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Technical Report

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

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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 & harmonise 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 referring to the definitions in this document.

The informative library of signal definitions is organised 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, ITU and ANSI (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 Telecommunication Union
LCL	Longitudinal Conversion Loss
LOV	Longitudinal Output Voltage
LT-port	Line Termination port
LVD	Low Voltage Directive
MDF	Main Distribution Frame
NBSP	Narrow band signal power
NBSV	Narrow band signal voltage
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
RMS	Root Mean Square
SDSL	Symmetrical (single pair high bitrate) 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 consequence 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 impairment 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. Bounding 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-compatible 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 wire pairs 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. The Individual Components of Spectral Pollution

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.

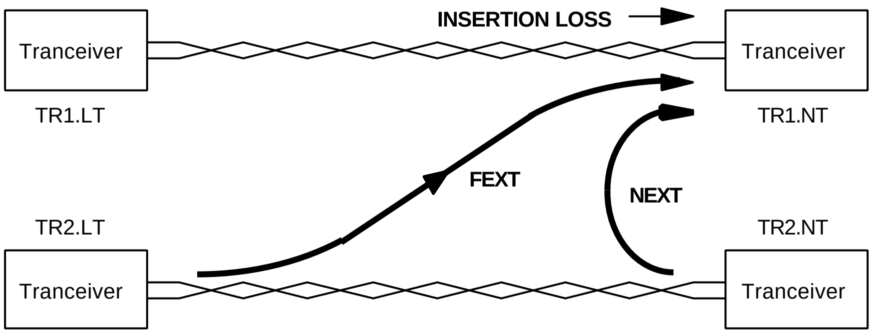


Figure 1. Various crosstalk paths .

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

This clause describes 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 equipment near the customer side.

The Local Loop Wiring (LLW) of an access network includes mainly cables, but may also include a Main Distribution Frame (MDF), street cabinets, and other distribution elements.

From a Spectral Management point of view, signal sources are identified on their location:

- CSS: Customer-side Signal Sources
- ESS: Exchange-side Signal Sources (such as local exchanges)
- RSS: Remote Signal Sources (such as repeaters and optical network units in street cabinets)

5.1. The concept of a Port, the interface the Local Loop Wiring

To give signal sources access to the Local Loop Wiring, their signals enter the LLW by flowing through so-called “ports”. The ports are the interfaces to the Local Loop Wiring, and should therefore be well identified.

The following port-types are defined in this reference model:

- ***LT-port***: The Line Termination port is generally used for connecting an ESS to the LLW.
- ***NT-port***: The Network Termination port is generally used for connecting an CSS to the LLW.
- ***LT.cab-port***: The LT-cabinet port is generally used for connecting an RSS to the LLW, that links this port with an NT-port (or NT.cab-port) elsewhere in the LLW.
- ***NT.cab-port***: The NT-cabinet port is generally used for connecting an RSS to the LLW, that links this port with an LT-port (or LT.cab-port) elsewhere in the LLW.

At least two ports are required for communication. In special cases where access to the LLW at additional *well-identified* ports (such as in street cabinets) is provided for remote active devices (such as repeaters and optical network units), more ports may be involved.

5.2. Bounding Spectral Pollution by limiting signals at the Ports

The signal limits that are summarised in this document, are to limit injected signals as they can be observed at the ports of the LLW.

The signals that many DSL systems generate are asymmetrical in nature. For instance ADSL systems generate different data signals in different transmission directions. ISDN and HDSL systems are symmetrical in their data signals, but their remote DC power feeding is asymmetrical. Therefore different port names are used in the Reference Model to simplify the description of signal limits that are transmission direction dependent.

NOTE Reversing the transmission direction is generally not recommended, and may be implicitly forbidden by asymmetric signal limits at the ports. For example, ADSL systems are designed to maximise self-compatibility when all ‘downstream’ signals in one cable flow into the same direction. Typically connection of one system the other way round would harm neighbouring systems unacceptably, and is excluded when it violates the limits.

In the case of symmetric signal limits, no further distinction on transmission direction is made. In the case of asymmetric signal limits, the following naming convention is used in this document:

- ***Downstream*** signal limits are mandatory for signals that are injected into an LT-port (or LT.cab-port) of the Local Loop Wiring. LT-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 an NT-port (or NT.cab-port) of the Local Loop Wiring. NT-ports are usually located at the customer side.

For each port, it must be well-identified if this is an LT- or NT-port, and which signal limits are mandatory for these ports.

NOTE An example of unintended reversal of transmission direction may occur when the main distribution frame (MDF) of another licensed operator is not co-located with the MDF of the network owner (at the local exchange). If some of the wire pairs of a distribution cable are used for connecting these two MDF’s, then upstream and downstream signals in different wire pairs have to flow in the same cable direction. In such a case, a so-called tie-cable can solve the problem. Such a tie-cable should be fully dedicated to this purpose, and fully *separated* from the standard distribution cables.

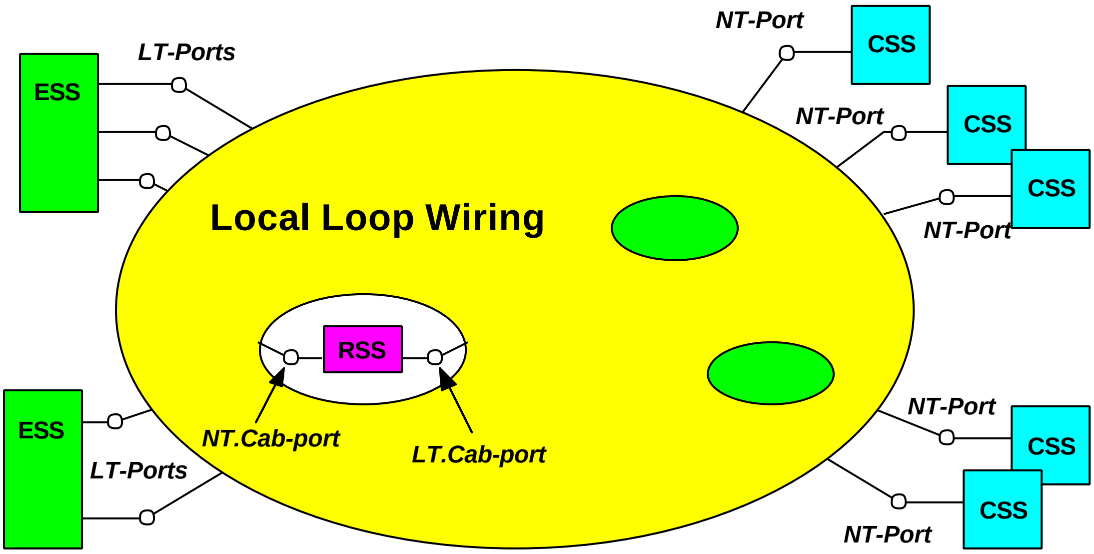
NOTE Signal limits need not be the same for all NT-ports or LT-ports. It is conceivable that the signal limits depend on e.g. the loop length. A specification of this possible length dependence is beyond the scope of this document.

5.3. Reference model

Figure 2 shows a generic reference model of the Local Loop Wiring, from a Spectral Management point of view. The signals of various Signal Sources connected to the LLW flow into the LLW through *well-identified* ports. The following naming convention is used:

- The signals that flow through an *LT-port* into the Local Loop Wiring have their origin in a *Exchange-side Signal So*urce (ESS), such as for instance a local exchange. When signal limits are direction dependent, the signals labelled in this document as *downstream* are intended for injection into these LT-ports, unless explicitly stated otherwise.
- The signals that flow through an *NT-port* into the Local Loop Wiring have their origin in a *Customer-side Signal Source* (CSS). When signal limits are direction dependent, the signals labelled in this document as *upstream* signals are intended for injection into these NT-ports, unless explicitly stated otherwise.
- The signals that flow through an optional *LT.cab-port* or *NT.cab-port* into the Local Loop Wiring have their origin in *Remote Signal Source*s (RSS). Their signal limits may be different from the limits that hold for LT-ports and NT-ports.

This model enables the identification 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.



CSS: Customer-side Signal Source
ESS: Exchange-side Signal Source
RSS: Remote Signal Source
LT-port: Line Termination Port, for injecting downstream signals from a ESS.
NT-port: Network Termination Port, for injecting upstream signals from a CSS.

LT.cab-port: LT-cabinet Port, for injecting downstream signals from a RSS
NT.cab-port: NT-cabinet Port, for injecting upstream signals from a RSS

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.

NOTE: "Connecting a Signal Source to a port of the Local Loop Wiring", does not necessary mean "intended for transmission through that local loop wiring". For instance, in-house transmission equipment (such as home-PNA), may use existing in-house telephony wires, so they are also "connected to the local loop wiring". They will (unintentional) inject signals into the Local Loop Wiring via the NT-ports. These signals are subject to the signal limits at the ports.

6. Minimum set of characteristics for signal descriptions

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

- Total signal voltage (or power)
- Peak amplitude
- Narrow-band signal voltage (or power)
- Unbalance about earth (LOV and LCL)
- 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 summarises signals that are generated by analogue transmission equipment (including POTS), voice band modems, analogue leased lines, telex signals encoded as voice band 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 distinction 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 compliant with all sub clauses below.

7.1.1. Total signal voltage

To be compliant 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 compliant 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)*

7.1.2. Peak amplitude

To be compliant 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)*

7.1.3. Narrow-band signal voltage

To be compliant with this signal category, the narrow-band signal voltage (NBSV) shall not exceed the limits given in table 1, 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 3 illustrates the NBSV in a bandwidth-normalised way.

The NBSV is the average rms-voltage ***U*** of a sending signal into a (complex) load impedance ***Z***, within a power bandwidth ***B***. The measurement method of the NBSV is described in sub-clause 12.1.

*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**	**Signal Level U**	**Power 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 1** 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.*

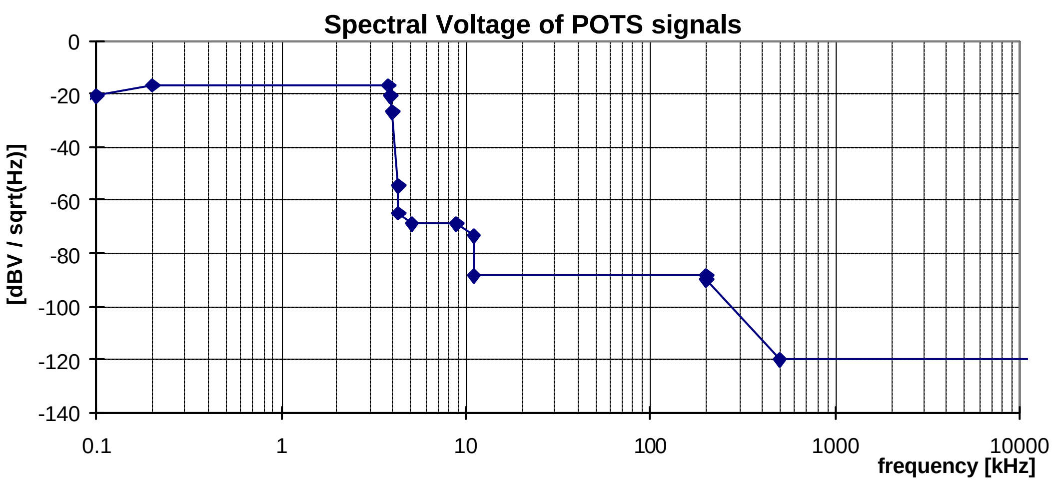


***Figure 3**: Spectral Voltage, for POTS signals, as specified in table 1.*

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 1 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]***

7.1.4. Unbalance about earth

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal output voltage (LOV) and a longitudinal conversion loss (LCL) measurement at the source of that signal, as specified in sub-clause 12.2.1 and 12.2.2.

The minimum LOV and LCL requirements hold for what can be observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.2.1 and 12.2.2.

The observed LOV shall have an rms voltage of below –46dBV, measured in a 1 kHz power bandwidth, centred over any frequency in the frequency range from 510 Hz to 10 kHz and averaged in any one second period. Compliance with this limitation is required with a longitudinal termination having an impedance of 100Ω in series with 150 nF nominal. The values for the components of the terminating impedance of the LCL measurements are given in table 3. Sub clause 12.2.1 defines an example measurement method for longitudinal output voltage.

The observed LCL shall be higher than the lower limits given in figure 4. The LCL values of the associated break frequencies of this figure are given in table 2. The values for the components of the terminating impedance of the LCL measurements are given in table 3. Sub clause 12.2.2 defines an example measurement method for longitudinal conversion loss.

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]***

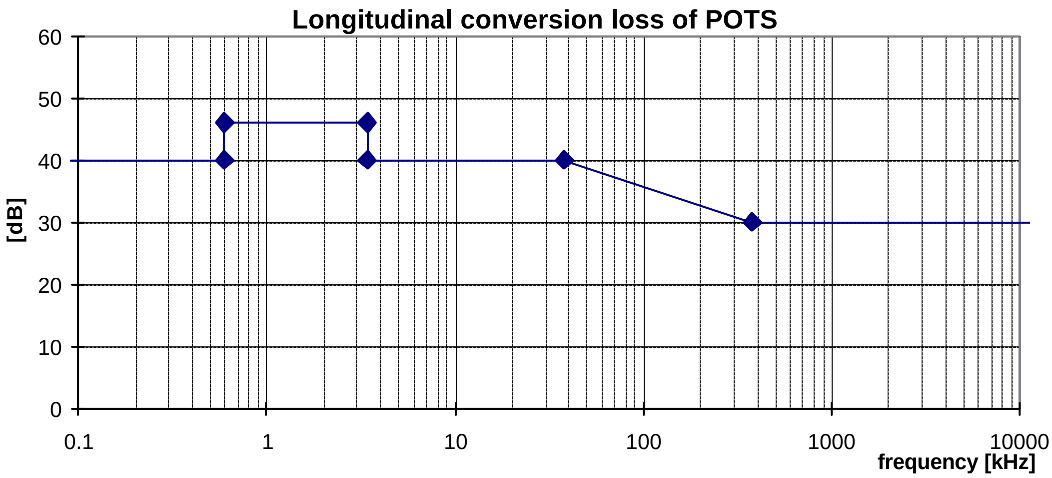


Figure 4: Minimum longitudinal conversion loss for a POTS-signal source

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 2: Frequencies and LCL values of the breakpoints of the LCL mask in figure 4.

