TITLE **Classification of signals for spectral management specifications on access networks**

PROJECT Spectral Management (new item)

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STATUS For decision

ABSTRACT This contribution is a basis for spectral management, by providing relevant definitions and a wide range of signal categories ranging from POTS to VDSL. Network owners, that want to set network-specific rules for access to unbundled lines, can do this with a short network-specific document that refers to a single ETSI document with relevant definitions and signal categories. This document provides a first basis for such a document and is an update of TD37 from the Edinburgh ETSI-TM6 meeting (993t37a0)

Problem Description

The unbundling of loops in European countries may cause that incompatible transmission systems from different network operators will be connected to wire pairs in the same cable of an access network cable. An incompatible mixture of transmission technologies that share the same cable bundle or binder group, will prevent an efficient use of the available capacity of these cables. Technical signal limits that distinct between what signals can be injected into a particular access network and what signals cannot, can prevent such a kind of spectral pollution. The process that enables an efficient use of the available capacity in cables is identified as “spectral management”.

Although rules for spectral management are network-specific in nature (set by network owners), we believe that a European framework around these network-specific approaches is required.

An essential part of such a European framework is a first ETSI document on Spectral Management, that classifies a wide range of signals. Network-specific rules for spectral management can use such a classification to identify what signal limits are mandatory, for a particular cable or network.
This document provides a detailed proposal how that first ETSI document on Spectral Management should look like. The description of additional ETSI documents on Spectral Management are beyond the scope of this proposal.

Aim of the discussion.

To decide whether the approach, as proposed by this document, is the appropriate one to deal with Spectral Management on an European level, and to open a work item that covers that work.

To make such a decision, the discussion should primarily focus on the structure and basic content of that first work item on Spectral Management.

Contents

1. Scope

This document is a technical description of signal categories needed for spectral management in copper access networks. These technical classifications may be used by a telecommunication access network owners.
Network-specific documents, that rule the selected penetration limits and technology mix for spectral management purposes, can be kept compact by refering to the definitions in this document.

The approach of this document is to classify and summarize relevant limits for all kinds of signals, that may be considered for injection into an access network. Since many (potentially incompatible) systems have been defined in many different standards, these signal limits are brought together into one document and organized in clusters of categories. Making any further selection between the4se signal limits is beyond the scope of this document.
Each category defines, independent from other categories, a full set of signal limits between DC and 30 MHz. These categories are dominantly based on standards from ETSI, ANSI and ITU (existing or in progress), and on the technical understanding of additional requirements to protect future technology.

2. Spectral management (informative)

2.1. Objective

The frequency of the signals in cables increases substantially due to the introduction of broadband transmission systems. These transmission systems use the existing (copper-) access networks. Therefore measures have to be taken in order to cope with crosstalk between individual transmission channels using the existing access network.

Usually, systems are designed to function optimally when they are only impaired (self-crosstalk) by identical systems 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 performance, compared to the above mentioned idealized 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*.

The objective for *spectral management* is to facilitate near-compatibility of systems that are connected to different wire-pairs 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 licenced operator make use of the same binders or cable bundles; it is also essential when one operator mixes different broadband technologies into one binder or cable bundle.
- The best that *network operators* can do is making estimates of the maximum impairment level in a wire-pair, and define adequate deployment rules. Deployment rules define the maximum reach or bitrate for a given transmission technology, with 'sufficient' noise margin (according to the network operator). Since the crosstalk coupling between the wirepairs in binders or cable bundles is only known by a very rough approximation, the maximum impairment level is also only known by a very rough estimate. In other words: the definition of adequate limits is an essential requirement for successfull 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 categories of signal limits, 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.

2.2. The origin of impairment

Impairment in a wire-pair of a binder or cable bundle is caused by crosstalk from signal sources that make use of the other wires in that binder or cable bundle. Connecting more systems to that cable will increase the crosstalk noise level in each wire-pair.
These impairments put a limit on the maximum bitrate that can be transported over a single wire-pair with given length, or the maximum length that can be reached with given bitrate. Above some impairment threshold, this noise causes harm to existing systems within the same binder or cable bundle, because the increased crosstalk noise will break down services to other users.

The crosstalk and 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.
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.

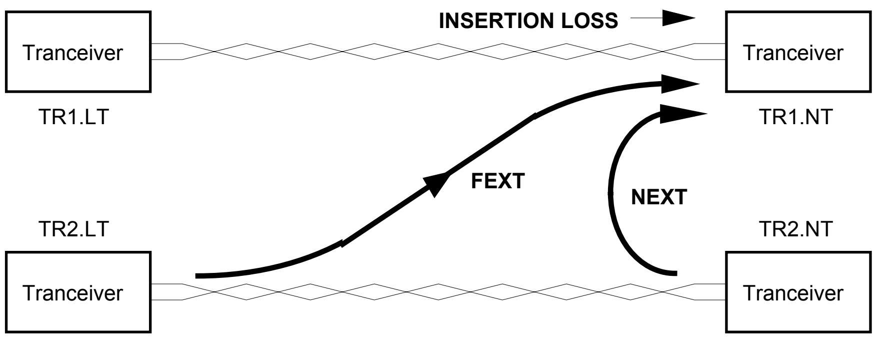


Figure 1. Various crosstalk paths .

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.

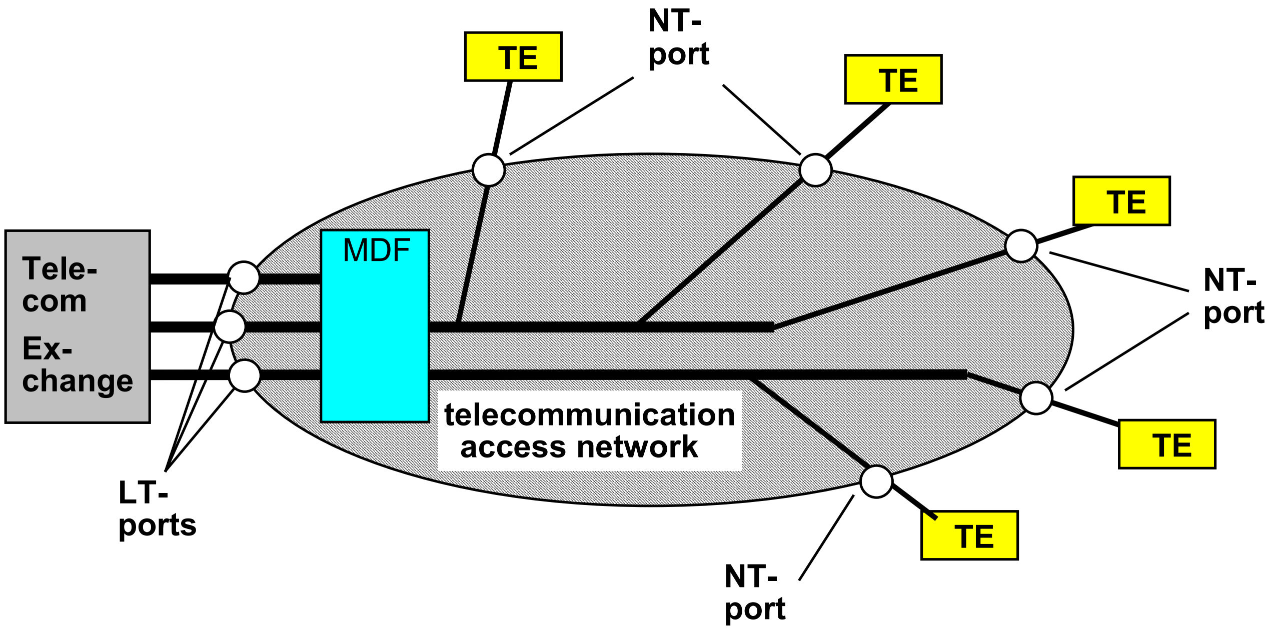
3. Reference model of access networks (normative)

Figure 2 shows the reference model of access networks from a spectral management point of view. It illustrates that access networks are asymmetrical in nature, that is characterized by the distinction between so-called LT-ports and NT-ports.
The reference model shows that an access network includes cables, but may also include a Main Distribution Frame (MDF), street cabinets, and other distribution elements.

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

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

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



LT-port:	Line Termination Point
NT-port:	Network Termination Point
TE:	Transmission Equipment
MDF:	Main Distribution Frame

Figure 2. Reference model of the 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.

Ports for upstream and downstream

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

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

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

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

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

4. Definitions

The terminology used in this a document follows international conventions. This chapter defines deviations from the general conventions. For convenience of the reader of this document, some details are explained, even when there is no difference with the general meaning.
In all cases where this chapter gives no definition, the ETSI definition takes prevalence over any other.

4.1. Network owner

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

4.2. Network operator

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

4.3. Transmission technique

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

4.4. Transmission equipment

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

4.5. Line Termination Port (LT-port)

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

4.6. Network Termination Port (NT-port)

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

4.7. 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.

4.8. 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.

4.9. 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.

