10.2.6. Narrow-band signal power (upstream only)

To be complient with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 36, at any point in the frequency range 100 Hz to 30 MHz. This table specifies the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. Figure 21 illustrates the NBSP in a bandwidth-normalized way.

The NBSP is the average power ***P*** of a sending signal into a load resitance ***R***, within a bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.4.

NOTE The NBSP specification in table 36 is reconstructed from the commonly used PSD specifications in [13, 16] (similar to figure 21), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.
The NBSP specification of this signal category has been split into two overlapping limits. Both upper limits shall hold simultaneously. The 10 kHz bandwidth values represent the "maximum PSD values" from [13, 16], and includes the pass band ripple. The 100 kHz bandwidth values represent the "average PSD values" in the passband to smooth out the spectrall ripple of 3.5 dB. The 1 MHz bandwidth specification is equivalent to the "sliding window" specification in [13, 16].

Reference [13]: ***[ETSI TS 101 388: clause 6.10]*** *reconstructed from PSD requirements*
Reference [16]: ***[ITU-G992.1: clause B.2.2]*** *reconstructed from PSD requirements*

frequency f	Impedance R	Sending level P	Bandwidth B	Spectral Power P/B
0,1 kHz	100Ω	-70 dBm	100 Hz	-90 dBm/Hz
1 kHz	100Ω	-70 dBm	100 Hz	-90 dBm/Hz
1 kHz	100Ω	-60 dBm	1 kHz	-90 dBm/Hz
4 kHz	100Ω	-60 dBm	1 kHz	-90 dBm/Hz
4 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
50 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
80 kHz	100Ω	-41.8 dBm	10 kHz	-81.8 dBm/Hz
120 kHz	100Ω	+5.5 dBm	10 kHz	-34.5 dBm/Hz
276 kHz	100Ω	+5.5 dBm	10 kHz	-34.5 dBm/Hz
614 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
11040 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
30000 kHz	100Ω	-50 dBm	10 kHz	-90 dBm/Hz
120 kHz	100Ω	+3.5 dBm	100 kHz	-38 dBm/Hz
276 kHz	100Ω	+3.5 dBm	100 kHz	-38 dBm/Hz
614 kHz	100Ω	-40 dBm	100 kHz	-90 dBm/Hz
1221 kHz	100Ω	-40 dBm	100 kHz	-90 dBm/Hz
1221 kHz	100Ω	-30 dBm	1 MHz	-90 dBm/Hz
1630 kHz	100Ω	-50 dBm	1 MHz	-110 dBm/Hz
11040 kHz	100Ω	-50 dBm	1 MHz	-110 dBm/Hz
30000 kHz	100Ω	-50 dBm	1 MHz	-110 dBm/Hz

Table 36: Break points of the narrow-band power limits.