	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 3: Values for the components for the terminating impedance for measuring the LOV and LCL.

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

7.1.5. Feeding Power (from the LT-port)

To be compliant 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- EN 300 001: clause 1.5]***

	Maximum Voltage:	**Maximum Current :**
ETSI- EG 201 188	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 270 Ω in series with a parallel combination of 750 Ω and 150 nF.

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

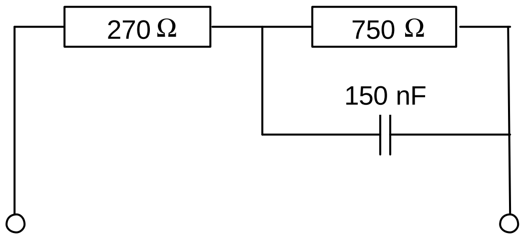


***Figure 5**: Reference impedance Z_R*

7.1.7. Ringing signal

To be compliant 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- EN 300 001: clause 1.7.2]***

	Frequency	Maximum Voltage
ETSI- EG 201 188	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 compliant 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 summarises 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 compliant with all subclauses below.

8.1.1. Total signal power

To be compliant with this signal category, the mean signal power into a resistive load of 135 Ω 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]***

8.1.2. Peak amplitude

To be compliant 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]***

8.1.3. Narrow-band signal power

To be compliant with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 7, 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 6 illustrates the NBSP in a bandwidth-normalised way.

The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a power bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.1.

NOTE The NBSP specification in table 7 is reconstructed from the commonly used PSD specification in [8] (similar to figure 6), 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. Mark that in [8] the lower frequency (300 kHz) has been specified , while table 7 specifies centre frequencies (starting at 300+500 kHz).

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

Centre Frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
510 Hz	135Ω	-0 dBm	1 kHz	-30 dBm/Hz	A
10 kHz	135Ω	-0 dBm	1 kHz	-30 dBm/Hz	
10 kHz	135Ω	10 dBm	10 kHz	-30 dBm/Hz	
50 kHz	135Ω	10 dBm	10 kHz	-30 dBm/Hz	
500 kHz	135Ω	-40 dBm	10 kHz	-80 dBm/Hz	
1.4 MHz	135Ω	-40 dBm	10 kHz	-80 dBm/Hz	
5 MHz	135Ω	-80 dBm	10 kHz	-120 dBm/Hz	
30 MHz	135Ω	-80 dBm	10 kHz	-120 dBm/Hz	
800 kHz	135Ω	-30 dBm	1 MHz	-90 dBm/Hz	B
1.4 MHz	135Ω	-30 dBm	1 MHz	-90 dBm/Hz	
3.637 MHz	135Ω	-60 dBm	1 MHz	-120 dBm/Hz	
30 MHz	135Ω	-60 dBm	1 MHz	-120 dBm/Hz	

***Table 7**: Break points of the narrow-band power limits.*

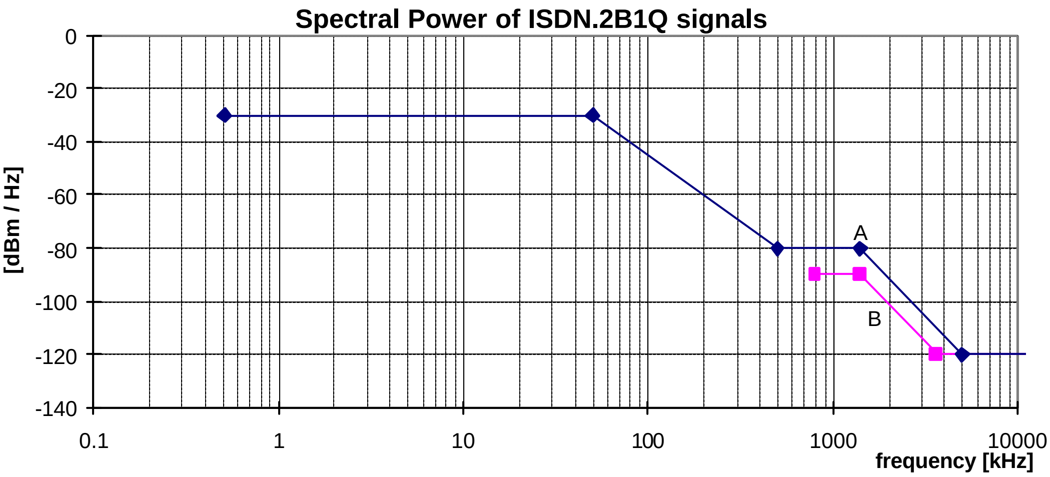


***Figure 6**: Spectral Power, for ISDN.2B1Q signals, as specified in table 7.*

8.1.4. Unbalance about earth

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal output voltage (LOV) and a longitudinal conversion loss (LCL) measurement at the source of that signal, as specified in sub-clause 12.2.1 and 12.2.2.

The minimum LOV and LCL requirements hold for what can be observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.2.1 and 12.2.2.

The observed LOV shall have an rms voltage of below –46dBV, measured in a 10 kHz power bandwidth, centred over any frequency in the frequency range from 5,1 kHz to 225 kHz and averaged in any one second period. Compliance with this limitation is required with a longitudinal termination having an impedance of 100Ω in series with 150 nF nominal. The values for the components of the terminating impedance of the LCL measurements are given in table 9. Sub clause 12.2.1 defines an example measurement method for longitudinal output voltage.

The observed LCL shall be higher than the lower limits given in figure 7. The LCL values of the associated break frequencies of this figure are given in table 8. The values for the components of the terminating impedance of the LCL measurements are given in table 9. Sub clause 12.2.2 defines an example measurement method for longitudinal conversion loss.

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]***

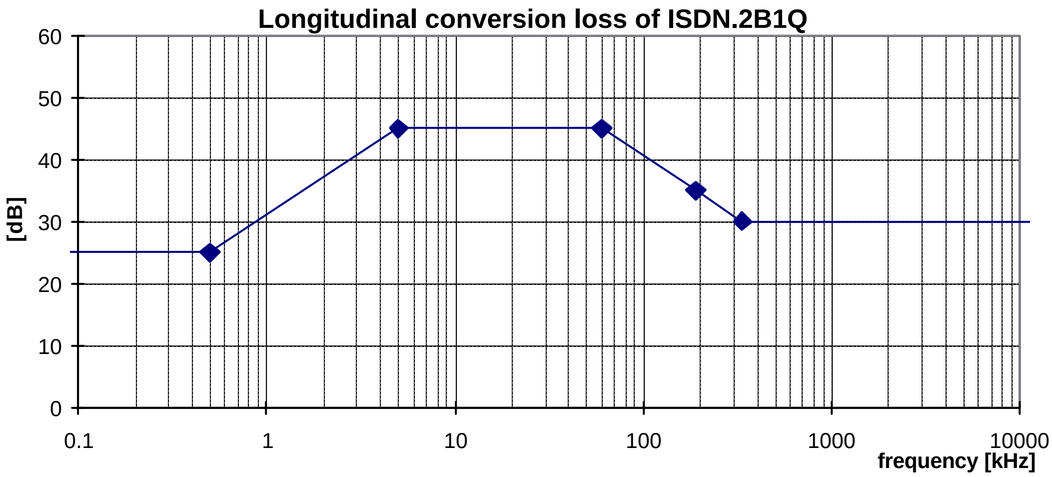


Figure 7: Minimum longitudinal conversion loss for a ISDN.2B1Q signal source

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

	Value	Tolerance
Resistance R1	135/2 ohm	R1/R2=1± 0,1 %
Resistance R2	135/2 ohm	R1/R2=1± 0,1 %
Capacitance	≥ 330 nF	

Table 9: Values for the components for the terminating impedance for measuring the LOV and LCL.

8.1.5. Feeding Power (from the LT-port)

To be compliant 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 at NT-port**
Maximum 99 V	40 mA	maximum 1100 mW

Table 10 *Maximum feeding requirements for the ISDN service*

8.2. "ISDN.MMS.43" Signals

This category covers signals generated by ISDN transmission equipment on a single wire-pair, based on MMS 43 (also known as 4B3T) line coding. This sub clause is based on the ETSI reports on ISDN equipment [8].

A signal can be classified as an "ISDN.MMS.43" signal if it is compliant with all subclauses below.

8.2.1. Total signal power

To be compliant with this signal category, the mean signal power into a resistive load of 150 Ω shall not exceed a level of 13.5 dBm (± 0.5 dBm), measured within a frequency band from at least 100 Hz to 100 kHz.

No full reference. Derived from reference [8]: ***[ETSI TS 102 080: clause A.12.3]***

8.2.2. Peak amplitude

To be compliant with this signal category, the nominal voltage peak of the largest signal pulse into a resistive load of 150Ω shall not exceed a level of 2,0 V (± 5%), measured within a frequency band from at least 100 Hz to 100 kHz.

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

8.2.3. Narrow-band signal power

To be compliant with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 11, 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 8 illustrates the NBSP in a bandwidth-normalised way.

The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a power bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.1.

NOTE The NBSP specification in table 11 is reconstructed from the commonly used PSD specification in [8] (similar to figure 8), 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.
Mark that in [8] the lower frequency (300 kHz) has been specified , while table 11 specifies centre frequencies (starting at 300+500 kHz).

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

Centre Frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
0.51Hz	150Ω	-0 dBm	1 kHz	-30 dBm/Hz	A
10 kHz	150Ω	-0 dBm	1 kHz	-30 dBm/Hz	
10 kHz	150Ω	10 dBm	10 kHz	-30 dBm/Hz	
50 kHz	150Ω	10 dBm	10 kHz	-30 dBm/Hz	
300 kHz	150Ω	-27 dBm	10 kHz	-67 dBm/Hz	
1 MHz	150Ω	-27 dBm	10 kHz	-67 dBm/Hz	
5 MHz	150Ω	-80 dBm	10 kHz	-120 dBm/Hz	
30 MHz	150Ω	-80 dBm	10 kHz	-120 dBm/Hz	
800 kHz	150Ω	-17 dBm	1 MHz	-77 dBm/Hz	B
1 MHz	150Ω	-17 dBm	1 MHz	-77 dBm/Hz	
3.69 MHz	150Ω	-60 dBm	1 MHz	-120 dBm/Hz	
30 MHz	150Ω	-60 dBm	1 MHz	-120 dBm/Hz	

***Table 11**: Break points of the narrow-band power limits.*

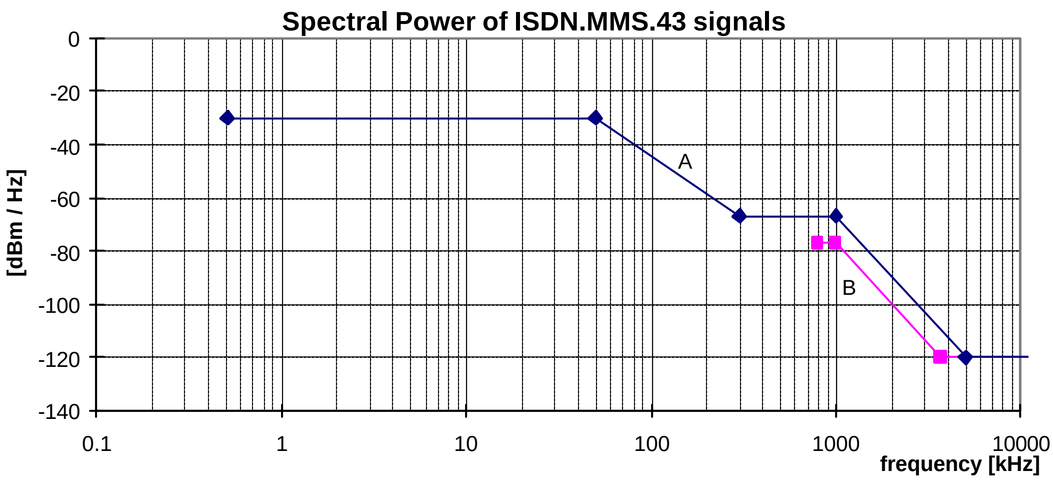


***Figure 8**: Spectral Power, for ISDN.MMS.43 signals, as specified in table 11.*

8.2.4. Unbalance about earth

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal output voltage (LOV) and a longitudinal conversion loss (LCL) measurement at the source of that signal, as specified in sub-clause 12.2.1 and 12.2.2.

The minimum LOV and LCL requirements hold for what can be observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.2.1 and 12.2.2.

The observed LOV shall have an rms voltage of below –46dBV, measured in a 10 kHz power bandwidth, centred over any frequency in the frequency range from 5,1 kHz to 245 kHz and averaged in any one second period. Compliance with this limitation is required with a longitudinal termination having an impedance of 100 Ω in series with 150 nF nominal. The values for the components of the terminating impedance of the LCL measurements are given in table 13. Sub clause 12.2.1 defines an example measurement method for longitudinal output voltage.

The observed LCL shall be higher than the lower limits given in figure 9. The LCL values of the associated break frequencies of this figure are given in table 12. The values for the components of the terminating impedance of the LCL measurements are given in table 13. Sub clause 12.2.2 defines an example measurement method for longitudinal conversion loss.