4.10. Unbalance about earth

The (LCL) longitudinal conversion loss is given by: LCL = 20 log (e_L/e_M) [dB] where e_L is the applied longitudinal voltage referenced to the building ground and e_M is the resultant metallic voltage appearing across a termination with the impedance as given in the relevant section.
*References [*20*]: **[ITU:O.9],***

4.11. Narrow band signal power (NBSP)

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

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

4.12. Sliding window signal power

The purpose of the sliding window is to perform a higher bandwidth measurement in order to make sure that different systems do not fill the entire allowable band with noise up to some limit.
The sliding window PSD shall be measured as the total average power within a 1 MHz sliding window (1MHz bandwidth). The requirement is applicable between 300 kHz and 30 MHz.
References [8,20]: ***[ETSI TS 102 080: A.12.4]***

<NEEDS IMPROVEMENT??>

5. Parameters for signal classification

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

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

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

6. List of Abbreviations

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
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
ETSI	European Telecommunications Standards Institute
HDSL	High bitrate Digital Subscriber Line
ISDN	Integrated Services Digital Network
ITU	International Telecommunication Union
LCL	Longitudinal Conversion Loss
LT-port	Line Termination port
LVD	Low Voltage Directive
MDF	Main Distribution Frame
NBSP	Narrow band signal power
NT-port	Network Termination port
NTE	Network Terminal equipment
NTI	Network Terminal Interface
OLO	Other Licensed Operator
ONP	Open Network Provision
PCM	Pulse Code Modulation
PSD	Power Spectral Density
POTS	Plain Old Telephony Services
PSTN	Public Switched Telephone Network
R&TTE	Radio and Telecommunications Terminal Equipment
TBR	Technical Basis for Regulation
TE	Transmission Equipment
SDSL	Symmetrical Digital Subscriber Line
xDSL	(all systems) Digital Subscriber Line
U-ADSL	Universal Asymmetrical Digital Subscriber Line
VDSL	Very high bit rate Digital Subscriber Line

7. Clusters of Signal categories

7.1. Cluster 1: transmission equipment (voice band)

This cluster covers analogue transmission equipment, including POTS, voice band modems, analogue leased lines, telex signals encoded as voiceband signals and music lines.

> **ED NOTE** Existing equipment connected to voice band lines like POTS and leased lines is not specified up to 30 MHz. Extension of the current frequency range up to 30 MHz is recommended to guarantee the proper working of VDSL systems which will be deployed in the near future (for ADSL, extension up to 1.1 MHz is required). This extention is based on the limits that have been agreed within ETSI-TM6 for ISDN
>
> For this the following steps are recommended :
>
> 1. Establish extended requirements (up to 30 MHz) for out of band signals and LCL of voice band Terminal Equipment. (definition of the maximum "out of band noise" produced by voice band equipment which is acceptable by ADSL and VDSL systems is necessary)
>
> 2. Check if the current equipment fulfils the extended requirements or not.
>
> 3. Define a reasonable date from which the produced equipment should fulfil the extended requirements (this date depend on the fact if the current equipment fulfils the extended requirements with or without modification of the design).
>
> 4. Adapt the relevant equipment standards with the extended requirements and the date of coming into force of the extension.

7.1.1. Category 1a: "POTS" (voice band lines 300 - 3400Hz)

This category covers 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.

7.1.1.1. Unbalance about earth

The longitudinal conversion loss shall be better than:

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 300 kHz	55 dB	135 Ω
300 kHz to 3 MHz	55 to 35 dB	135 Ω
3 MHz to 30 MHz	35 dB	135 Ω

> ED NOTE: This is an extension of the frequency range of the current recommandation / standard, with the goal of protection of VDSL transmission.
>
> Systems deployed after <day - month - year > <under study> have to meet this extended LCL requirement.

References [1, 17, 4, 5] ***ETSI-TBR 21, 4.4.3, ETSI-TS 101 270-1 clause 8.3.3, ETSI-ETS 300 450 clause 4.4.2, ETSI-ETS 300 453 clause 4.4.2***

7.1.1.2. Total signal voltage

The mean sending level in the frequency range from 200 Hz to 3.8 kHz over a one-minute period shall not be greater than -9,7 dBV when the equipment interface is terminated with the category 1a reference impedance Z_R (figure 3). This requirement does not apply to DTMF signals.
*Reference [1]: **[ETSI-TBR21, 4.7.3.1]**, (tested according to annex A, sub clause A.4.7.3.1)*

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 reference impedance Z_R.
*Reference [1]: **[ETSI-TBR21, 4.8.2.2.1]** (tested according to annex A, sub clause A.4.8.2.2)*

7.1.1.3. Peak amplitude

The peak to peak voltage in the frequency range 200 Hz to 3.8 kHz shall not exceed 5,0 volts when the equipment interface is terminated with the reference impedance Z_R.
*Reference [1]: **[ETSI-TBR21, 4.7.3.2]** (tested according to annex A, sub clause A.4.7.3.2)*

7.1.1.4. Narrow-band signal voltage

The average voltage ***U*** of a category 1a sending signal into a (complex) load impedance ***Z***, within a bandwidth ***B***, centered at any point in the frequency range 100 Hz to 30 MHz, shall not exceed the limits given in table 1. 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. This requirement does not apply to DTMF signals.

> ED NOTE: This is an extension of the frequency range of the current recommendation / standard, with the goal of protection of VDSL transmission
>
> Systems deployed after <date , month , year > <under study> have to meet this extended PSD requirement

Points	frequency f	impedance Z	Sending level U	Bandwidth B	U/√B
A	30 Hz	Z_R	-33.7 dBV	10 Hz	–43.7 dBV/√Hz
B	100 Hz	Z_R	-10.7 dBV	10 Hz	–20.7 dBV/√Hz
C	200 Hz	Z_R	-6.7 dBV	10 Hz	–16.7 dBV/√Hz
D	3.8 kHz	Z_R	-6.7 dBV	10 Hz	–16.7 dBV/√Hz
E	3.9 kHz	Z_R	-10.7 dBV	10 Hz	–20.7 dBV/√Hz
F	4.0 kHz	Z_R	-16.7 dBV	10 Hz	–26.7 dBV/√Hz
G	4.3 kHz	Z_R	-44.7 dBV	10 Hz	–54.7 dBV/√Hz
G	4.3 kHz	Z_R	-40 dBV	300 Hz	–65 dBV/√Hz
H	5.1 kHz	Z_R	-44 dBV	300 Hz	–69 dBV/√Hz
I	8.9 kHz	Z_R	-44 dBV	300 Hz	–69 dBV/√Hz
J	11.0 kHz	Z_R	-58.5 dBV	300 Hz	–73.5 dBV/√Hz
J	11.0 kHz	Z_R	-58.5 dBV	1 kHz	–88.5 dBV/√Hz
K	200 kHz	Z_R	-58.5 dBV	1 kHz	–88.5 dBV/√Hz
K	200 kHz	135 Ω	-60 dBV	1 kHz	–90 dBV/√Hz
L	500 kHz	135 Ω	-90 dBV	1 kHz	–120dBV/√Hz
M	30 MHz	135 Ω	-90 dBV	1 kHz	–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 Ω and 8.7 dBm in 135 Ω.*

Reference [1]: [ETSI-TBR21], (30 Hz - 4.3kHz, clause 4.7.3.3), (4.3 kHz - 200kHz, clauses 4.7.3.4) the requirements above 200kHz are extended from [1]. This extension is essential to guarantee compatibility with xDSL systems (Category 3 and higher).

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 135 Ω.

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

7.1.1.5. Power spectral density (PSD)

Due to their nature, voice signals in this document are not restricted in terms of PSD, but narrow-band signal power.

Note: Voice band modems shall meet the Narrow-band signal voltage requirement. The technology of these modems is such that there is no need for an additional PSD requirement.

7.1.1.6. Feeding Power (from the LT-port)

The DC feeding voltage and feeding current, used for the POTS service shall not exceed the maximum values in table 2.
Reference [2] ***[ETSI- EG 201 188, sec 6.2.1 and 6.3.1]***
Reference [3] ***[ETSI- TRS 300 001, sec 1.5]***

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

Table 2 *Maximum feeding requirents for the POTS service*

7.1.1.7. Reference impedance Z_R

The category 1a reference impedance, is thew Eoropean harmonized complex impedance Z_R, which is used to enable the specification of signal power. This harmonized complex impedance (see figure 3) equals 270 Ω in series with a parallel combination of 750 Ω and 150 nF.
Reference [1]: ***[ETSI-TBR21, sec A.2.1]***

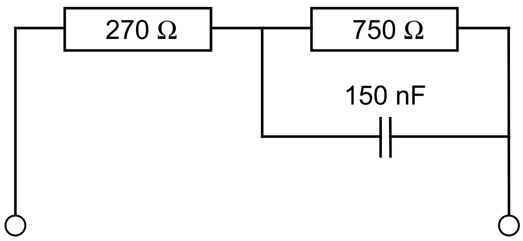


Figure 3*: Reference impedance* Z_R

7.1.1.8. Ringing signal

The AC ringing voltage shall not exceed the maximum values in table 3. The AC ringing signal may be or may be not superimposed on the DC feeding voltage.
Reference [2] ***[ETSI- EG 201 188, sec 12.1]***
Reference [3] ***[ETSI- TRS 300 001, sec 1.7.2]***

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

Table 3 *Maximum ringing signal (POTS service)*

ED NOTE: The text below 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-hoog disturbance are worth considering for inclusion.

This issue is for further study.

7.1.1.9. Metering signals

If 50 Hz common mode metering pulses are added to POTS lines, then they shall be within the limits of table 4.
NOTE: Most access networks are using a different type of metering signals.
Reference [3] ***[ETSI- ETS 300 001, sec 1.7.8]***

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

***Table 4** Maximum metering signal*

7.2. Cluster 2: transmission equipment (semi broad band)

This cluster covers digital transmission equipment up to 160 kb/s, including ISDN-BRA and 64 and 128 kb/s leased lines.