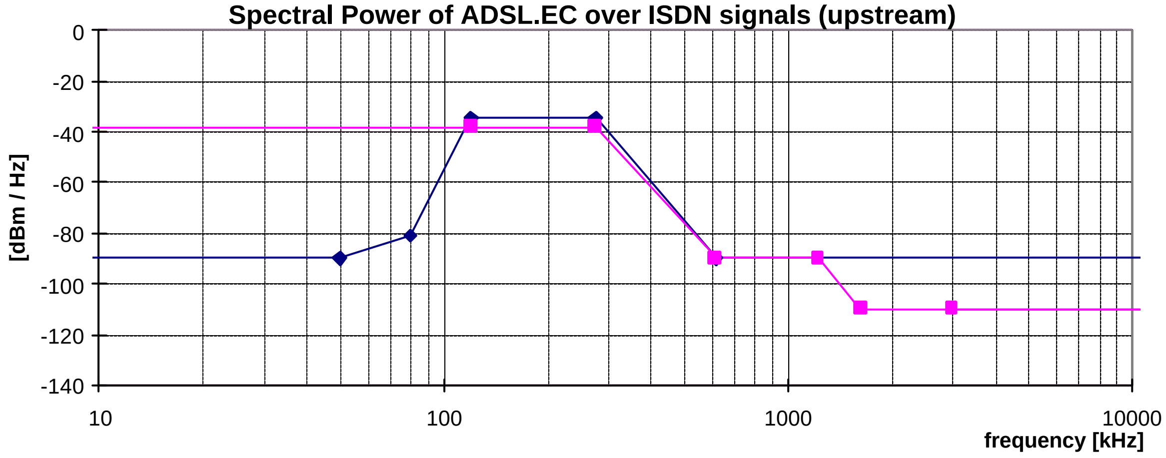


***Figure 21**: Spectral Power, for ADSL.EC over ISDN signals, as specified in table **36**.*

10.3. "ADSL.FDD over POTS" Signals

10.4. "ADSL.FDD over ISDN" Signals

11. Cluster 5 Signals (broad band up to 30 MHz)

<Text>

11.1. "VDSL" Signals

12. Measurement methods of signal parameters

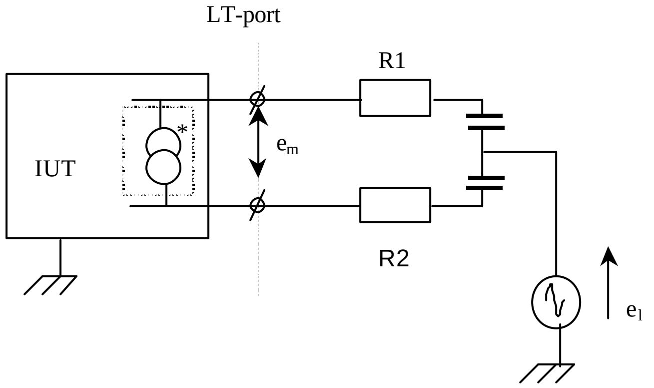
ED NOTE <this clause needs improvement>

12.1. Unbalance about earth

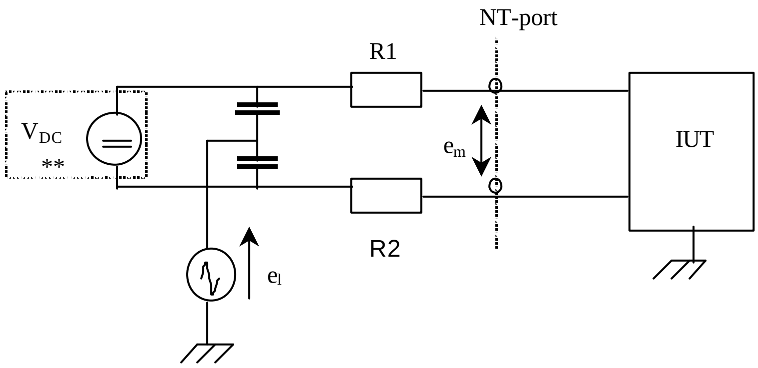
The (LCL) longitudinal conversion loss is given by: LCL = 20 log (e_l/e_m) [dB] where e_l is the applied longitudinal voltage referenced to the building ground and e_m is the resultant metallic voltage appearing across a termination with the impedance as given in the relevant section.

*References [**23**]: **[ITU:O.9],***

Figure 22 defines the measurement method for the longitudinal conversion loss (LCL). The LCL is given by: LCL = 20log(e_l/e_m) [dB] where e_l is the applied longitudinal voltage referenced to the building ground and e_m is the resultant metallic voltage appearing across a defined termination. Measurement should be performed with the IUT powered up but inactive (no transmit signal).



* For LT test only if remote powering is supplied.



** For NT test only if remote powering is required. The power supply shall have at least an impedance of 10* (R1+R2) for the test frequencies of the LCL.

Figure 22: Measurement method for longitudinal conversion loss.

12.2. Total signal voltage (or power)

12.3. Peak amplitude

12.4. Narrow-band signal power (voltage)

The narrow band signal power is defined as the average power **P** of a sending signal into a resistive load **R**, within a bandwidth **B** centred at any point of a frequency range. A sending signal shall never exceed the limits given in the tables in the relevant sections. These tables specify the break points of the limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale.

NOTE The purpose of NBSP definitions (narrow band signal power), instead of a PSD definition (power spectral density) is that NBSP definitions are more tolerant to signals that are not near random in nature but carry some harmonic components. A PSD mask will exclude signals with irrelevant peaks in their PSD, while a NBSP mask is more tolerant to these peaks. Therefore all categories in this document are specified in terms of NBSP, while PSD mask, or sliding window PSD-masks are provided to demonstrate compliance with associated standards.

<Text>

Also known as Sliding window signal power

The purpose of the sliding window is to perform a higher bandwidth measurement in order to make sure that different systems do not fill the entire allowable band with noise up to some limit.

The sliding window PSD shall be measured as the total average power within a 1 MHz sliding window (1MHz bandwidth). The requirement is applicable between 300 kHz and 30 MHz.

References [8,20]: ***[ETSI TS 102 080: clause A.12.4]***

Annex <yy> (normative): Title of normative annex

yy.1 First clause of this normative annex

<Text>

yy.1.1 First subclause of this normative annex

<Text>

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History

Document history		
0.0.1	feb 2000	First Draft