Reference [8]: ***[ETSI TS 102 080: clause B.13.3]*** *extended tot 30 MHz according to [20].*
Reference[20]: ***[ETSI TS 101 270-1: clause 8.3.3]***

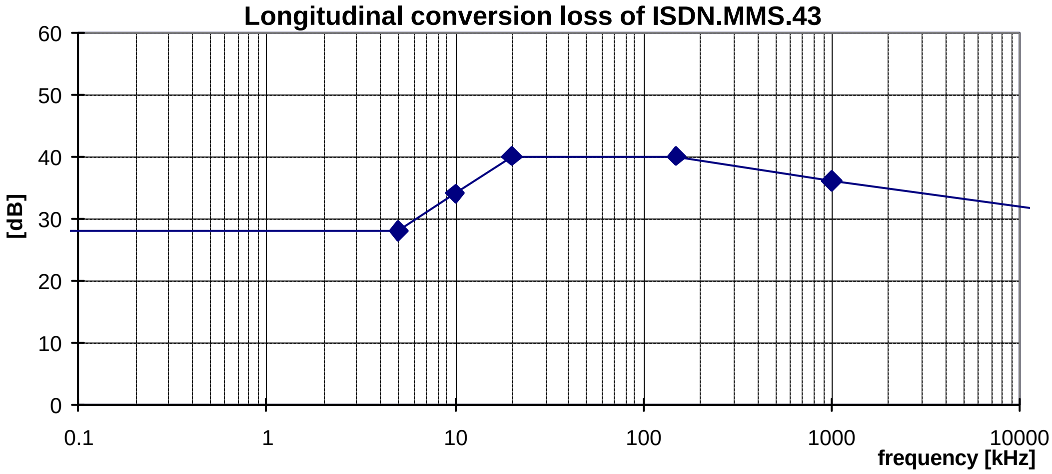


Figure 9: Minimum longitudinal conversion loss for a ISDN.MMS43 signal source

Frequency range	LCL
<5 kHz	28 dB
10 kHz	34 dB
20 kHz	40 dB
150 kHz	40 dB
1000 kHz	36 dB
30 MHz	30 dB

Table 12: Frequencies and LCL values of the breakpoints of the LCL mask in figure 9.

	Value	Tolerance
Resistance R1	150/2 ohm	R1/R2=1± 0,1 %
Resistance R2	150/2 ohm	R1/R2=1± 0,1 %
Capacitance	≥ 330 nF	

Table 13: Values for the components for the terminating impedance for measuring the LOV and LCL.

8.2.5. Feeding Power (from the LT-port)

To be compliant with this signal category, the DC feeding voltage and feeding current, used for the ISDN 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 [8]: ***[ETSI TS 102 080: clause 10.5 and 10.6.1.1]***

Voltage	Current	Power at NT-port
Maximum 99 V	Maximum 55 mA	maximum 1100 mW

Table 14 *Maximum feeding requirements for the ISDN service*

9. Cluster 3 Signals (symmetrical broad band)

This cluster summarises 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]. 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 compliant 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. Total signal power

To be compliant 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 784 kHz.

Reference [9]: ***[ETSI TS 101 135: clause 5.8.4.4]***

9.1.2. Peak amplitude

To be compliant 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 [9]: ***ETSI TS 101 135: clause 5.8.4.1]***

9.1.3. Narrow-band signal power

To be compliant with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 15, 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 10 illustrates the NBSP in a bandwidth-normalised way.

The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a power bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.1.

NOTE The NBSP specification in table 15 is reconstructed from the commonly used PSD specification in [9] (similar to figure 10), 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: [9]: ***[ETSI TS 101 135: clause 5.8.4.3]****. These numbers are reconstructed from PSD requirements in [9]*

Centre Frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B
0.51 kHz 10 kHz	135Ω 135Ω	-7 dBm -7 dBm	1 kHz 1 kHz	-37 dBm/Hz -37 dBm/Hz
10 kHz 196 kHz 1.96 MHz	135Ω 135Ω 135Ω	3 dBm 3 dBm -77 dBm	10 kHz 10 kHz 10 kHz	-37 dBm/Hz -37 dBm/Hz -117 dBm/Hz
1.96 MHz 30 MHz	135Ω 135Ω	-57 dBm -57 dBm	1 MHz 1 MHz	-117 dBm/Hz -117 dBm/Hz

Table 15 *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.*

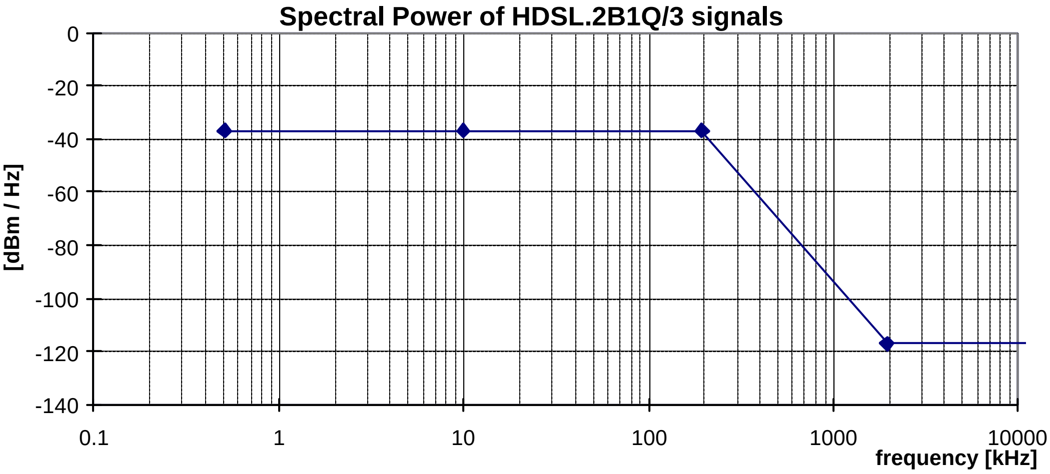


Figure 10*: Spectral Power, for HDSL.2B1Q/3 signals, as specified in table 15.*

9.1.4. Unbalance about earth

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal output voltage (LOV) and a longitudinal conversion loss (LCL) measurement at the source of that signal, as specified in sub-clause 12.2.1 and 12.2.2.

The minimum LOV and LCL requirements hold for what can be observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.2.1 and 12.2.2.

The observed LOV shall have an rms voltage of below –46dBV, measured in a 10 kHz power bandwidth, centred over any frequency in the frequency range from 5,1 kHz to 410 kHz and averaged in any one second period. Compliance with this limitation is required with a longitudinal termination having an impedance of 100Ω in series with 150 nF nominal. The values for the components of the terminating impedance of the LCL measurements are given in table 17. Sub clause 12.2.1 defines an example measurement method for longitudinal output voltage.

The observed LCL shall be higher than the lower limits given in figure 11. The LCL values of the associated break frequencies of this figure are given in table 16. The values for the components of the terminating impedance of the LCL measurements are given in table 17. Sub clause 12.2.2 defines an example measurement method for longitudinal conversion loss.

Reference [9]: ***[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]***

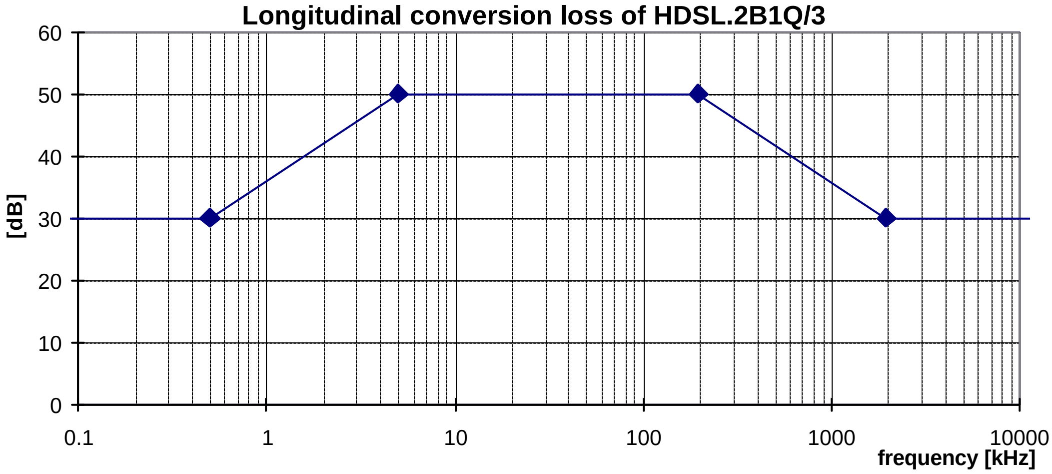


Figure 11: Minimum longitudinal conversion loss for a HDSL.2B1Q/3 signal source (392 kbaud/wirepair)

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

Table 16: Frequencies and LCL values of the breakpoints of the LCL mask in figure ***11****.*

	Value	**Tolerance**
Resistance R1	135/2 ohm	R1/R2=1± 0,1 %
Resistance R2	135/2 ohm	R1/R2=1± 0,1 %
Capacitance	≥ 330 nF	

Table 17: Values for the components for the terminating impedance for measuring the LOV and LCL.

9.1.5. Feeding Power (from the LT-port)

To be compliant 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 [9]: ***[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*

9.2. "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]. 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 compliant 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. Total signal power

To be compliant 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 1168 kHz.

Reference [9]: ***[ETSI TS 101 135: clause 5.8.4.4]***

9.2.2. Peak amplitude

To be compliant 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 [9]: ***[ETSI TS 101 135: clause 5.8.4.1]***

9.2.3. Narrow-band signal power

To be compliant with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 19, 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 12 illustrates the NBSP in a bandwidth-normalised way.

The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a power bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.1.

NOTE The NBSP specification in table 19 is reconstructed from the commonly used PSD specification in [9] (similar to figure 12), 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: [9]: ***[ETSI TS 101 135: clause 5.8.4.3]****. These numbers are reconstructed from PSD requirements in [9]*

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B
0.51 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 19: 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.

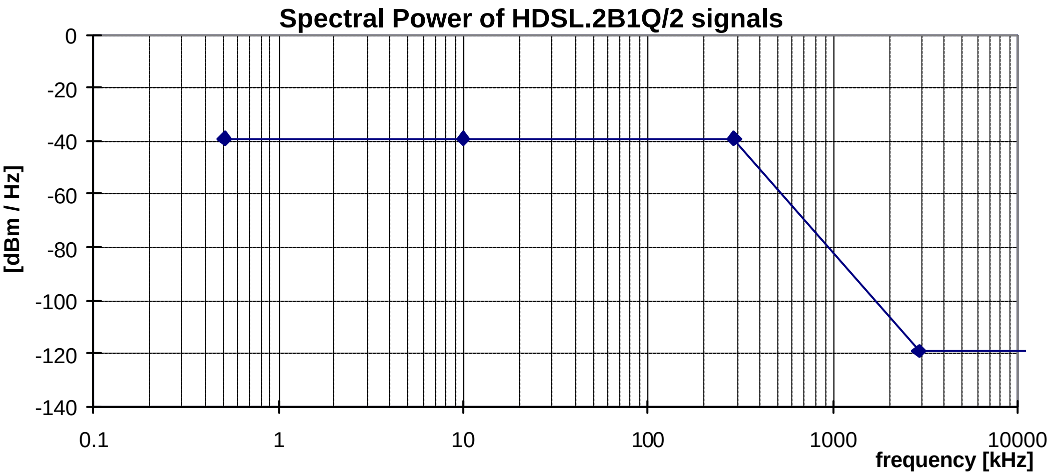


Figure 12*: Spectral Power, for HDSL.2B1Q/2 signals, as specified in table 19.*

9.2.4. Unbalance about earth

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal output voltage (LOV) and a longitudinal conversion loss (LCL) measurement at the source of that signal, as specified in sub-clause 12.2.1 and 12.2.2.

The minimum LOV and LCL requirements hold for what can be observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.2.1 and 12.2.2.

The observed LOV shall have an rms voltage of below –46dBV, measured in a 10 kHz power bandwidth, centred over any frequency in the frequency range from 5,1 kHz to 575 kHz and averaged in any one second period. Compliance with this limitation is required with a longitudinal termination having an impedance of 100 Ω in series with 150 nF nominal. The values for the components of the terminating impedance of the LCL measurements are given in table 21. Sub clause 12.2.1 defines an example measurement method for longitudinal output voltage.

The observed LCL shall be higher than the lower limits given in figure 13. The LCL values of the associated break frequencies of this figure are given in table 20. The values for the components of the terminating impedance of the LCL measurements are given in table 21. Sub clause 12.2.2 defines an example measurement method for longitudinal conversion loss.

*Reference [9]: **[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]***

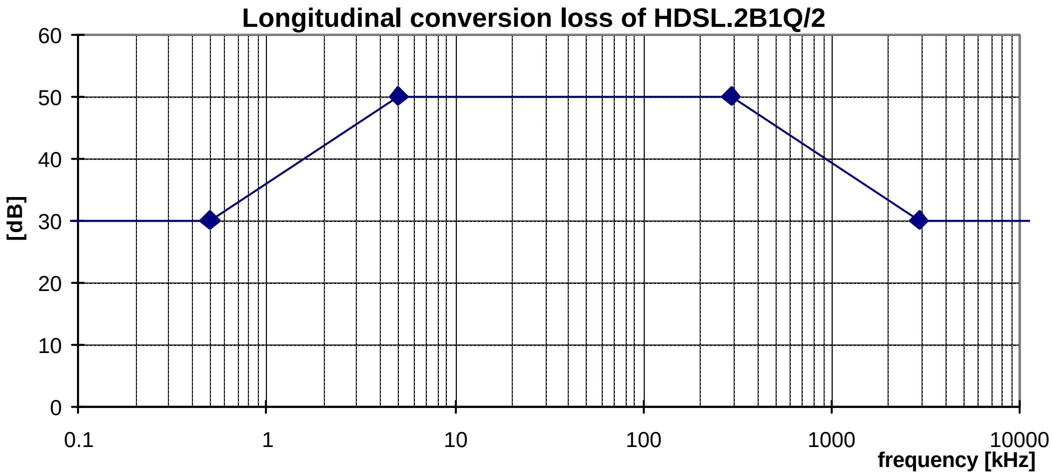


Figure 13: Minimum longitudinal conversion loss for a HDSL.2B1Q/2 signal source (584 kbaud/wirepair)

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

Table 20: Frequencies and LCL values of the breakpoints of the LCL mask in figure 13.