7.2.1. Category 2a: "ISDN-2B1Q"

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

7.2.1.1. Impedance unbalance about earth

The longitudinal conversion loss shall be better than

Points	Frequency range	Minimum value in any band of 4kHz	Impedance
A	500 Hz to 5 kHz	25 to 45 dB (slope 6 dB /oct)	135Ω
B	5 kHz to 60 kHz	45 dB	135Ω
C	60 kHz to 190 kHz	45 to 40 dB (slope)	135Ω
D	190 kHz to 30 MHz	40 dB	135Ω

Table 5: *Break points of the unbalance about earth of cat2 equipment*

Reference [8] ***[ETSI-TS 102 080: A.13.3.1]***
*Reference[*17*]* ***ETSI-TS 101 270-1 clause 8.3.3***

7.2.1.2. Total signal power

The average power of a category 2a sending signal into a resistive load of 135 Ω shall not exceed a level of 13.5 dBm (± 0.5 dBm), over the frequency band from 100 Hz to 80 kHz.
Reference [8]: ***[ETSI TS 102 080: A.12.3]***

7.2.1.3. Peak amplitude

The nominal peak of the largest pulse into a resistive load of 135Ω shall be 2,5 V (± 5%)
Reference [8]: ***[ETSI TS 102 080: A.12.1]***

7.2.1.4. Power spectral density (PSD)

The upper bound of the single sided power spectral density of the sending signal shall be as shown in figure 4. Table 6 specifies the break points of this figure. Measurements to verify compliance with this requirement shall use a noise power bandwidth of 1 kHz and a resistive load of 135Ω. See also the additional sliding window requirements, as specified in table 7.
References [8]: ***[TS 102 080: A.12.4]***

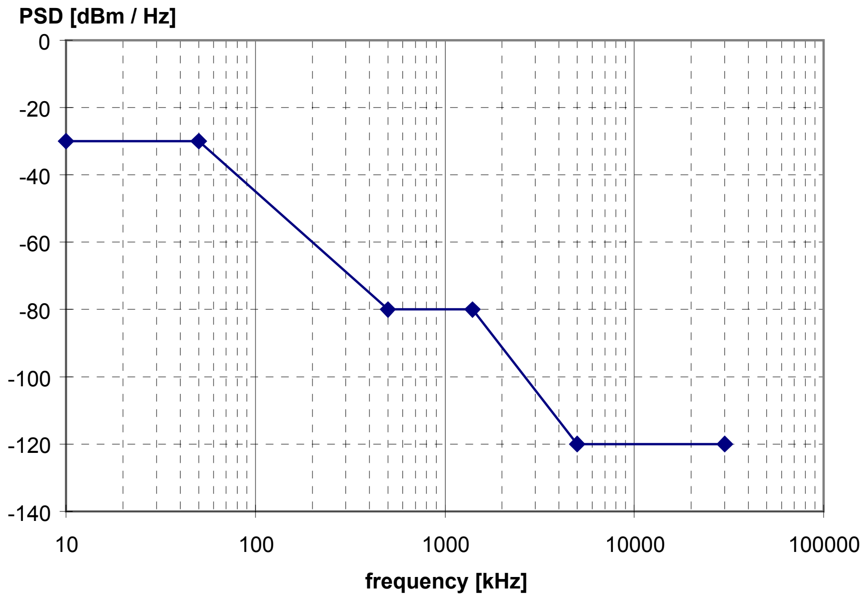


***Figure 4**: Upper bound of the average power spectral density of category 2a equipment (ISDN 2B1Q)*

Points	Impedance	Frequency	PSD
A	135 Ω	10 Hz	–30 dBm/Hz
B	135 Ω	50 kHz	–30 dBm/Hz
C	135 Ω	500 kHz	–80 dBm/Hz
D	135 Ω	1400 kHz	–80 dBm/Hz
E	135 Ω	5 MHz	–120 dBm/Hz
F	135 Ω	30 MHz	–120 dBm/Hz

Table 6: Upper bound of the average power spectral density of category 2a equipment (ISDN 2B1Q)

7.2.1.5. Narrow-band signal power

The average power ***P*** of a category 2a sending signal into a resistive load ***R***, within a bandwidth ***B***, centred at any point in the frequency range 100 Hz to 30 MHz, shall not exceed the limits given in table 7. 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.

Table 7 is reconstructed from the PSD requirements, as defined in figure 4. Measurements to verify compliance with this requirement above 10 kHz shall use a bandwidth of 10 kHz. Above 300 kHz, an additional sliding window requirement shall be met. This is to perform a higher bandwidth measurement in order to make sure that different systems do not fill the entire allowable bandwidth with noise up to the PSD limit shown in figure 4.

This sliding window approach is defined in section 4.12. Above 3.6 MHz, the result shall be less than -120 dBm/Hz or at least more than 10 dB below the PSD limit shown in figure 4. The requirement is applicable between 300 kHz and 30 MHz. Systems deployed before January 1, 2000, do not have to meet the additional sliding window PSD requirement.

Points	Frequency f	Impedance R	Sending level P	Bandwidth B	P/B
A	0.1 kHz	135Ω	-0 dBm	1 kHz	-30 dBm/Hz
B	10 kHz	135Ω	-0 dBm	1 kHz	-30 dBm/Hz
B	10 kHz	135Ω	10 dBm	10 kHz	-30 dBm/Hz
C	50 kHz	135Ω	10 dBm	10 kHz	-30 dBm/Hz
D	300 kHz	135Ω	-30 dBm	10 kHz	-69 dBm/Hz
D	300 kHz	135Ω	-19 dBm	1 MHz	-79 dBm/Hz
E	500 kHz	135Ω	-30 dBm	1 MHz	-90 dBm/Hz
F	1.4 MHz	135Ω	-30 dBm	1 MHz	-90 dBm/Hz
G	3.637 MHz	135Ω	-60 dBm	1 MHz	-120 dBm/Hz
H	30 MHz	135Ω	-60 dBm	1 MHz	-120 dBm/Hz

***Table** 7: Break points of the narrow-band power limits. When measured at 1MHz bandwidth, the center frequency is 500 kHz above the lowest frequency that is specified in this table (sliding window approach)*

Reference: These numbers have been reconstructed from PSD requirements in [8]
References [8,20]: ***[TS 102 080: A.12.4]***

7.2.1.6. Feeding Power (from the LT-port)

The DC feeding voltage and feeding current, used for the ISDN service shall not exceed the maximum values in table 8. The value for power includes a possible overload or short circuit condition at the user-network interface.
Reference [8]: ***[ETSI TS 102 080: 10.5 and 10.6.1.1]***

Voltage	Power
maximum 99 V	maximum 1100 mW

***Table 8** Maximum feeding requirents for the ISDN service*

7.3. Cluster 3 transmission equipment (symmetrical broadband)

This cluster covers symmetrical digital transmission equipment up to 2 Mb/s, such as HDSL. If such a system requires more than one wire-pair for carrying that bitrate, the specifications in this document hold for each individual wire-pair.
This type of equipment is commonly used for services like high quality leased lines, with symmetrical bit rates (in up- and downstream directions).

7.3.1. Category 3a: "HDSL.2B1Q/3" (392 kbaud /s leased lines)

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

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).

7.3.1.1. Unbalance about earth

The (LCL) longitudinal conversion loss of the system shall meet the requirement of: - 50 dB between 5 kHz and 196 kHz for a 392 kbaud system as shown in fig 5.
Reference [9,10]: ***[ETR152: 5.8.5.1]***

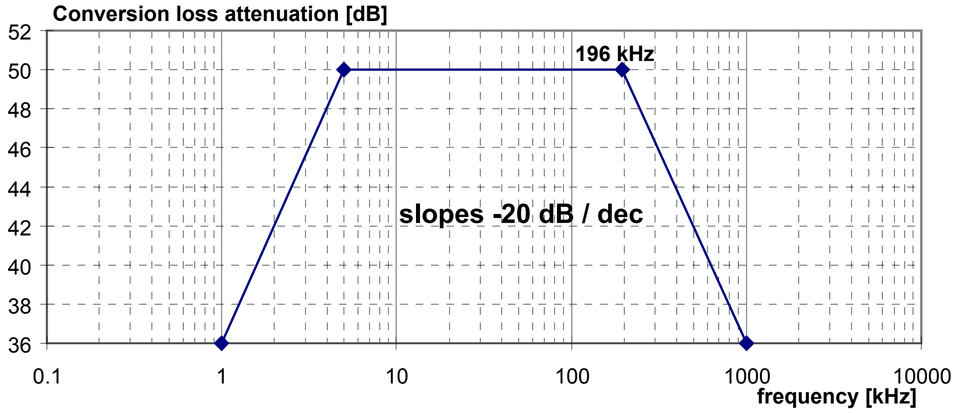


Figure 5*: Minimum longitudinal conversion loss for a 392 kbaud system*

7.3.1.2. Total signal power

The average power of a sending signal shall not exceed a level of 13.5 dBm (± 0.5 dBm), over the frequency band from 0 Hz to 784 kHz.
Reference [9,10]: ***[ETR152: 5.8.4.4]***

7.3.1.3. Peak amplitude

The nominal peak of the largest pulse shall be 2.64 V (±7%) into a resistive load of 135 Ω.
Reference [9,10]: ***[ETR152: 5.8.4.1]***

7.3.1.4. Power spectral density (PSD)

The upper bound of the single sided power spectral density of the sending signal shall be as shown in figure 6. Table 9 specifies the break points of this figure. Measurements to verify compliance with this requirement shall use a noise power bandwidth of 1 kHz (and a resistive load of 135Ω).
Reference [9,10]: ***[ETR152: 5.8.4.3.1]***