	Value	**Tolerance**
Resistance R1	135/2 ohm	R1/R2=1± 0,1 %
Resistance R2	135/2 ohm	R1/R2=1± 0,1 %
Capacitance	≥ 330 nF	

Table 21: Values for the components for the terminating impedance for measuring the LOV and LCL.

9.2.5. Feeding Power (from the LT-port)

To be compliant 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 [9]: ***[ETSI TS 101 135: 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*

9.3. "HDSL.2B1Q/1" Signals (1160 kbaud/s leased lines)

This category covers signals, generated by HDSL transmission equipment on a single wire-pair, based on 2B1Q line coding. This sub clause is based on the ETSI reports on HDSL equipment [9].

A signal (per wire-pair) can be classified as an "HDSL.2B1Q/1 signal" if it is compliant 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. Total signal power

To be compliant 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 2320 kHz.

Reference [9]: ***[ETSI TS 101 135: clause 5.8.4.4]***

9.3.2. Peak amplitude

To be compliant 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 2,50 V (± 7%), measured within a frequency band from at least 100 Hz to 2320 kHz.

Reference [9]: ***[ETSI TS 101 135: clause 5.8.4.1]***

9.3.3. Narrow-band signal power

To be compliant with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 23, 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 14 illustrates the NBSP in a bandwidth-normalised way.

The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a <u>power</u> bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.1.

NOTE The NBSP specification in table 23 is reconstructed from the commonly used PSD specification in [9] (similar to figure 14), 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: [9]: ***[ETSI TS 101 135: clause 5.8.4.3]****. These numbers are reconstructed from PSD requirements in [9]*

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B
0.51 kHz 10 kHz	135Ω 135Ω	-11.5 dBm -11.5 dBm	1 kHz 1 kHz	-41.5 dBm/Hz -41.5 dBm/Hz
10 kHz 485 kHz 4.850 MHz	135Ω 135Ω 135Ω	-1.5 dBm -1.5 dBm -81.5 dBm	10 kHz 10 kHz 10 kHz	-41.5 dBm/Hz -41.5 dBm/Hz -121.5 dBm/Hz
4.850 MHz 30 MHz	135Ω 135Ω	-61.5 dBm -61.5 dBm	1 MHz 1 MHz	-121.5 dBm/Hz -121.5 dBm/Hz

Table 23: Break points of the narrow-band power limits. These limits are frequency independent between 100 Hz to 485 kHz, and decrease with 24 dB/octave (80 dB/decade) above 485 kHz.

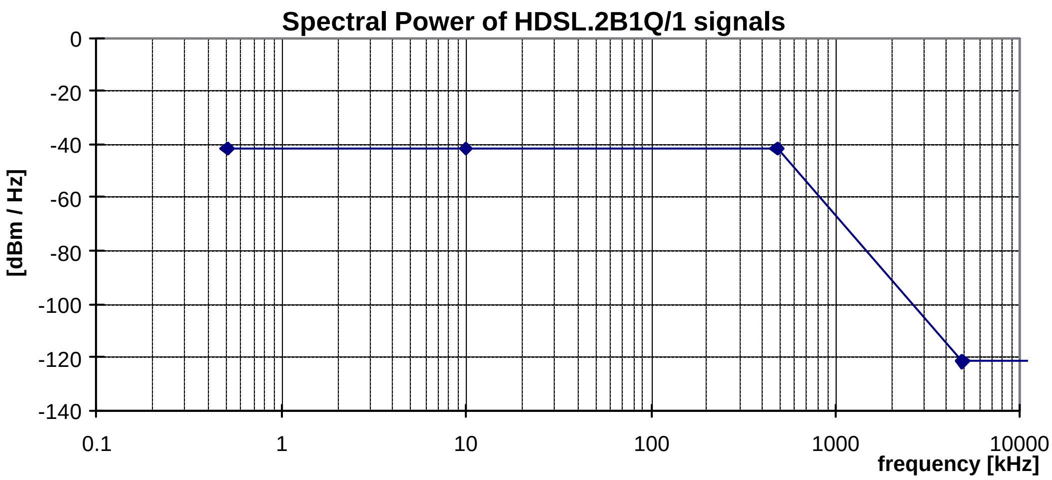


***Figure 14**: Spectral Power, for HDSL.2B1Q/1 signals, as specified in table 23.*

9.3.4. Unbalance about earth

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal output voltage (LOV) and a longitudinal conversion loss (LCL) measurement at the source of that signal, as specified in sub-clause 12.2.1 and 12.2.2.

The minimum LOV and LCL requirements hold for what can be observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.2.1 and 12.2.2.

The observed LOV shall have an rms voltage of below –46dBV, measured in a 10 kHz power bandwidth, centred over any frequency in the frequency range from 5,1 kHz to 890 kHz and averaged in any one second period. Compliance with this limitation is required with a longitudinal termination having an impedance of 100Ω in series with 150 nF nominal. The values for the components of the terminating impedance of the LCL measurements are given in table 25. Sub clause 12.2.1 defines an example measurement method for longitudinal output voltage.

The observed LCL shall be higher than the lower limits given in figure 15. 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. Sub clause 12.2.2 defines an example measurement method for longitudinal conversion loss.

*Reference [9]: **[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]***

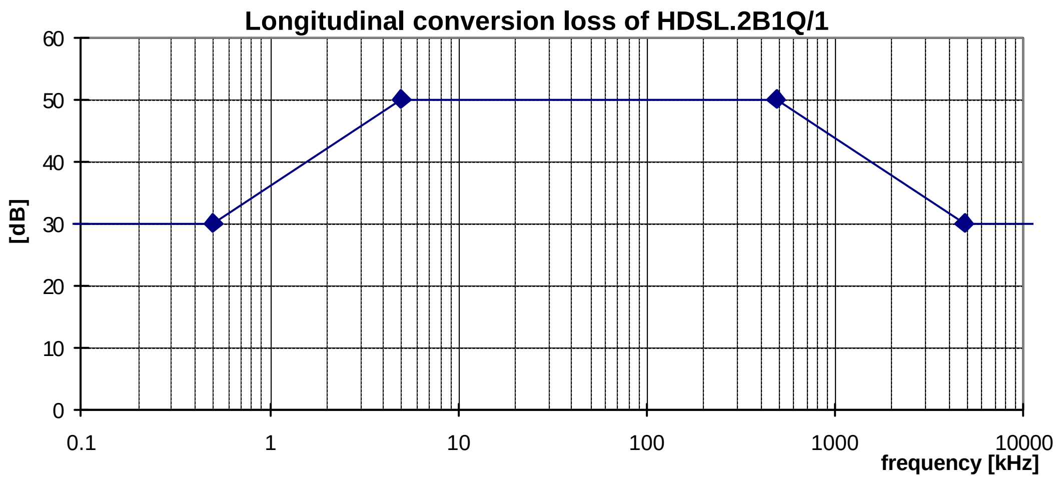


Figure 15:
Minimum longitudinal conversion loss for a HDSL.2B1Q/1 signal source

Frequency	LCL
<0.5 kHz	30 dB
5 kHz	50 dB
485 kHz	50 dB
4850 kHz	30 dB
30000 kHz	30 dB

Table 24: Frequencies and LCL values of the breakpoints of the LCL mask in figure ***15****.*

	Value	**Tolerance**
Resistance R1	135/2 ohm	R1/R2=1± 0,1 %
Resistance R2	135/2 ohm	R1/R2=1± 0,1 %
Capacitance	≥ 330 nF	

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

9.3.5. Feeding Power (from the LT-port)

To be compliant with this signal category, the DC feeding voltage and feeding current, used for the HDSL service shall not exceed the maximum values in table 26. The value for power includes a possible overload or short circuit condition at the user-network interface.

Reference [9]: ***[ETSI TS 101 135: clause 9.2]***

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

Table 26 *Maximum feeding requirements for the leased line service over HDSL*

9.4. "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].

A signal (per wire-pair) can be classified as an "HDSL.CAP/2 signal" if it is compliant 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).

9.4.1. Total signal power

To be compliant 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 [9]: ***[ETSI TS 101 135: clause B.5.8.4.1]***

9.4.2. Peak amplitude

To be compliant 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)

9.4.3. Narrow-band signal power (NBSP)

To be compliant with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 27, 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 16 illustrates the NBSP in a bandwidth-normalised way.

The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a power bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.1.

NOTE The NBSP specification in table 27 is reconstructed from the commonly used PSD specification in [9] (similar to figure 16), 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 [9], 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 [9]: ***[ETSI TS 101 135: clause B.5.8.4.2]****. (reconstructed from the PSD requirements in [9])*

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
0.51 kHz 3.98 kHz	135Ω 135Ω	-25.5 dBm -25.5 dBm	1 kHz 1 kHz	-55.5 dBm/Hz -55.5 dBm/Hz	A
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 -80 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	
30 kHz 250 kHz	135Ω 135Ω	+10 dBm +10 dBm	100 kHz 100 kHz	-40 dBm/Hz -40 dBm/Hz	B

Table 27*:Frequencies of the break points and the corresponding peak and average values of the narrow-band signal power.*

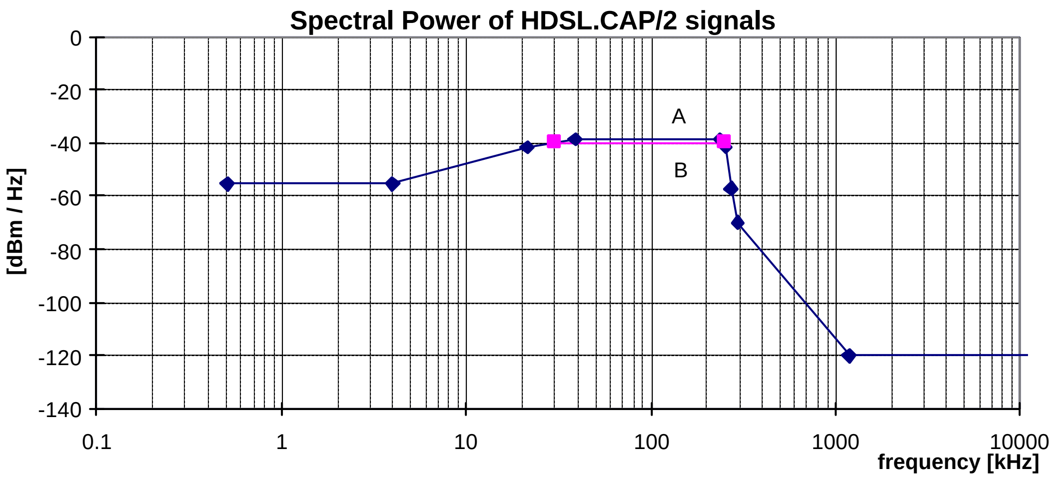


Figure 16*: Spectral Power, for HDSL.CAP/2 signals, as specified in table* ***27****.*

9.4.4. Unbalance about earth

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal output voltage (LOV) and a longitudinal conversion loss (LCL) measurement at the source of that signal, as specified in sub-clause 12.2.1 and 12.2.2.

The minimum LOV and LCL requirements hold for what can be observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.2.1 and 12.2.2.

The observed LOV shall have an rms voltage of below –46dBV, measured in a 10 kHz power bandwidth, centred over any frequency in the frequency range from 5,1 kHz to 285 kHz and averaged in any one second period. Compliance with this limitation is required with a longitudinal termination having an impedance of 100Ω in series with 150 nF nominal. The values for the components of the terminating impedance of the LCL measurements are given in table 29. Sub clause 12.2.1 defines an example measurement method for longitudinal output voltage.

The observed LCL shall be higher than the lower limits given in figure 17. The LCL values of the associated break frequencies of this figure are given in table 28. The values for the components of the terminating impedance of the LCL measurements are given in table 29. Sub clause 12.2.2 defines an example measurement method for longitudinal conversion loss.

*Reference [9]****: [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]***

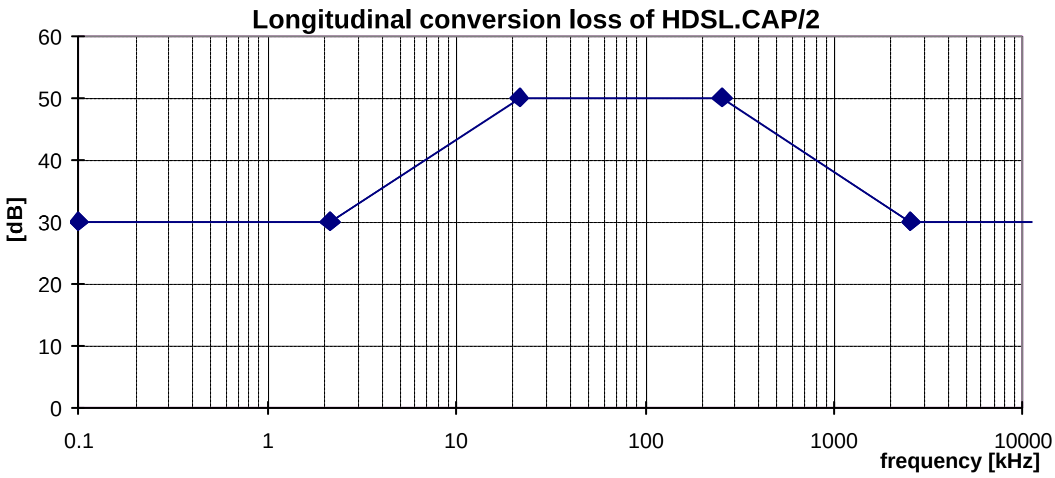


Figure 17: Minimum longitudinal conversion loss.