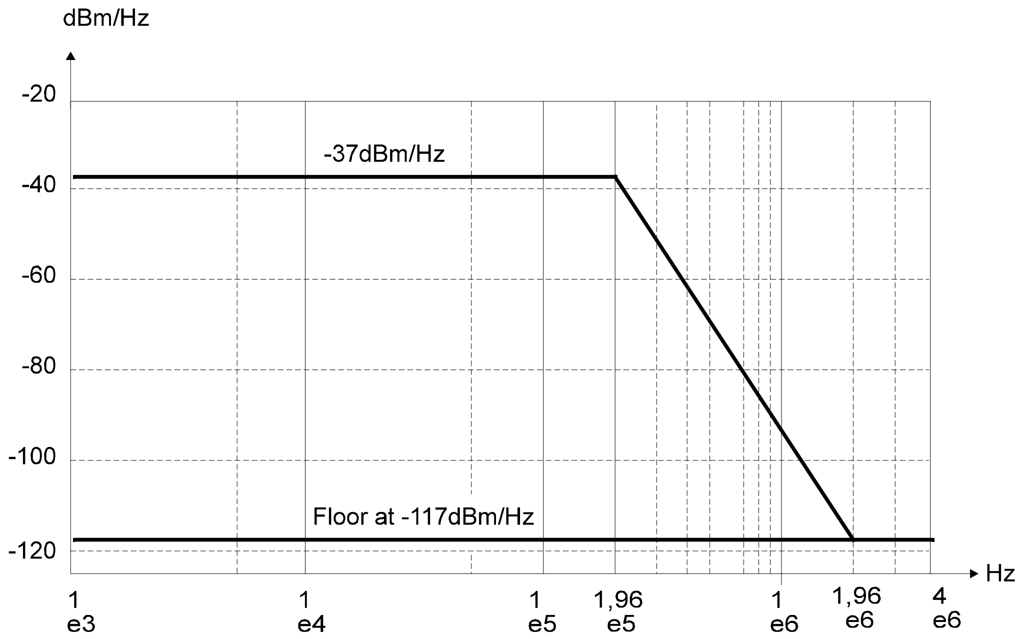


Figure 6: *Upper bound of the average power spectral density of category 3a equipment*

Points	frequency	PSD
A	0.1 kHz	-37 dBm/Hz
B	196 kHz	-37 dBm/Hz
C	1.96 MHz	-117 dBm/Hz
D	30 MHz	-117 dBm/Hz

Table 9: *Break points of the spectral mask in figure 6*

7.3.1.5. Narrow-band signal power

The average power ***P*** of a category 3a sending signal into a resistive load ***R***, within a bandwidth ***B*** centred at any point in the frequency range 100 Hz to 30 MHz, shall not exceed the limits given in table 10. This table specifies the break points of the limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. These limits are frequency independent between 100 Hz to 196 kHz, and decrease with 24 dB/octave (80 dB/decade) above 196 kHz.
Reference: These numbers have been reconstructed from PSD requirements in ETSI-ETR152 [9,10].

Points	Frequency f	Impedance R	Sending level P	Bandwidth B	P/B
A	0.1 kHz	135Ω	-7 dBm	1 kHz	-37 dBm/Hz
B	196 kHz	135Ω	-7 dBm	1 kHz	-37 dBm/Hz
C	1.96 MHz	135Ω	-87 dBm	1 kHz	-117 dBm/Hz
D	30 MHz	135Ω	-87 dBm	1 kHz	-117 dBm/Hz

Table 10 *Break points of the narrow-band power limits.*

7.3.2. Category 3b: "HDSL.2B1Q/2" (584 kbaud /s leased lines)

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

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).

7.3.2.1. Unbalance about earth

The (LCL) longitudinal conversion loss is given by: LCL = 20 log (e_L/e_M) [dB] where e_L is the applied longitudinal voltage referenced to the building ground and e_M is the resultant metallic voltage appearing across a 135 Ω termination. The LCL of the system shall meet the requirement of: - 50 dB between 5 kHz and 292 kHz for a 584 kbaud system as shown in fig 7.
Reference [9,10]: ***[ETR152: 5.8.5.1]***

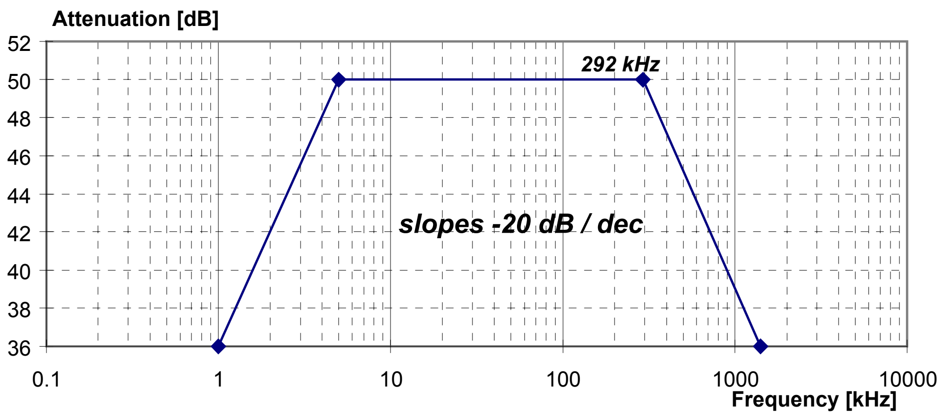


Figure 7: *Minimum longitudinal conversion loss for a 584 kbaud system*

7.3.2.2. Total signal power

The average power of a sending signal shall not exceed a level of 13.5 dBm (±0.5 dBm), over the frequency band from 0 Hz to 1168 kHz.
Reference [9,10]: ***[ETR152: 5.8.4.4]***

7.3.2.3. Peak amplitude

The nominal peak of the largest pulse shall be 2.64 V (±7%) into a resistive load of 135 Ω.
Reference [9,10]: ***[ETR152: 5.8.4.1]***

7.3.2.4. Power spectral density (PSD)

The upper bound of the single sided power spectral density of the sending signal shall be as shown in figure 8. Table 11 specifies the break points of this figure. Measurements to verify compliance with this requirement shall use a noise power bandwidth of 1 kHz (and a resistive load of 135 Ω).
Reference [9,10]: ***[ETR152: 5.8.4.3.1]***

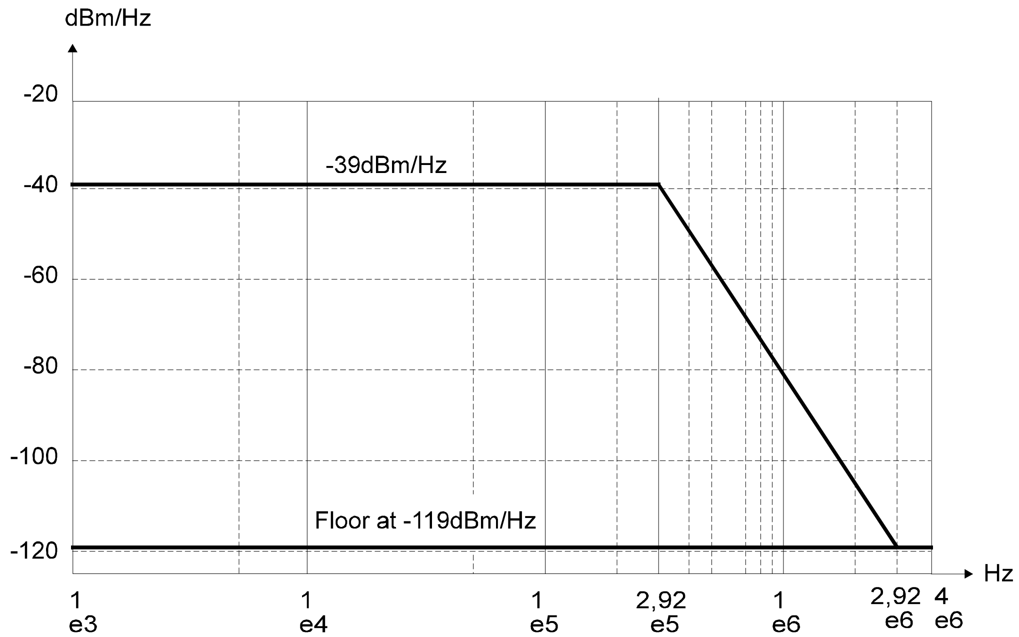


***Figure 8**: Upper bound of the average power spectral density of category 3b equipment.*

Points	frequency	PSD
A	0.1 kHz	-39 dBm/Hz
B	292 kHz	-39 dBm/Hz
C	2.92 MHz	-119 dBm/Hz
D	30 MHz	-119 dBm/Hz

Table 11: **Break points of the PSD mask in figure 8**

7.3.2.5. Narrow-band signal power

The average power ***P*** of a category 3b sending signal into a resistive load ***R***, within a bandwidth ***B*** centred at any point in the frequency range 100 Hz to 30 MHz, shall not exceed the limits given in table 12. This table specifies the break points of the limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. These limits are frequency independent between 100 Hz to 292 kHz, and decrease with 24 dB/octave (80 dB/decade) above 292 kHz.
Reference: These numbers have been reconstructed from PSD requirements in ETSI-ETR152 [9,10].

Points	frequency f	Impedance R	Sending level P	Bandwidth B	P/B
A	0.1 kHz	135Ω	-9 dBm	1 kHz	-39 dBm/Hz
B	292 kHz	135Ω	-9 dBm	1 kHz	-39 dBm/Hz
C	2.92 MHz	135Ω	-89 dBm	1 kHz	-119 dBm/Hz
D	30 MHz	135Ω	-89 dBm	1 kHz	-119 dBm/Hz

Table 12: **Break points of the narrow-band power limits.**

7.3.3. Category 3c: "HDSL.CAP/2" (2 Mb/s leased lines)

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

7.3.3.1. Unbalance about earth

The (LCL) longitudinal conversion loss is given by: LCL = 20 log (e_L/e_M) [dB] where e_L is the applied longitudinal voltage referenced to the building ground and e_M is the resultant metallic voltage appearing across a 135 Ω termination. The LCL of the system shall meet the requirement of: -50 dB between 5 kHz and 485 kHz for a 1160 kbaud system as shown in fig 9.
Reference [9,10]: ***[ETR152: 5.8.5.1]***

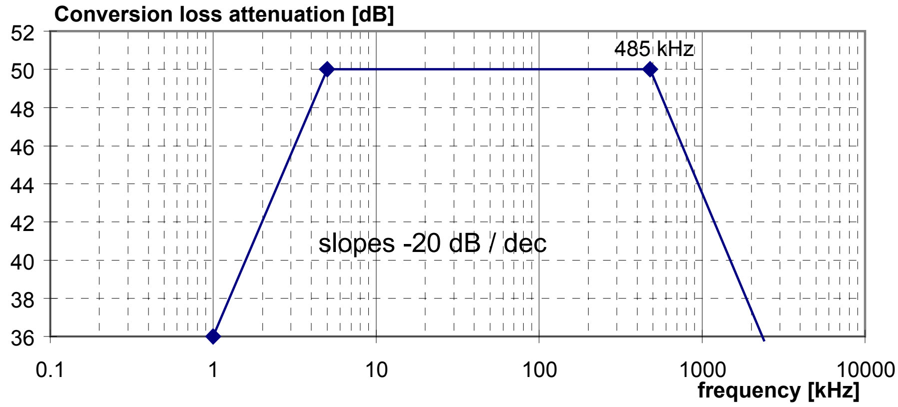


Figure 9: *Minimum longitudinal conversion loss.*

7.3.3.2. Total signal power

The average power of a sending signal shall not exceed a level of 13.5 dBm (± 0.5 dBm), over the frequency band from 0 Hz to 1 MHz.
Reference [9,10]: ***[ETR152: B.5.8.4.1.1]***

7.3.3.3. Peak amplitude

The nominal peak of the largest pulse shall be 2,64 V (±7%) into a resistive load of 135Ω.
(no ETSI reference)

7.3.3.4. Power spectral density (PSD)

The single sided power spectral density of the sending signal shall not exceed a level of P_0=–40 dBm/Hz (± 1,5 dBm) at any frequency. The upper bound of this PSD shall be as shown in figure 10. Table 13 specifies the break points of this figure. The signal power spectral density in the frequency band below f_1=3.98 kHz shall be at least 17 dB below the nominal signal power density in the pass band.
Measurements to verify compliance with this requirement shall use a noise power bandwidth of 1 kHz (and a resistive load of 135Ω).
Reference [9,10]: ***[ETR152: B.5.8.4.2]***

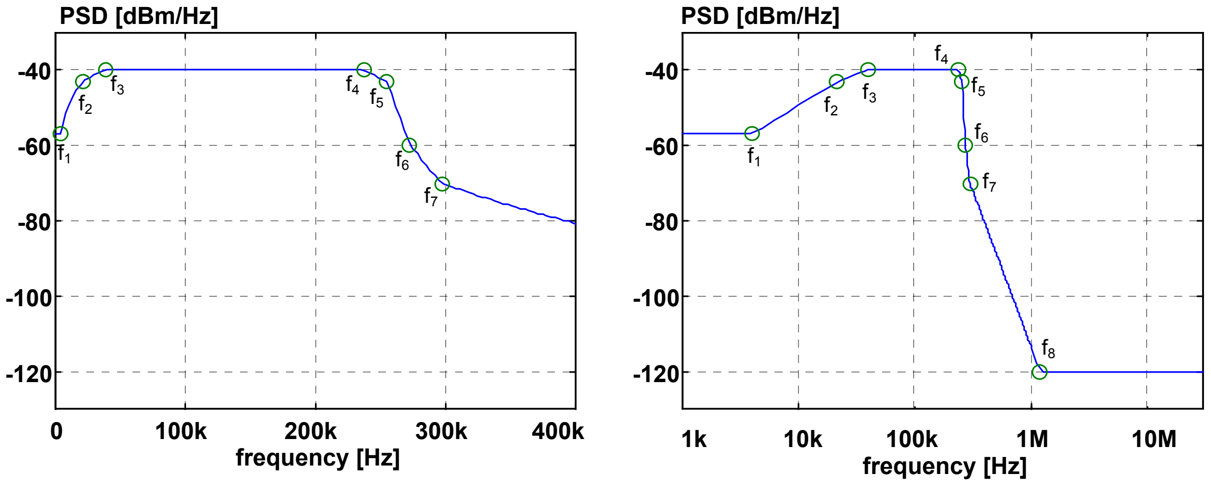


Figure 10: ***Upper bound of the average power spectral density of category 3b equipment.***

Points	Frequency	PSD P_0 = -40 dBm/Hz	
f0	0.1 kHz	P_0-17 dBm/Hz	± 3,0 dB
f1	3.98 kHz	P_0-17 dBm/Hz	± 3,0 dB
f2	21.50 kHz	P_0-3 dBm/Hz	± 1 dB
f3	39.02 kHz	P_0 dBm/Hz	
f4	237.58 kHz	P_0 dBm/Hz	
f5	255.10 kHz	P_0-3 dBm/Hz	± 1 dB
f6	272.62 kHz	P_0-20 dBm/Hz	± 3,0 dB
f7	297.00 kHz	P_0-30 dBm/Hz	
f8	1200.00 kHz	-120 dBm/Hz	
f9	30000.00 kHz	-120 dBm/Hz	

Table 13*: Break frequencies of the spectral mask in figure 10.*

7.3.3.5. Narrow-band signal power

The average power ***P*** of a category 3a sending signal into a resistive load ***R***, within a bandwidth ***B*** centred at any point in the frequency range 100 Hz to 30 MHz, shall not exceed the limits given in table 14. This table specifies the break points of the limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale. *Reference: These numbers have been reconstructed from PSD requirements in ETSI-ETR152 [9,10].*

Points	frequency f	Impedance R	Sending level P	Bandwidth B	P/B	
f0	0.1 kHz	135Ω	–27 dBm	1 kHz	–57 dBm/Hz	± 3,0 dB
f1	3.98 kHz	135Ω	–27 dBm	1 kHz	–57 dBm/Hz	± 3,0 dB
f2	21.50 kHz	135Ω	–13 dBm	1 kHz	–43 dBm/Hz	± 1 dB
f3	39.02 kHz	135Ω	–10 dBm	1 kHz	–40 dBm/Hz	
f4	237.58 kHz	135Ω	–10 dBm	1 kHz	–40 dBm/Hz	
f5	255.10 kHz	135Ω	–13 dBm	1 kHz	–43 dBm/Hz	± 1 dB
f6	272.62 kHz	135Ω	–30 dBm	1 kHz	–60 dBm/Hz	± 3,0 dB
f7	297.00 kHz	135Ω	–40 dBm	1 kHz	–70 dBm/Hz	
f8	1200.00 kHz	135Ω	–90 dBm	1 kHz	–120 dBm/Hz	
f9	30000.00 kHz	135Ω	–90 dBm	1 kHz	–120 dBm/Hz	

Table 14: ***Break points of the narrow-band power limits.***

7.3.4. Category 3d: "SDSL"

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

Reference [19]: ***ETSI WG TM6(98)9, Rev. 1, living list***

7.3.4.1. Unbalance about earth
<For further study>

7.3.4.2. Total signal power
<For further study>

7.3.4.3. Peak amplitude
<For further study>

7.3.4.4. Power spectral density (PSD)
<For further study>

7.3.4.5. Narrow-band signal power
<For further study>

7.3.4.6. Feeding Power (from the LT-port)
<For further study>

7.4. Cluster 4 transmission equipment (asymmetrical broadband)

This cluster is intended for transmission equipment up to about 8Mb/s on a single wire-pair, combined with POTS or ISDN services on the same wire-pair. The service is expected to be asymmetrically, which means a higher bit rate in the downstream direction and a significantly lower bitrate (e.g. 20%) in the upstream direction.

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

7.4.1. Category 4a: "ADSL over POTS" (Echo cancelled with POTS window)

This category covers ADSL transmission equipment on a single wire-pair, that can coexist with a POTS service on the same wire-pair. This sub clause is based on ETSI [11] and ANSI [13,14] reports on ADSL.
Its a technology, that leaves the signal spectrum unused from DC to about 25 kHz, to enable a simultaneously delivery of ADSL based services and POTS based services on the same wire-pair.

7.4.1.1. Downstream unbalance about earth

Longitudinal balance of equipment connected to the LT-port shall be > 40 dB over the frequency range 30 kHz to 1104 kHz and >30 dB over 300 Hz to 30 MHz, whichever is the highest demand. The modem shall meet this requirement both, switched on and off.
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 12.3.1 (extended to 30 MHz) and E.3.2.*

7.4.1.2. Downstream total signal power

The aggregate transmit power of a sending downstream signal shall not exceed a level of 20.4 dBm into 100Ω, over the frequency band from 4 kHz to 3 MHz.
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 6.15.1*

If measurement of the upstream power indicates that downstream power back-off is necessary, as described for the downstream PSD, then the aggregate transmit power shall be reduced accordingly.
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 6.15.1*
<Details are for further study>

The aggregate transmit power of a sending downstream signal shall not exceed a level of –61.5 dBm into 600Ω, over the frequency band from 0 to 4 kHz.