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 28: Frequencies and LCL values of the breakpoints of the LCL mask in figure ***17****.*

	Value	Tolerance
Resistance R1	135/2 ohm	R1/R2=1± 0,1 %
Resistance R2	135/2 ohm	R1/R2=1± 0,1 %
Capacitance	≥ 330 nF	

Table 29*: Values for the components for the terminating impedance for measuring the LOV and LCL.*

9.4.5. Feeding Power (from the LT-port)

To be compliant with this signal category, the DC feeding voltage and feeding current, used for the HDSL service shall not exceed the maximum values in table 30. The value for power includes a possible overload or short circuit condition at the user-network interface.

Reference [9]: ***[ETSI TS 101 135: clause 9.2]***

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

Table 30 *Maximum feeding requirements for the leased line service over HDSL*

9.5. "SDSL" Signals

This category covers Symmetrical DSL transmission equipment on a single wire-pair.

ED. The signals that will be generated by SDSL equipment are currently under study, within the ETSI-TM6 SDSL project. When that study has been completed, the description of the agreed signal will be included here

*Reference [**10**]: **[ETSI WG TM6(98)8, Draft Part 1: Functional requirements]***

9.6. "Proprietary.MSDSL.CAP/1::Fn" Signals

This category covers signals, generated by Proprietary multi-rate HDSL transmission equipment on one (or two) wire-pairs. This signal is labelled as *Proprietary*, since it is not covered by ETSI, ITU nor ANSI product standards.

This signal definition is linecode independent, but dedicated to signals from transmission equipment for variable bit-rate leased lines that are using CAP modulation. These definitions are partly based on the ETSI specifications on HDSL equipment [9].

In the naming convention "Proprietary.MSDSL.CAP::Fn", is the phrase "Fn" a placeholder for a number that is used as parameter F_N in the signal definition. Replacing "Fn" in the signal name by a value, changes the generic signal description into a specific description, since its value is required in the sub clauses below. It is referred to as the *Nyquist frequency* of the signal.
The Nyquist frequency F_N is indicative for the maximum symbol rate [kbaud/s] that can be transported within these signal limits. A signal with a higher Nyquist Frequency occupies a wider spectrum. Values between 72 kHz and 387 kHz are commonly used.

Table 31 gives several examples on how to use the naming convention for specifying the actual parameter value *Fn*. 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_N [kHz]		Baud Rate [kbaud/s]	Bit Rate [kb/s]	Bit/Symbol	Constellation size
Proprietary.MSDSL.CAP/1::72	72 kHz		72	144	2	8
Proprietary.MSDSL.CAP/1::91	91 kHz		91	272	3	16
Proprietary.MSDSL.CAP/1::133	133 kHz		133	400	3	16
Proprietary.MSDSL.CAP/1::176	176 kHz		176	528	3	16
Proprietary.MSDSL.CAP/1::261	261 kHz		261	784	3	16
Proprietary.MSDSL.CAP/1::261	261 kHz		261	1040	4	32
Proprietary.MSDSL.CAP/1::311	311 kHz		311	1552	5	64
Proprietary.MSDSL.CAP/1::344	344 kHz		344	2064	6	128
Proprietary.MSDSL.CAP/1::387	387 kHz		387	2320	6	128

Table 31: *Example on how the naming convention relates to the actual parameter value F_N that is used in the subclauses below to specify the signal limits of this signal category. The bitrates and modulation parameters are informative only, and implementation dependent.*

A signal (per wire-pair) can be classified as a "Proprietary.MSDSL.CAP/1::Fn" signal if it is compliant with all subclauses below, and if parameter "Fn" is specified by a numerical value.

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).

9.6.1. Total signal power

To be compliant 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 1 MHz.

(no ETSI reference)

9.6.2. Peak amplitude

To be compliant 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)

9.6.3. Narrow-band signal power (NBSP)

To be compliant with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 32, 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-normalised way.

The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a power bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.1.

(no ETSI reference)

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

Table 32: *Break points of the narrow-band signal power **P**, as a function of the Nyquist frequency F_N of the signal category (see table 31). The parameter values for F_L, and α are defined as F_L=10 kHz, and α=0.15.*

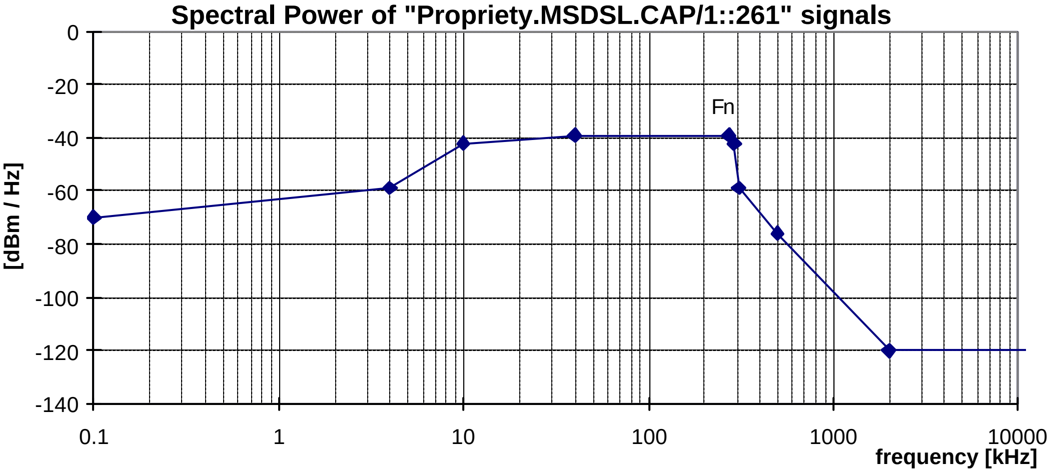


Figure 18: *Spectral Power, for "Proprietary.MSDSL.CAP/1::261" signals (at F_N=261 kHz), as specified in table 32. Note that these curves are dependent on the Nyquist frequency F_N, and that this figure shows an example only.*

9.6.4. Unbalance about earth

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal output voltage (LOV) and a longitudinal conversion loss (LCL) measurement at the source of that signal, as specified in sub-clause 12.2.1 and 12.2.2.

The minimum LOV and LCL requirements hold for what can be observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.2.1 and 12.2.2.

The observed LOV shall have an rms voltage of below –46dBV, measured in a 10 kHz power bandwidth, centred over any frequency in the frequency range from 5,1 kHz to 500 kHz and averaged in any one second period. Compliance with this limitation is required with a longitudinal termination having an impedance of 100Ω in series with 150 nF nominal. The values for the components of the terminating impedance of the LCL measurements are given in table 34. Sub clause 12.2.1 defines an example measurement method for longitudinal output voltage.

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 33. The values for the components of the terminating impedance of the LCL measurements are given in table 34. Sub clause 12.2.2 defines an example measurement method for longitudinal conversion loss.

(no ETSI reference)

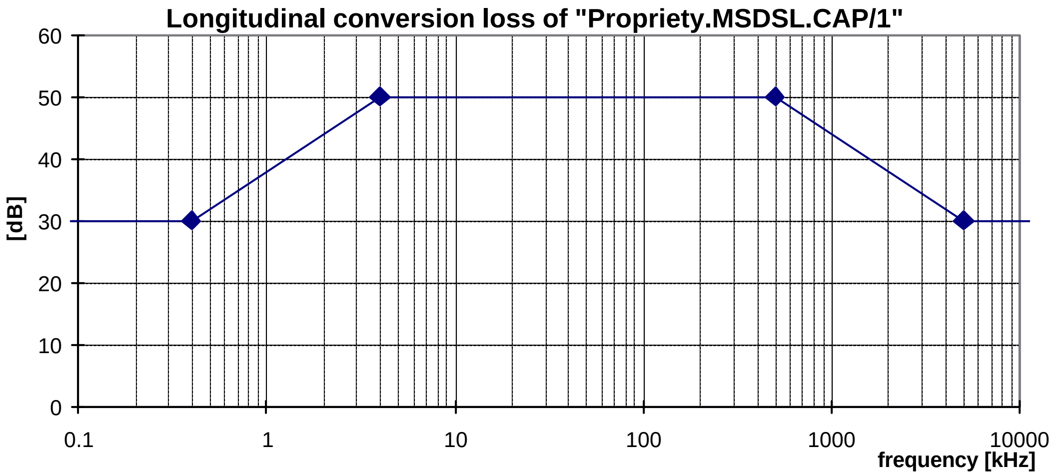


Figure 19: Minimum longitudinal conversion loss for a "Proprietary.MSDSL.CAP/1::261" signal source.

Frequency	LCL
<0.4 kHz	30 dB
4 kHz	40 dB
500 kHz	40 dB
5 MHz	30 dB
30 MHz	30 dB

Table 33: Frequencies and LCL values of the breakpoints of the LCL mask in figure 19.

	Value	Tolerance
Resistance R1	135/2 ohm	R1/R2=1± 0,1 %
Resistance R2	135/2 ohm	R1/R2=1± 0,1 %
Capacitance	≥ 330 nF	

Table 34: Values for the components for the terminating impedance for measuring the LOV and LCL.

9.7. "Proprietary.MDSL.PAM::Fn" Signals

This category covers signals, generated by Proprietary MDSL transmission equipment on a single wire pair. This signal is labelled as *Proprietary*, since it is not covered by ETSI, ITU nor ANSI product standards.

This signal definition is linecode independent, but dedicated to signals from transmission equipment that are using PAM modulation.

In the naming convention "Proprietary.MDSL.PAM::Fn", is the phrase "Fn" a placeholder for a number that is used as parameter F_N in the signal definition. Replacing "Fn" in the signal name by a value, changes the generic signal description into a specific description, since its value is required in the sub clauses below. It is referred to as the *Nyquist frequency* of the signal.
The Nyquist frequency F_N is indicative for the maximum symbol rate [kbaud/s] that can be transported within these signal limits. A signal with a higher Nyquist Frequency occupies a wider spectrum. The subclause below are defined for all Nyquist frequencies between 80kHz and 264 kHz.

Table 35 gives several examples on how to use the naming convention for specifying the actual parameter value *Fn*. 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_N [kHz]		Baud Rate [kbaud/s]	Bit/symbol	Bit Rate [kb/s]
Proprietary.MDSL.PAM::80	80 kHz		80	2	160
Proprietary.MDSL.PAM::80	80 kHz		80	3	240
Proprietary.MDSL.PAM::264	262 kHz		262	3	786

Table 35: *Example on how the naming convention relates to the actual parameter value F_N that is used in the sub clauses below to specify the signal limits of this signal category. The actual bitrates and modulation parameters are implementation dependent, and informative only. They are included here to illustrate that different bitrates can be carried by signals having the same Nyquist frequency*

Two slightly different additional variants are identified for all signals with specified Nyquist Frequency:
- Option A signals, are dedicated to Ungerboeck Coded PAM with 2, 3 or 4 bits per symbol (before encoding)
- Option B signals, are dedicated to 2B1Q linecoded signals.

A signal can be classified as a "Proprietary.MDSL.PAM::Fn" signal if it is compliant with all subclauses below <u>and</u> if parameter "Fn" is specified by a numerical value.

NOTE The narrow band signal power (NBSP) of "Proprietary.MDSL.PAM::Fn" signals, having a Nyquist frequency between 80 - 141.3 kHz, also fit under the NBSP mask of ISDN.2B1Q signals. This does not hold for the Peak amplitude and Unbalance about earth, so these signal limits are not 100% compliant with ISDN.2B1Q signals.

9.7.1. Total Signal Power

To be compliant 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 $2\times F_N$.

(no ETSI reference)

9.7.2. Peak amplitude

To be compliant 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 V_{peak} (± 7%), measured within a frequency band from at least 100 Hz to $F_N\times 2$. Two signal options have been defined, that are different only in their V_{peak} specification:

- For “option A” signals, V_{peak} shall not exceed 7.2 V (14.4 V peak-peak) (*dedicated to Ungerboeck Coded PAM*)
- For “option B” signals, V_{peak} shall not exceed 5.7 V (11.4 V peak-peak) (*dedicated to 2B1Q linecoded signals*)

(no ETSI reference)

9.7.3. Narrow-band signal power (NBSP)

To be compliant with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in tables 36 and 37, at any point in the frequency range 100 Hz to 30 MHz. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. Table 36 describes the break points of these limits in a general way, table 37 specifies the associated parameters for all Nyquist frequencies between 80 and 264 kHz. Figure 20 illustrates the NBSP in a bandwidth-normalised way.

The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a power bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.1.