7.4.1.3. Downstream peak amplitude

The nominal peak of the largest pulse shall be 7.5 V into a resistive load of 100Ω.
(no ETSI reference)

7.4.1.4. Downstream power spectral density (PSD)

The ***nominal PSD*** in the band from 25.875 to 1104 kHz shall be set at –40 dBm/Hz into 100Ω. If measurement of the upstream power indicates that power cut-back is necessary, then the nominal PSD shall be set at –42, –44, –46, –48, –50, or –52 dBm/Hz (i.e., the nominal PSD is (–40–2 ×n) dBm/Hz with n = (0 to 6).
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 6.15.1*

Power back-off. If the total received upstream power from 28.035 to 79.791 kHz (ADSL sub-carriers 7–18) is greater than 3 dBm, then the nominal downstream PSD shall not exceed the values shown below. 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
Max downstream PSD (dBm/Hz)	–40	–42	–44	–46	–48	–50	–52

*Reference [14]: [**ANSI-T1.413, issue 2]** clause 9.4.6*

The pass band ***ripple*** during steady-state shall be no greater than +3.5 dB; the maximum PSD of (–40 – 2n + 3.5) dBm/Hz applies across the whole pass band. The transmit PSD within the 25.875 kHz to 1104 kHz pass band shall therefore be no greater than –36.5 dBm/Hz into 100Ω, reduced by power cut-back in multiples of 2 dB.
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 6.14.1*

The single sided power spectral density of the sending signal shall not exceed the values shown in figure 12 and table 15. 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.
All PSD measurements above 4kHz are in 100 Ω. Above 25.875 kHz, the peak PSD shall be measured with a 10 kHz resolution bandwidth.
See also the additional sliding window requirements, as specified in table 16 . The dashed lines in figure 12 indicate the resulting narrow band signal power in 1 MHz, divided by the measurement bandwidth of 1 MHz.
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 6.14*

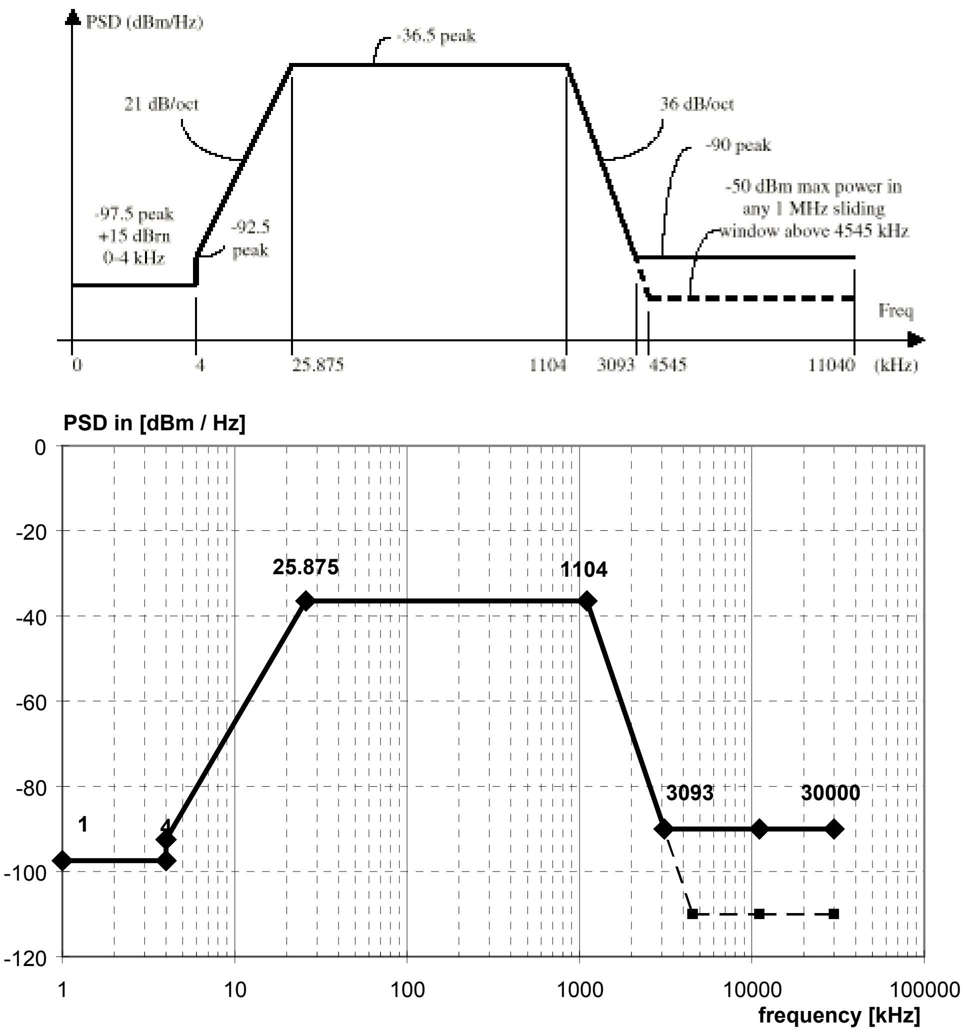


Figure 12: Upper bound of the downstream spectral density of ADSL over POTS

Points	Frequency	Impedance Ω	PSD [dBm / Hz]
F0	0	600	-97.5
F1	4 kHz	600	-97.5
F2	4 kHz	100	-92.5
F3	25.875 kHz	100	-36.5
F4	1.104 MHz	100	-36.5
F5	3.093 MHz	100	-90
F6	11.040 MHz	100	-90
F7	30 MHz	100	-90

Table 15: *Break points of the upper bound of the downstream spectral density of ADSL over POTS*

7.4.1.5. Downstream narrow-band signal power

The average power ***P*** of a category 4a sending downstream signal into a resistive load ***R***, within a bandwidth ***B***, centred at any point in the frequency range 100 Hz to 30 MHz, shall not exceed the limits given in table 16. 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.

Table 16 is reconstructed from the PSD requirements, as defined in figure 12 and table 15. Measurements to verify compliance with this requirement above 4 kHz shall use a bandwidth of 10 kHz. Above 3 MHz, an additional sliding window requirement shall be met, with 1MHz resolution bandwidth. At all frequencies above 3 MHz, the transmit downstream power in the [f, f + 1 MHz] window shall not exceed -50 dBm. This is to perform a higher bandwidth measurement in order to make sure that different systems do not fill the entire allowable bandwidth with noise up to the PSD limit shown in figure 12. The dashed line in figure 12 indicate the resulting narrow band signal power in 1 MHz, divided by the measurement bandwidth of 1 MHz. This sliding window approach is defined in section 4.12.
*Reference [14]: **[ANSI-T1.413, issue 2]** clause 6.14*

Points	Frequency f	Impedance R	Sending level P	Bandwidth B	P/B
F0	0	600Ω	–67.5 dBm	1 kHz	–97.5 dBm/Hz
F1	4 kHz	600Ω	–67.5 dBm	1 kHz	–97.5 dBm/Hz
F1	4 kHz	100Ω	–52.5 dBm	10 kHz	–92.5 dBm/Hz
F2	25.875 kHz	100Ω	+3.5 dBm	10 kHz	–36.5 dBm/Hz
F3	1.104 MHz	100Ω	+3.5 dBm	10 kHz	–36.5 dBm/Hz
F4	3.093 MHz	100Ω	–50 dBm	10 kHz	–90 dBm/Hz
F4	3.093 MHz	100Ω	–30 dBm	1 MHz	–90 dBm/Hz
F5	4.545 MHz	100Ω	–50 dBm	1 MHz	–110 dBm/Hz
F6	11.040 MHz	100Ω	–50 dBm	1 MHz	–110 dBm/Hz
F7	30 MHz	100Ω	–50 dBm	1 MHz	–110 dBm/Hz

Table 16*: Downstream narrow band signal powers. The power in a 1 MHz sliding window is measured in 1 MHz bandwidth, starting at the measurement frequency, (F4) and in the [f, f+1MHz] window.*

7.4.1.6. Upstream unbalance about earth

Longitudinal balance of equipment connected to the NT-port shall be > 40 dB over the frequency range 30 kHz to 1104 kHz and >30 dB over 300 Hz to 30 MHz, whichever is the highest demand. The modem shall meet this requirement both, switched on and off.
*Reference [14]: **[ANSI-T1.413, issue 2]** clause 12.3.1 (extended to 30 MHz) and E.3.2.*

7.4.1.7. Upstream total signal power

The aggregate transmit power of a sending upstream signal shall not exceed a level of 12.5 dBm into 100Ω, over the frequency band from 4 kHz to 3 MHz.
*Reference [14]: **[ANSI-T1.413, issue 2]** clause 7.15.1*

The aggregate transmit power of a sending downstream signal shall not exceed a level of –61.5 dBm into 600Ω, over the frequency band from 0 to 4 kHz.

7.4.1.8. Upstream peak amplitude

The nominal peak of the largest pulse shall be 7.5 V into a resistive load of 100Ω.
(no ETSI reference)

7.4.1.9. Upstream power spectral density (PSD)

The ***nominal*** PSD in the band from 25 to 138 kHz shall be –38 dBm/Hz into 100Ω.
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 7.15.1*

The pass band ***ripple*** during steady state shall be no greater than +3.5 dB; the maximum PSD applies across the whole pass-band. The transmit PSD within 25.875 kHz to 138 kHz shall therefore be no greater than –34.5 dBm/Hz into 100Ω.
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 7.14.1*

The single sided power spectral density of the sending signal shall not exceed the values shown in figure 13 and table 17. 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.
All PSD measurements above 4kHz are in 100Ω. Above 25.875 kHz, the peak PSD shall be measured with a 10 kHz resolution bandwidth.
See also the additional sliding window requirements, as specified in table 18. The dashed lines in figure 13 indicate the resulting narrow band signal power in 1 MHz, divided by the measurement bandwidth of 1 MHz.
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 7.14*

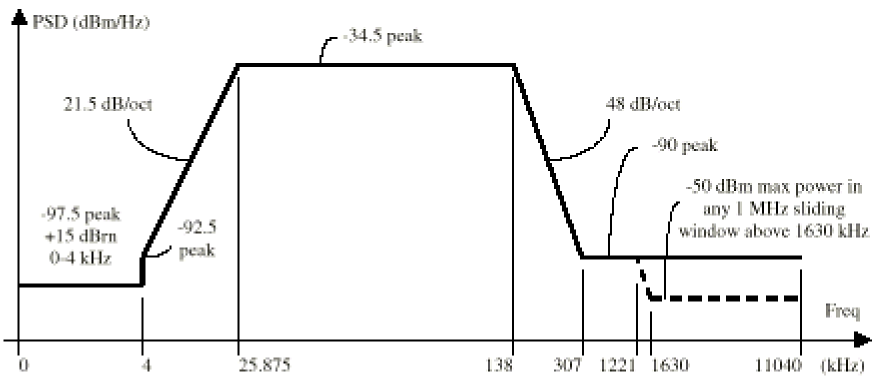


***Figure 13**: Upper bound of the upstream spectral density of ADSL over POTS*

Points	Frequency	Impedance Ω	PSD [dBm / Hz]
F0	0	600	-97.5
F1	4 kHz	600	-97.5
F2	4 kHz	100	-92.5
F3	25.875 kHz	100	-34.5
F4	138 kHz	100	-34.5
F5	307 kHz	100	-90
F6	11.040 MHz	100	-90
F7	30 MHz	100	-90

***Table 17**: Break points of the upper bound of the upstream spectral density of ADSL over POTS.*

7.4.1.10. Upstream narrow-band signal power

The average power ***P*** of a category 4a sending upstream signal into a resistive load ***R***, within a bandwidth ***B***, centred at any point in the frequency range 100 Hz to 30 MHz, shall not exceed the limits given in table 18. 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.