(no ETSI reference)

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B
0.1 kHz	135Ω		100 Hz	$SP_1(F_N)$
1 kHz	135Ω		100 Hz	$SP_1(F_N)$
1 kHz	135Ω	$P_{1,1k}(F_N)$	1 kHz	$SP_1(F_N)$
10 kHz	135Ω	$P_{1,1k}(F_N)$	1 kHz	$SP_1(F_N)$
10 kHz	135Ω	$P_{1,10k}(F_N)$	10 kHz	$SP_1(F_N)$
$F_1(F_N)$	135Ω	$P_{1,10k}(F_N)$	10 kHz	$SP_1(F_N)$
$F_2(F_N)$	135Ω	$P_{2,10k}(F_N)$	10 kHz	$SP_2(F_N)$
$F_3(F_N)$	135Ω	-77 dBm	10 kHz	-117 dBm/Hz
$F_3(F_N)$	135Ω	-57 dBm	1 MHz	-117 dBm/Hz
30 MHz	135Ω	-57 dBm	1 MHz	-117 dBm/Hz

***Table 36**: Break points of the narrow-band signal power **P**, as a function of the Nyquist frequency F_N of the signal category (see table 35). The parameter values for F_1,F_2,F_3,$P_{1,1k}$,$P_{1,10k}$,$P_{2,10}$,SP_1,SP_2, are defined for each F_N in table 37.*

F_N [kHz]	F_1	F_2	F_3	SP_1 [dBm/Hz]	$P_{1,1k}$ [dBm]	$P_{1,10k}$ [dBm]	SP_2 [dBm/Hz]	$P_{2,1k}$ [dBm]	$P_{2,10k}$ [dBm]
80 £ F_N < 92	1/3×F_N	3/4×F_N	6×F_N	- 30.0	0.0	10	- 38.0	- 8.0	2.0
92 £ F_N < 104	1/3×F_N	3/4×F_N	6×F_N	- 30.5	-0.5	9.5	- 38.5	- 8.5	1.5
104 £ F_N < 116	1/3×F_N	3/4×F_N	6×F_N	- 31.0	-1.0	9.0	- 39.0	- 9.0	1.0
116 £ F_N < 129	1/3×F_N	3/4×F_N	5×F_N	- 31.5	-1.5	8.5	- 39.5	- 9.5	0.5
129 £ F_N < 146	1/3×F_N	3/4×F_N	5×F_N	- 32.0	-2.0	8.0	- 40.0	- 10.0	0.0
146 £ F_N < 164	1/3×F_N	3/4×F_N	5×F_N	- 32.5	-2.5	7.5	- 40.5	- 10.5	- 0.5
164 £ F_N < 185	1/3×F_N	3/4×F_N	5×F_N	- 33.0	-3.0	7.0	- 41.0	- 11.0	- 1.0
185 £ F_N < 207	1/3×F_N	2/3×F_N	5×F_N	- 33.5	-3.5	6.5	- 41.5	- 11.5	- 1.5
207 £ F_N < 232	1/3×F_N	2/3×F_N	4×F_N	- 34.0	-4.0	6.0	- 42.0	- 12.0	- 2.0
232 £ F_N < 259	1/3×F_N	2/3×F_N	4×F_N	- 34.5	-4.5	5.5	- 42.5	- 12.5	- 2.5
259 £ F_N £ 264	1/3×F_N	2/3×F_N	4×F_N	- 35.0	-5.0	5.0	- 43.0	- 13.0	- 3.0

***Table 37**: Definition of all Nyquist-frequency-dependent parameters that are used in table 36, for all Nyquist frequencies between 80 kHz and 264 kHz.*

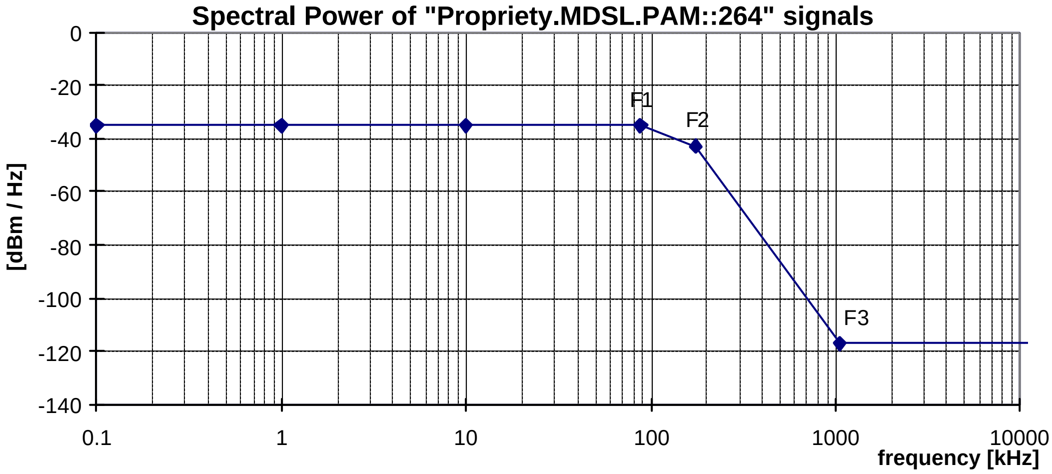


***Figure 20**: Spectral Power, for "Proprietary.MDSL.PAM::264" signals (at F_N=264 kHz), as specified in table 36 and 37. Note that these curves are dependent on the Nyquist frequency F_N, and that this figure shows an example only.*

9.7.4. Unbalance about earth

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal output voltage (LOV) and a longitudinal conversion loss (LCL) measurement at the source of that signal, as specified in sub-clause 12.2.1 and 12.2.2.

The minimum LOV and LCL requirements hold for what can be observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.2.1 and 12.2.2.

The observed LOV shall have an rms voltage of below –46dBV, measured in a 10 kHz power bandwidth, centred over any frequency in the frequency range from 5,1 kHz to 500 kHz and averaged in any one second period. Compliance with this limitation is required with a longitudinal termination having an impedance of 100Ω in series with 150 nF nominal. The values for the components of the terminating impedance of the LCL measurements are given in table 39. Sub clause 12.2.1 defines an example measurement method for longitudinal output voltage.

The observed LCL shall be higher than the lower limits given in figure 21. The LCL values of the associated break frequencies of this figure are given in table 38. The values for the components of the terminating impedance of the LCL measurements are given in table 39. Sub clause 12.2.2 defines an example measurement method for longitudinal conversion loss.

(no ETSI reference)

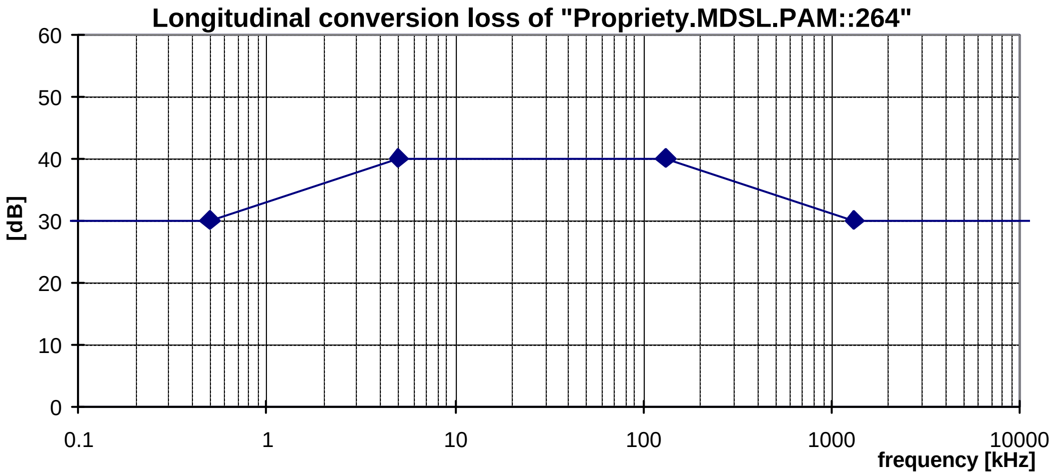


Figure 21: Minimum longitudinal conversion loss for a "Proprietary.MDSL.PAM::264" signal source.

Frequency	**LCL**
<0.5 kHz	30 dB
0.5 kHz	30 dB
5 kHz	40 dB
$1/2 \times F_N$	40 dB
$5 \times F_N$	30 dB
30 MHz	30 dB

Table 38: Frequencies and LCL values of the breakpoints of the LCL mask in figure 21.

	Value	**Tolerance**
Resistance R1	135/2 Ω	R1/R2=1±0.1%
Resistance R2	135/2 Ω	R1/R2=1±0.1%
Capacitance	≥ 330 nF	

Table 39: Values for the components for the terminating impedance for measuring the LOV and LCL.

9.7.5. Feeding Power (from the LT-port)

To be compliant with this signal category, the DC feeding voltage and feeding current, used for the MDSL service shall not exceed the maximum values in table 40. The value for power includes a possible overload or short circuit condition at the user-network interface.

(no ETSI reference)

Voltage	**Current**	**Power NT-Port**
Maximum 99V	40 mA	Maximum 1100 mW

Table 40: *Maximum feeding requirements for the leased line service over "Proprietary.MDSL.PAM::Fn"*

10. Cluster 4 Signals (asymmetrical broad band)

This cluster summarises 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 split into upstream and downstream specifications.

10.1. "ADSL over POTS" Signals

This category covers signals, generated by ADSL transmission equipment. These signals may share the same wire pair with POTS signals.

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

10.1.1. Total signal power (downstream only)

To be compliant 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]***

10.1.2. Total signal power (upstream only)

To be compliant 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]***

10.1.3. Peak amplitude (upstream and downstream)

To be compliant 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)

10.1.4. Narrow-band signal power (downstream only)

To be compliant with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 41, 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 22 illustrates the NBSP in a bandwidth-normalised way.

The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a power bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.1.

NOTE The NBSP specification in table 41 is reconstructed from the commonly used PSD specifications in [13,14,16] (similar to figure 22), 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 spectral 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*

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
0,1 kHz	600Ω	-77.5 dBm	100 Hz	-97.5 dBm/Hz	A
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	
60 kHz	100Ω	P_{BO} + 50 dBm	100 kHz	P_{BO} dBm/Hz	B
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 41: Break points of the narrow-band power limits. The values for parameter P_{BO} are defined in table **42**, and are dependent from the received upstream power (Power back-off).*

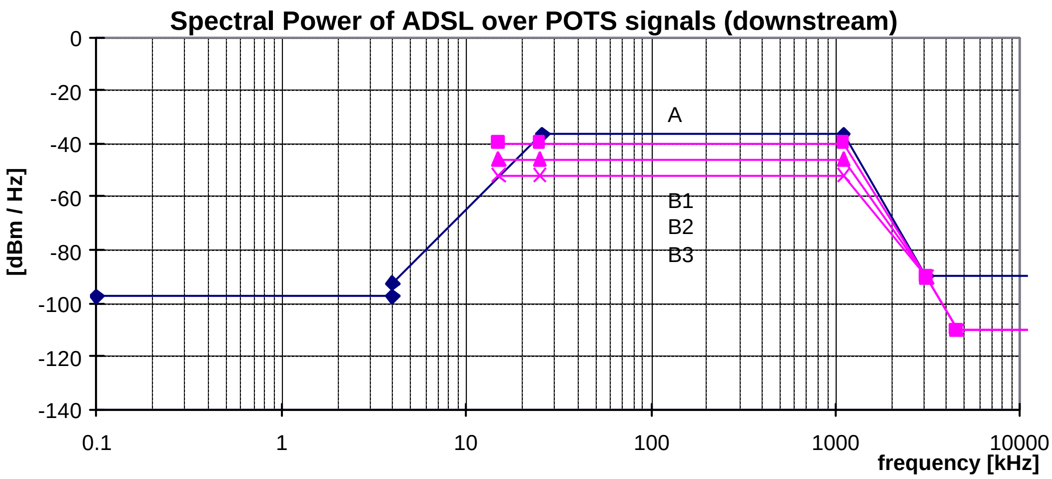


Figure 22*: Spectral Power, for ADSL over POTS signals, as specified in table* ***41****. The maximum spectral power varies with the value of parameter P_{BO}, as defined in table 42. Only the curves for the values P_{BO}=-40 dBm/Hz, P_{BO}=-46 dBm/Hz, and P_{BO}=-52 dBm/Hz are shown here.*

Power back-off. To be compliant with this signal category, the maximum downstream signal power shall be reduced when the received upstream power is above 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 42. 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} [dBm/Hz]	-40	-42	-44	-46	-48	-50	-52

Table 42: ***Definition of parameter P_{BO}, as used in table*** *41* ***(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]***

10.1.5. Narrow-band signal power (upstream only)

To be compliant with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 43, 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 23 illustrates the NBSP in a bandwidth-normalised way.

The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a power bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.1.

NOTE The NBSP specification in table 41 is reconstructed from the commonly used PSD specifications in [13,14,16] (similar to figure 23), 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 spectral 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*

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
0,1 kHz 1 kHz	600Ω 600Ω	-77.5 dBm -77.5 dBm	100 Hz 100 Hz	-97.5 dBm/Hz -97.5 dBm/Hz	A
1 kHz 4 kHz	600Ω 600Ω	-67.5 dBm -67.5 dBm	1 kHz 1 kHz	-97.5 dBm/Hz -97.5 dBm/Hz	
4 kHz 25.875 kHz 138 kHz 307 kHz 11040 kHz 30000 kHz	100Ω 100Ω 100Ω 100Ω 100Ω 100Ω	-52.5 dBm +5.5 dBm +5.5 dBm -50 dBm -50 dBm -50 dBm	10 kHz 10 kHz 10 kHz 10 kHz 10 kHz 10 kHz	-92.5 dBm/Hz -34.5 dBm/Hz -34.5 dBm/Hz -90 dBm/Hz -90 dBm/Hz -90 dBm/Hz	
60 kHz 138 kHz 307 kHz 1221 kHz	100Ω 100Ω 100Ω 100Ω	+12 dBm +12 dBm -40 dBm -40 dBm	100 kHz 100 kHz 100 kHz 100 kHz	-38 dBm/Hz -38 dBm/Hz -90 dBm/Hz -90 dBm/Hz	B
1221 kHz 1630 kHz 11040 kHz 30000 kHz	100Ω 100Ω 100Ω 100Ω	-30 dBm -50 dBm -50 dBm -50 dBm	1 MHz 1 MHz 1 MHz 1 MHz	-90 dBm/Hz -110 dBm/Hz -110 dBm/Hz -110 dBm/Hz	

Table 43: Break points of the narrow-band power limits.