Table 18 is reconstructed from the PSD requirements, as defined in figure 13 and table 17. Measurements to verify compliance with this requirement above 4 kHz shall use a bandwidth of 10 kHz. Above 1.630 MHz, an additional sliding window requirement shall be met, with 1MHz resolution bandwidth. At all frequencies above 1.630 MHz, the transmit upstream power in the [f, f + 1 MHz] window shall not exceed -50 dBm. This is to perform a higher bandwidth measurement in order to make sure that different systems do not fill the entire allowable bandwidth with noise up to the PSD limit shown in figure 13. The dashed line in figure 13 indicate the resulting narrow band signal power in 1 MHz, divided by the measurement bandwidth of 1 MHz. This sliding window approach is defined in section 4.12.
*Reference [*14*]: [**ANSI-T1.413, issue 2]** clause 7.14*

Points	Frequency F	Impedance R	Sending level P	Bandwidth B	P/B
F0	0	600Ω	–67.5 dBm	1 kHz	–97.5 dBm/Hz
F1	4 kHz	600Ω	–67.5 dBm	1 kHz	–97.5 dBm/Hz
F1	4 kHz	100Ω	–52.5 dBm	10 kHz	–92.5 dBm/Hz
F2	25.875 kHz	100Ω	+5.5 dBm	10 kHz	–34.5 dBm/Hz
F3	138 kHz	100Ω	+5.5 dBm	10 kHz	–34.5 dBm/Hz
F4	307 MHz	100Ω	–50 dBm	10 kHz	–90 dBm/Hz
F5	1.221 MHz	100Ω	–50 dBm	10 kHz	–90 dBm/Hz
F5	1.221 MHz	100Ω	–30 dBm	1 MHz	–90 dBm/Hz
F6	1.630 MHz	100Ω	–50 dBm	1 MHz	–110 dBm/Hz
F7	11.040 MHz	100Ω	–50 dBm	1 MHz	–110 dBm/Hz
F8	30 MHz	100Ω	–50 dBm	1 MHz	–110 dBm/Hz

Table 18*: Upstream narrow band signal powers. The power in a 1 MHz sliding window is measured in 1 MHz bandwidth, starting at the measurement frequency, (F4) and in the [f, f+1MHz] window.*

7.4.2. Category 4b: "ADSL over ISDN" (Echo cancelled with ISDN window)

This category covers ADSL transmission equipment on a single wire-pair, which can coexist with a POTS or ISDN service on the same wire-pair. This sub clause is based on ETSI-TM6 studies on ADSL. over ISDN.
Its a modified version for ADSL over POTS, that leaves the signal spectrum unused from DC to about 138 kHz, to enable a simultaneously delivery of ADSL based services and ISDN based services on the same wire-pair.

7.4.2.1. Downstream unbalance about earth

Longitudinal balance of equipment connected to the LT-port shall be > 40 dB over the frequency range 30 kHz to 1104 kHz and >30 dB over 300 Hz to 30 MHz, whichever is the highest demand. The modem shall meet this requirement both, switched on and off.
*Reference [*14*]: [**ANSI-T1.413, issue 2]** clause 12.3.1 (extended to 30 MHz) and E.3.2.*

7.4.2.2. Downstream total signal power

The aggregate transmit power of a sending downstream signal shall not exceed a level of 19.83 dBm into 100 Ω, over the frequency band from 50 kHz to 3 MHz.
*Reference [12]: **[ETSI TS 101 388]** clause 5.2*

If measurement of the upstream power indicates that downstream power back-off is necessary, as described for the downstream PSD, then the aggregate transmit power shall be reduced accordingly.
<Details are for further study>

The aggregate transmit power of a sending downstream signal shall not exceed a level –48.5 dBm into 600Ω, over the frequency band from 0 to 80 kHz.

7.4.2.3. Downstream peak amplitude

The nominal peak of the largest pulse shall be 7.5 V into a resistive load of 100Ω.
(no ETSI reference)

7.4.2.4. Downstream power spectral density (PSD)

The ***nominal PSD*** in the band from 50 to 1104 kHz shall be set at –40 dBm/Hz into 100Ω. If measurement of the upstream power indicates that power cut-back is necessary, then the nominal PSD shall be set at –42, –44, –46, –48, –50, or –52 dBm/Hz (i.e., the nominal PSD is (–40–2 ×n) dBm/Hz with n = (0 to 6).
Reference [12]: ***[ETSI TS 101 388]*** *clause 5.4 extended to 30 MHz*
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 6.15.1*

Power back-off. If the total received upstream power from 140.156 to 191.906 kHz (ADSL sub-carriers 33-44) is greater than 0 dBm, then the nominal downstream PSD shall not exceed the values shown below. 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	< 5.5	< 6.5	< 7.5
Max downstream PSD (dBm/Hz)	–40	–42	–44	–46	–48	–50	–52

*No reference, but calculated by insertion loss scaling from reference [14]: [**ANSI-T1.413, issue 2]** clause 9.4.6*
<For further study>

The pass band ***ripple*** during steady-state shall be no greater than +3.5 dB; the maximum PSD of (–40 – 2n + 3.5) dBm/Hz applies across the whole pass band. The transmit PSD within the 50 kHz to 1104 kHz pass band shall therefore be no greater than –36.5 dBm/Hz into 100Ω, reduced by power cut-back in multiples of 2 dB.
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 6.14.1*

The single sided power spectral density of the sending signal shall not exceed the values shown in figure 14 and table 19. 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.
All PSD measurements above 4kHz are in 100Ω. Above 50 kHz, the peak PSD shall be measured with a 10 kHz resolution bandwidth.
See also the additional sliding window requirements, as specified in table 20. The dashed lines in figure 14 indicate the resulting narrow band signal power in 1 MHz, divided by the measurement bandwidth of 1 MHz.
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 6.14*

Transmitter PSD masks that reduce the spectral overlap between upstream and downstream signals are ***for further study***. Their purpose is to reduce the NEXT.
*Reference [14]: [**ANSI-T1.413, issue 2]** Annex F.*

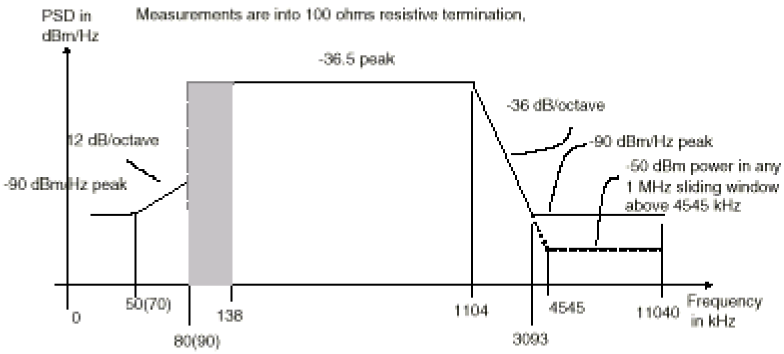


Figure 14*: Upper bound of the downstream spectral density of ADSL over ISDN*

Points	Frequency	Impedance Ω	PSD [dBm / Hz]
F0 F1	0 50 kHz	600 600	–90 –90
F1 F2	50 kHz 80 kHz	100 100	–90 –81.8
F2 F3	80 kHz 138 kHz	100 100	See Note
F3 F4 F5 F6 F7	138 kHz 1.104 MHz 3.093 MHz 11.040 MHz 30 MHz	100 100 100 100 100	–36.5 –36.5 –90 –90 –90

Table 19: *Break points of the upper bound of the downstream spectral density of ADSL over ISDN.*
NOTE*: The PSD between 80 and 138 kHz is an area of further study and will be addressed by ETSI-TM6.*

7.4.2.5. Downstream narrow-band signal power

The average power ***P*** of a category 4b sending downstream signal into a resistive load ***R***, within a bandwidth ***B***, centred at any point in the frequency range 100 Hz to 30 MHz, shall not exceed the limits given in table 20. 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.