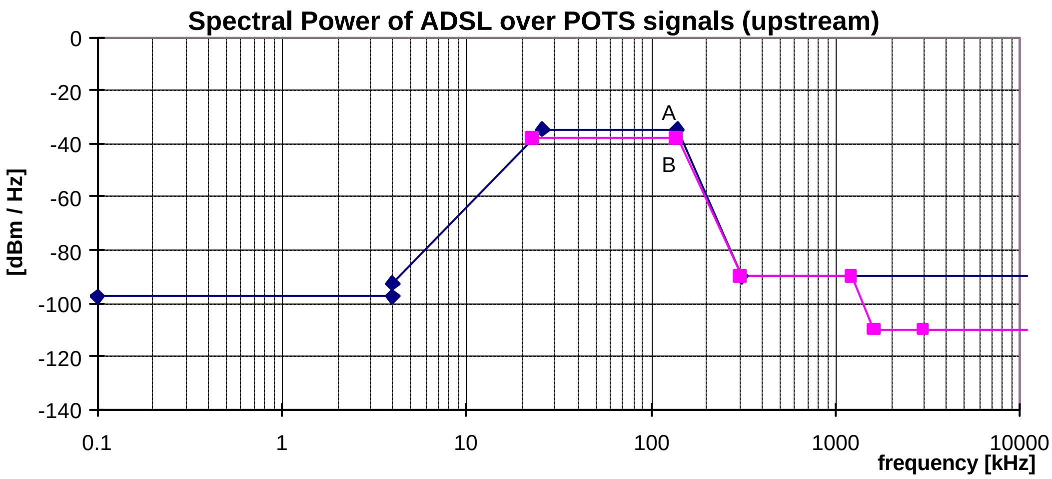


***Figure 23**: Spectral Power, for ADSL over POTS signals, as specified in table 43.*

10.1.6. Unbalance about earth (upstream and downstream)

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal output voltage (LOV) and a longitudinal conversion loss (LCL) measurement at the source of that signal, as specified in sub-clause 12.2.1 and 12.2.2.

The minimum LOV and LCL requirements hold for what can be observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.2.1 and 12.2.2.

The observed LOV of shall have an rms voltage of below –46dBV, measured in a 10 kHz power bandwidth, centred over any frequency in the frequency range from 5,1 kHz to F_{LOV} and averaged in any one second period. The value of F_{LOV} is F_{LOV}=1825 kHz for *downstream* signals, and F_{LOV}=210 kHz for *upstream* signals.
Compliance with this limitation is required with a longitudinal termination having an impedance of 100Ω in series with

150 nF nominal. The values for the components of the terminating impedance of the LCL measurements are given in table 45. Sub clause 12.2.1 defines an example measurement method for longitudinal output voltage.

The observed LCL shall be higher than the lower limits given in figure 24. The LCL values of the associated break frequencies of this figure are given in table 44. The values for the components of the terminating impedance of the LCL measurements are given in table 45. Sub clause 12.2.2 defines an example measurement method for longitudinal conversion loss. To be compliant with this signal category, the this requirement shall be met for both the switched-on and switched-off mode of the signal source.

*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.*

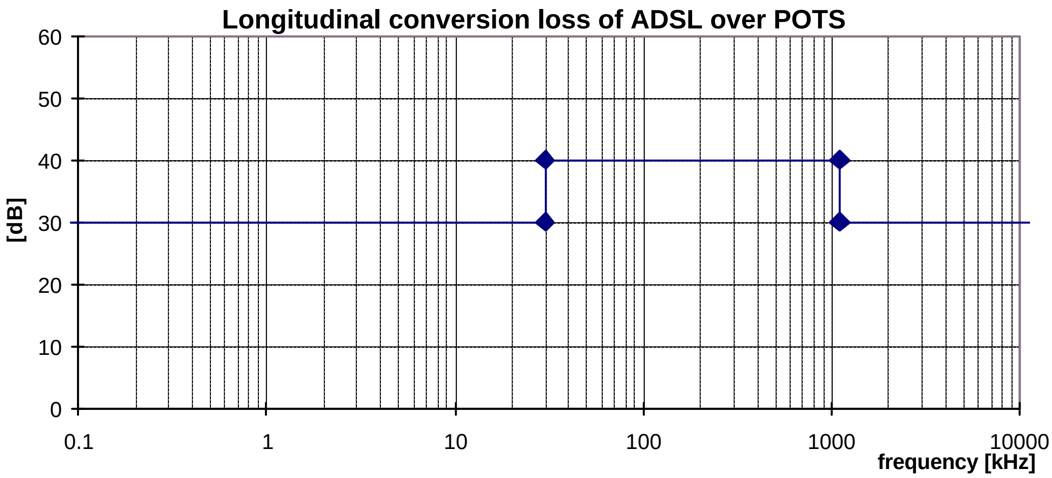


Figure 24: Minimum longitudinal conversion loss.

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

Table 44: Frequencies and LCL values of the breakpoints of the LCL mask in figure 24.

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

Table 45: Values for the components for the terminating impedance for measuring the LOV and LCL.

10.2. "ADSL over ISDN" Signals

This category covers signals, generated by ADSL transmission equipment. These signals may share the same wire pair with ISDN signals.

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

10.2.1. Total signal power (downstream only)

To be compliant 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]***

10.2.2. Total signal power (upstream only)

To be compliant with this signal category, the mean upstream signal power into a resistive load of 100Ω 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]***

10.2.3. Peak amplitude (upstream and downstream)

To be compliant 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)

10.2.4. Narrow-band signal power (downstream only)

To be compliant with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 46, 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 25 illustrates the NBSP in a bandwidth-normalised way.

The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a power bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.1.

NOTE The NBSP specification in table 46 is reconstructed from the commonly used PSD specifications in [13, 16] (similar to figure 25), 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 spectral 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*

Centre Frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
0,1 kHz	100Ω	-70 dBm	100 Hz	-90 dBm/Hz	A
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	
100 kHz	100Ω	P_{BO} + 50 dBm	100 kHz	P_{BO} dBm/Hz	B
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 46: Break points of the narrow-band power limits. The values for parameter P_{BO} are defined in table **47**, and are dependent from the received upstream power (Power back-off).*

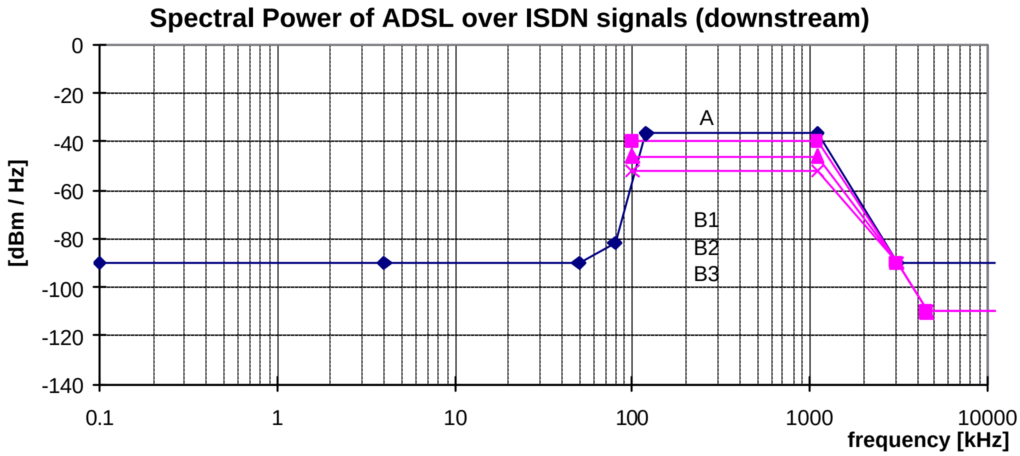


***Figure 25**: Spectral Power, for ADSL over ISDN signals, as specified in table 46. The maximum spectral power varies with the value of parameter P_{BO}, as defined in table 47. Only the curves for the values P_{BO}=-40 dBm/Hz, P_{BO}=-46 dBm/Hz, and P_{BO}=-52 dBm/Hz are shown here.*

Power back-off. To be compliant with this signal category, the maximum downstream signal power shall be reduced when the received upstream power is above 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 47. 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 47: ***Definition of parameter P_{BO}, as used in table 46 (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)*

10.2.5. Narrow-band signal power (upstream only)

To be compliant with this signal category, the narrow-band signal power (NBSP) into a resistive load impedance ***R***, shall not exceed the limits given in table 48, 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 26 illustrates the NBSP in a bandwidth-normalised way.

The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a power bandwidth ***B***. The measurement method of the NBSP is described in sub-clause 12.1.

NOTE The NBSP specification in table 48 is reconstructed from the commonly used PSD specifications in [13, 16] (similar to figure 26), 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 spectral 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*

Centre frequency f	**Impedance R**	**Signal Level P**	**Power bandwidth B**	**Spectral Power P/B**	
0,1 kHz	100Ω	-70 dBm	100 Hz	-90 dBm/Hz	A
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	+12 dBm	100 kHz	-38 dBm/Hz	B
276 kHz	100Ω	+12 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 48: Break points of the narrow-band power limits.

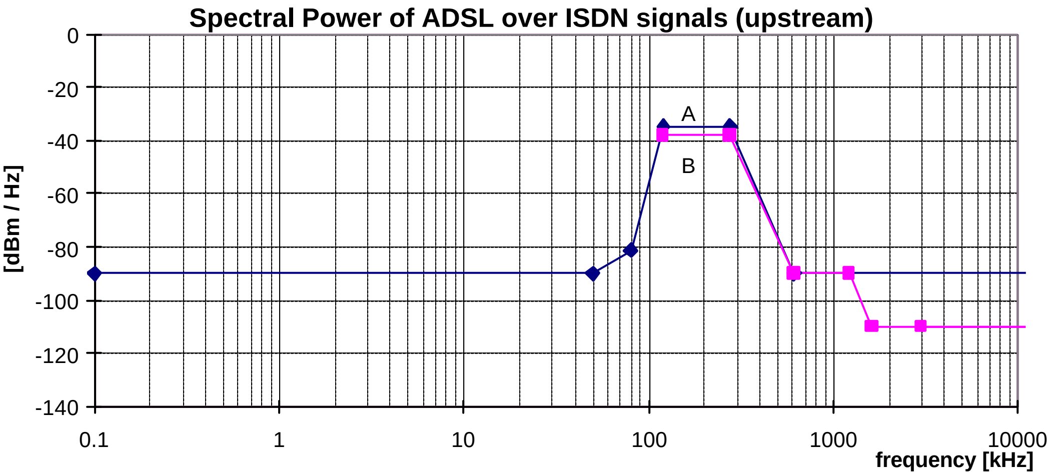


***Figure 26**: Spectral Power, for ADSL over ISDN signals, as specified in table 48.*

10.2.6. Unbalance about earth (upstream and downstream)

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a longitudinal output voltage (LOV) and a longitudinal conversion loss (LCL) measurement at the source of that signal, as specified in sub-clause 12.2.1 and 12.2.2.

The minimum LOV and LCL requirements hold for what can be observed at the LT-port or NT-port, when the local loop wiring is replaced by an artificial impedance network described in sub-clause 12.2.1 and 12.2.2.

The observed LOV shall have an rms voltage of below –46dBV, measured in a 10 kHz power bandwidth, centred over any frequency in the frequency range from 5,1 kHz to F_{LOV} and averaged in any one second period. The value of F_{LOV} is F_{LOV}=1825 kHz for *downstream* signals, and F_{LOV}=415 kHz for *upstream* signals.
Compliance with this limitation is required with a longitudinal termination having an impedance of 100 Ω in series with 150 nF nominal. The values for the components of the terminating impedance of the LCL measurements are given in table 50. Sub clause 12.2.1 defines an example measurement method for longitudinal output voltage.

The observed LCL shall be higher than the lower limits given in figure 27. The LCL values of the associated break frequencies of this figure are given in table 49. The values for the components of the terminating impedance of the LCL measurements are given in table 50. Sub clause 12.2.2 defines an example measurement method for longitudinal conversion loss. The signal source 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]***

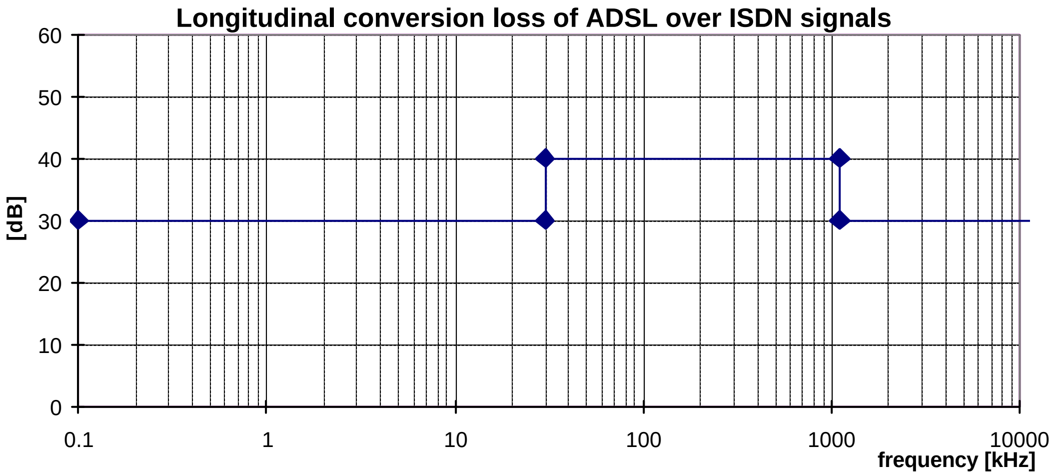


Figure 27: Minimum longitudinal conversion loss.

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

***Table 49**: Frequencies and LCL values of the breakpoints of the LCL-mask in figure 27.*

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

Table 50: Values for the components of the termination for measuring the LOV and LCL.

10.3. "ADSL.FDD over POTS" Signals

This category covers signals, generated by ADSL transmission equipment, that work in a Frequency Division Duplexing mode to minimise crosstalk between upstream and downstream signals. This category is a subset of the (full) "ADSL over POTS" signal category.

ED. This FDD mode for ADSL is currently under study, within the ETSI-TM6 ADSL project. When that study has been completed, the description of the agreed signal will be included here

10.4. "ADSL.FDD over ISDN" Signals

This category covers signals, generated by ADSL transmission equipment, that work in a Frequency Division Duplexing mode to minimise crosstalk between upstream and downstream signals. This category is a subset of the (full) "ADSL over ISDN" signal category.

ED. This FDD mode for ADSL is currently under study, within the ETSI-TM6 ADSL project. When that study has been completed, the description of the agreed signal will be included here

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

<Text>

11.1. "VDSL" Signals

ED. The signals that will be generated by VDSL equipment are currently under study, within the ETSI-TM6 VDSL project. When that study has been completed, the description of the agreed signal will be included here

12. Measurement methods of signal parameters

12.1. 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 power bandwidth **B** centred at a specified frequency. The power bandwidth is different the from commonly used –3dB bandwidth, since it fully accounts for the shape of the transfer function H(f) of frequency selective filters while measuring narrow band power (or rms-voltage). The power bandwidth of a frequency selective filter is defined as shown below.

$$B_{power} = \frac{1}{|H_{max}|^2} \cdot \int |H(f)|^2 \cdot df$$

12.1.1. Calibrating Narrow-band signal measurements

Scaling from slightly different Power bandwidth values

- white noise method
- true rms method

ED This section has not yet been completed

12.2. Unbalance about earth

Poor balance of a signal source, connected to a local loop wiring, leads to conditions in the network where systems using the same cable could be harmed. If the combination of system and wire pair shows a poor balance about earth, this will result in unwanted radiated emissions (egress) which will be visible in the environment of the wire pair and which also will be received by adjacent wire pairs (crosstalk).

12.2.1. Transmitter Balance - LOV

The balance of transmitters is normally expressed in the "Longitudinal Output Voltage" (LOV). This is the common mode portion of the generated signal, and specified for may transmission systems defined by ETSI TM6 (e.g. [8, 9]).

The longitudinal output voltage is the longitudinal component of the output signal which occurs on the line interface. (ports of the local loop wiring). The definition of the LOV can be found in the ITU recommendations [23].

Figure 28 gives an example measurement method for longitudinal output voltage. Further examples can be derived from [22,23]. For direct use of this test configurations, the IUT should be able to generate a signal in the absence of a signal from the far end. The ground reference for these measurements shall be the building ground.

NOTE: During regenerator test (where required) each wire on the side which is not under test has to be connected to ground by a terminating impedance having the value of $R_T/2$ Ohms in series with a capacitance of at least 330 nF.

*References [22]: **[ITU:O.9],***
*References [23]: **[ITU:G.117]***

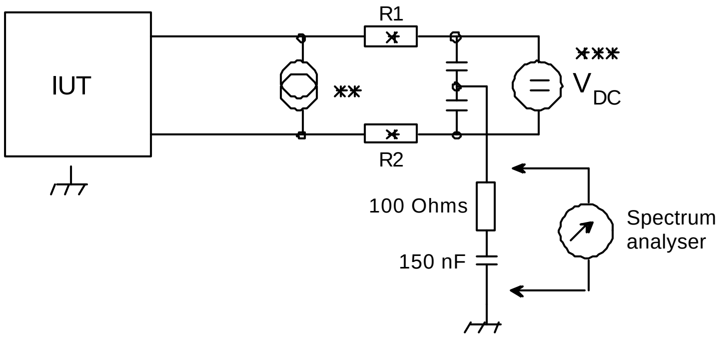


***Figure 28**: Measurement method for longitudinal output voltage (LOV).*
* *These resistors have to be matched: R1 = R2 = R_T/2 and R1/R2 = 1 ± 0,1 %*
** *For LTU test only if remote power feeding is supplied*
*** *For NTU test only if remote power feeding is required*

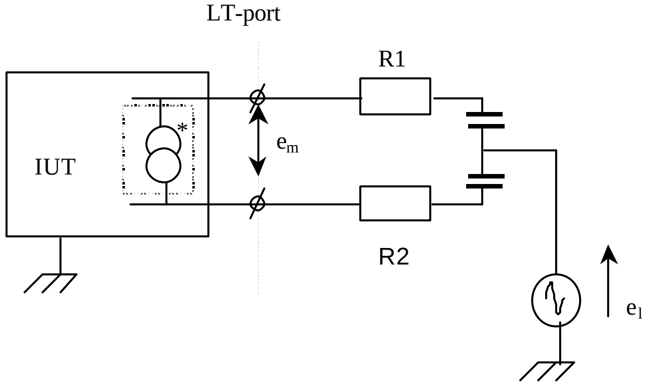
12.2.2. Receiver Balance - LCL

The balance of receivers is normally expressed in the "Longitudinal Conversion Loss" (LCL). The definition of the LCL can be found in [22]. Additionally, LCL is specified for all transmission systems defined by ETSI TM6 (e.g. [8, 9])

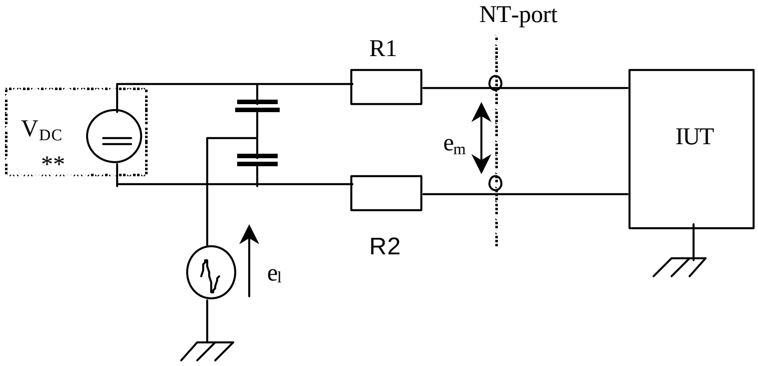
The (LCL) longitudinal conversion loss is given by: LCL = 20 log (e_l/e_m) [dB] where e_l is the applied longitudinal voltage referenced to the building ground and e_m is the resultant metallic voltage appearing across a termination with the impedance as given in the relevant section (see figure 29)

Figure 29 defines an example of he 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).

References [22]: ***[ITU:O.9],***



* 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 29: Measurement method for longitudinal conversion loss.

Bibliography

The following material, though not specifically referenced in the body of the present document (or not publicly available), gives supporting information.

<POTS & ANALOGUE>

[1] **ETSI-TBR 21 (1998-01)**: "Attachment requirements for pan-European approval for connection to the analogue Public Switched Telephone Networks (PSTNs) of TE (excluding TE supporting the voice telephony service) in which network addressing, if provided, is by means of Dual Tone Multi Frequency (DTMF) signalling". ETSI, January 1998.

[2] **ETSI-EG 201 188 (1999-06)**: "Public Switched Telephone Networks (PSTNs); Network Termination Point (NTP) analogue interface; Specification of physical and electrical characteristics at a 2-wire analogue presented NTP for short to medium length loop applications". ETSI, june 1999.

[3] **ETSI-EN 300 001 (1998-10)**: "Attachments to Public Switched Telephone Network (**PSTN**); General technical requirements for equipment connected to an analogue subscriber interface in the PSTN" ETSI, oct 1998.

[4] **ETSI ETS 300 450** Business TeleCommunications (BTC); Ordinary and Special quality voice bandwidth 2-wire analogue leased lines (A2O and A2S); Terminal equipment interface, February 1996.
Reference: DE/BTC-02028

[5] **ETSI ETS 300 453** Business TeleCommunications (BTC); Ordinary and Special quality voice bandwidth 4-wire analogue leased lines (A4O and A4S); Terminal equipment interface. February 1996
Reference: DE/BTC-02032

<AUDIO>

[6] **ITU-T Recommendations N.11 to N.16.** Maintenance of international sound - programme and television circuits, 1988, (extract from the Blue Book):
Rec N.11 - Essential transmission performance objectives for international sound-programme centres (ISPC) (8) Rec N.12 - Measurements to be made during the line-up period that precedes a sound-programme transmission (8) Rec N.13 - Measurements to be made by the broadcasting organizations during the preparatory period (11) Rec N.15 - Maximum permissible power during an international sound-programme transmission (7) Rec N.16 - Identification signal (8)

[7] **ITU-T Recommendations J.21.** (08/94) - Performance characteristics of 15 kHz-type sound-programme circuits - circuits for high quality monophonic and stereophonic transmissions (8)

<ISDN>

[8] **ETSI-TS 102 080: "**Transmission and Multiplexing (TM); Integrated Services Digital Network (**ISDN**) basic rate access; Digital transmission system on metallic local lines", ETSI Technical Specification, v 1.3.1, nov 1998

<HDSL>

[9] **ETSI-TS 101 135** V1.5.1. (1998-11): "Transmission and Multiplexing (TM); High bit rate Digital Subscriber Line (HDSL) transmission system on metallic local lines; HDSL core specification and applications for combined ISDN-BA and 2 048 kbit/s transmission

<SDSL>

[10] **ETSI:** "Transmission and Multiplexing (TM); Symmetric single pair high bit rate digital subscriber line (SDSL) transmission system on metallic local lines; Part 1: Functional Requirements", ETSI-TM6 workitem RE/TM-06011-1, TM6(98)08 980p08r5, dec 1999.

[11] **ETSI WG TM6**, 980p09a0, Permanent Document TM6(98)9, Rev. 1, Living List for DTS/TM-06011-1

<ADSL>

[12] **ETSI-ETR 328:** “Transmission and Multiplexing (TM); Asymmetric Digital Subscriber Line (**ADSL**); Requirements and performance”, ETSI, European Telecommunication Standard, November 1996

[13] **ETSI TS 101 388**: "Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Asymmetric Digital Subscriber Line (ADSL) -Coexistence of ADSL and ISDN-BA on the same pair". ETSI, European Telecommunication Standard, November 1998

[14] **ANSI-T1.413, issue 1:** “Network and customer installation interfaces - Asymmetrical Digital Subscriber Line (**ADSL**) Metallic Interface”, ANSI, American National Standardization Institute, Issue 1, August 1995.

[15] **ANSI-T1.413, issue 2:** “Standards Project for Interfaces Relating to Carrier to Customer Connection of Asymmetrical Digital Subscriber Line (**ADSL**) Equipment”, ANSI, American National Standardization Institute, draft specification issue 2, T1E1.4/97-007R6, Sept 1997. (ADSL_98R5)

[16] **ITU-T G.992.1:** "Transmission Systems and Media; Asymmetrical Digital Subscriber Line (ADSL) Transceivers" ITU-T, International Telecommunication Union", draft specification, April 1999.

[17] **ITU-T G.992.2:** "Transmission Systems and Media; Splitterless Asymmetrical Digital Subscriber Line (ADSL) Transceivers" ITU-T, International Telecommunication Union", draft specification, Feb 1999.

<VDSL>

[18] **ETSI-DTS/TM-06003:** “Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Very high speed Digital Subscriber Line (**VDSL**); Part 1: Functional requirements”. ETSI, European Telecommunication Standard, draft Edition 1 revision 7, February 1998

[19] **ANSI-T1.VDSL**: “Very high-speed Digital Subscriber Lines (**VDSL**)”, ANSI, Draft Technical report, revision 12 T1E1.4/97-131R3, may 1997.

[20] **ETSI-TS 101 270-1:** Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Very high speed Digital Subscriber Line (VDSL); Part 1: Functional requirements

[21] **ETSI-TS 101 270-1 V1.2.1 (1999)** Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Very high speed Digital Subscriber Line (VDSL); Part 1: Functional requirements

<EMC & UNBALANCE>

[22] **ITU-T Recommendation O.9.** (1988) - Measuring arrangements to assess the degree of unbalance about earth, vol IV.4-Rec O.9 (1972, amended in 1984 and 1988)

[23] **ITU-T Recommendation G.117.**

[24] **ETSI EN 300 386-2.** - Electromagnetic compatibility and Radio spectrum Matters (ERM); Telecommunication network equipment; ElectroMagnetic Compatibility (EMC) requirements; Part 2: Product family standard, dec 1997

<VARIOUS>

[25] **ETSI-TM6(97)02**. “Cable reference models for simulating metallic access networks”, R.F.M. van den Brink, ETSI-TM6, Permanent document TM6(97)02, revision 3, Luleå, Sweden, June 1998.

[26] **ETSI STC TM6, TD 16** meeting, 22- 26 June 1998, Luleå, Sweden, 983t16a0, PSD + Crest factor is not sufficient to specify noise in performance tests.

[27] **ETSI STC TM6, TD 42** meeting, 21-25 September 1998, Vienna, Austria, 984t42a0, Specification of crest distribution mask for noise in performance tests.

History

Document history		
0.0.1	feb 2000	First Draft
0.0.2	april 2000	Enhanced Reference Model (see WD22 of Montreux) ; general bugfix; Signals added (ISDN.MMS.43, HDSL.2B1Q/1, Proprietary.MDSL.PAM); Inclusion of LOV (see WD18 of Montreux); frequencies specified as centre frequencies