Table 20 is reconstructed from the PSD requirements, as defined in figure 14 and table 19. Measurements to verify compliance with this requirement above 4 kHz shall use a bandwidth of 10 kHz. Above 3 MHz, an additional sliding window requirement shall be met, with 1MHz resolution bandwidth. At all frequencies above 3 MHz, the transmit downstream power in the [f, f + 1 MHz] window shall not exceed -50 dBm. This is to perform a higher bandwidth measurement in order to make sure that different systems do not fill the entire allowable bandwidth with noise up to the PSD limit shown in figure 14. The dashed line in figure 14 indicates the resulting narrow band signal power in 1 MHz, divided by the measurement bandwidth of 1 MHz. This sliding window approach is defined in section 4.12.
Reference [12]: ***[ETSI TS 101 388],*** *clause 5.4 extended to 30 MHz*

Points	**Frequency f**	**Impedance R**	**Sending level P**	**Bandwidth B**	**P/B**
F0	0	600Ω	–60 dBm	1 kHz	–90 dBm/Hz
F1	50 kHz	600Ω	–60 dBm	1 kHz	–90 dBm/Hz
F1	50 kHz	100Ω	–50.0 dBm	10 kHz	–90 dBm/Hz
F2	80 kHz	100Ω	–42.2 dBm	10 kHz	–81.8 dBm/Hz
F2	80 kHz	100Ω	See	10 kHz	See
F3	138 kHz	100Ω	note	10 kHz	note
F3	138 kHz	100Ω	+3.5 dBm	10 kHz	–36.5 dBm/Hz
F4	1.104 MHz	100Ω	+3.5 dBm	10 kHz	–36.5 dBm/Hz
F5	3.093 MHz	100Ω	–50 dBm	10 kHz	–90 dBm/Hz
F5	3.093 MHz	100Ω	–30 dBm	1 MHz	–90 dBm/Hz
F6	4.545 MHz	100Ω	–50 dBm	1 MHz	–110 dBm/Hz
F7	11.040 MHz	100Ω	–50 dBm	1 MHz	–110 dBm/Hz
F8	30 MHz	100Ω	–50 dBm	1 MHz	–110 dBm/Hz

***Table 20**: Downstream narrow band signal powers. The power in a 1 MHz sliding window is measured in 1 MHz bandwidth, starting at the measurement frequency, (F4) and in the [f, f+1MHz] window.*
NOTE: The narrow band power between 80 and 138 kHz is an area of further study and will be addressed by ETSI-TM6.

7.4.2.6. Upstream unbalance about earth
Longitudinal balance of equipment connected to the LT-port shall be > 40 dB over the frequency range 30 kHz to 1104 kHz and >30 dB over 300 Hz to 30 MHz, whichever is the highest demand. The modem shall meet this requirement both, switched on and off.
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 12.3.1 (extended to 30 MHz) and E.3.2.*

7.4.2.7. Upstream total signal power
The aggregate transmit power of a sending upstream signal shall not exceed a level of 13.26 dBm into 100Ω, over the frequency band from 4 kHz to 3 MHz.
*Reference [12]: **[ETSI TS 101 388]** clause 6.3*

7.4.2.8. Upstream peak amplitude
The nominal peak of the largest pulse shall be 7.5 V into a resistive load of 100Ω.
(no ETSI reference)

7.4.2.9. Upstream power spectral density (PSD)
The ***nominal*** PSD in the band from 25 to 138 kHz shall be –38 dBm/Hz into 100Ω.
*Reference [12]: **[ETSI TS 101 388]** clause 6.10*
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 7.15.1*

The pass band ***ripple*** during steady state shall be no greater than +3.5 dB; the maximum PSD applies across the whole pass-band. The transmit PSD within 25.875 kHz to 138 kHz shall therefore be no greater than –34.5 dBm/Hz into 100Ω.
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 7.14.1*

The single sided power spectral density of the sending signal shall not exceed the values shown in figure 15 and table 21. 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.
All PSD measurements above 4kHz are in 100Ω. Above 50 kHz, the peak PSD shall be measured with a 10 kHz resolution bandwidth.
See also the additional sliding window requirements, as specified in table 22. The dashed lines in figure 15 indicate the resulting narrow band signal power in 1 MHz, divided by the measurement bandwidth of 1 MHz.
*Reference [14]: [**ANSI-T1.413, issue 2]** clause 7.14*

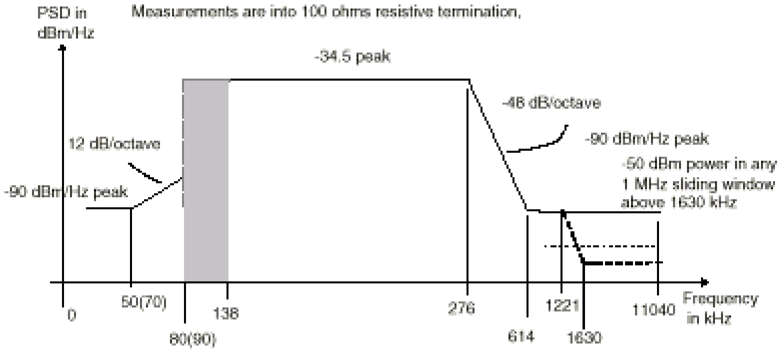


Figure 15*: Upper bound of the upstream spectral density of ADSL over ISDN*

Points	Frequency	Impedance Ω	PSD [dBm / Hz]
F0 F1	0 50 kHz	135 135	–90 –90
F1 F2	50 kHz 80 kHz	100 100	–90.0 –81.8
F2 F3	80 kHz 138 kHz	100 100	See Note
F3 F4 F5 F6 F7	138 kHz 276 kHz 614 kHz 11.040 MHz 30 MHz	100 100 100 100 100	–34.5 –34.5 –90 –90 –90

Table 21*: Break points of the upper bound of the upstream spectral density of ADSL over ISDN.*
NOTE*: The narrow band power between 80 and 138 kHz is an area of further study and will be addressed by ETSI-TM6.*

7.4.2.10. Upstream narrow-band signal power

The average power ***P*** of a category 4b sending upstream signal into a resistive load ***R***, within a bandwidth ***B***, centred at any point in the frequency range 100 Hz to 30 MHz, shall not exceed the limits given in table 22. 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.

Table 22 is reconstructed from the PSD requirements, as defined in figure 15 and table 21. Measurements to verify compliance with this requirement above 4 kHz shall use a bandwidth of 10 kHz. Above 1.630 MHz, an additional sliding window requirement shall be met, with 1MHz resolution bandwidth. At all frequencies above 1.630 MHz, the transmit upstream power in the [f, f + 1 MHz] window shall not exceed -50 dBm. This is to perform a higher bandwidth measurement in order to make sure that different systems do not fill the entire allowable bandwidth with noise up to the PSD limit shown in figure 15. The dashed line in figure 15 indicates the resulting narrow band signal power in 1 MHz, divided by the measurement bandwidth of 1 MHz. This sliding window approach is defined in section 4.12.
*Reference [*14*]: [**ANSI-T1.413, issue 2]** clause 7.14*

Points	Frequency F	Impedance R	Sending level P	Bandwidth B	P/B
F0	0	135Ω	–60.0 dBm	1 kHz	–90 dBm/Hz
F1	50 kHz	135Ω	–60.0 dBm	1 kHz	–90 dBm/Hz
F1	50 kHz	100Ω	–50.0 dBm	10 kHz	–90 dBm/Hz
F2	80 kHz	100Ω	–41.5 dBm	10 kHz	–81.8 dBm/Hz
F2	80 kHz	100Ω	See	10 kHz	See
F3	138 kHz	100Ω	Note	10 kHz	Note
F3	138 kHz	100Ω	+5.5 dBm	10 kHz	–34.5 dBm/Hz
F4	276 kHz	100Ω	+5.5 dBm	10 kHz	–34.5 dBm/Hz
F5	614 kHz	100Ω	–50 dBm	10 kHz	–90 dBm/Hz
F6	1.221 MHz	100Ω	–50 dBm	10 kHz	–90 dBm/Hz
F6	1.221 MHz	100Ω	–30 dBm	1 MHz	–90 dBm/Hz
F7	1.630 MHz	100Ω	–50 dBm	1 MHz	–110 dBm/Hz
F8	11.040 MHz	100Ω	–50 dBm	1 MHz	–110 dBm/Hz
F9	30 MHz	100Ω	–50 dBm	1 MHz	–110 dBm/Hz

Table 22*: Upstream narrow band signal powers. The power in a 1 MHz sliding window is measured in 1 MHz bandwidth, starting at the measurement frequency, (F4) and in the [f, f+1MHz] window.*
NOTE*: The narrow band power between 80 and 138 kHz is an area of further study and will be addressed by ETSI-TM6.*

7.4.3. Category 4c: "ADSL-lite" (with POTS window)

This category covers ADSL transmission equipment on a single wire-pair, that do not necessary requires the installation of a splitter filter at the customer.

ADSL-lite is a placeholder name for a class of ADSL look-alike modems. Compatibility with other categories cannot be predicted at this moment because of the rapid changing descriptions of this category.
<For further study: Specifications are available from ITU-T G.992.2>

7.4.3.1. Downstream unbalance about earth
<For further study>

7.4.3.2. Downstream total signal power
<For further study>

7.4.3.3. Downstream peak amplitude
<For further study>

7.4.3.4. Downstream power spectral density (PSD)
<For further study>

7.4.3.5. Downstream narrow-band signal power
<For further study>

7.4.3.6. Upstream unbalance about earth
<For further study>

7.4.3.7. Upstream total signal power
<For further study>

7.4.3.8. Upstream peak amplitude
<For further study>

7.4.3.9. Upstream power spectral density (PSD)
<For further study>

7.4.3.10. Upstream narrow-band signal power
<For further study>

7.4.4. Category 4d: “ADSL.FDD over POTS” (without echo cancellation)

Transmitter PSD masks that reduce the spectral overlap between upstream and downstream signals are ***for further study***. There purpose is to reduce the NEXT.
*Reference [14]: [**ANSI-T1.413, issue 2]** Annex F.*

7.4.5. Category 4e: “ADSL.FDD over ISDN” (without echo cancellation)

Transmitter PSD masks that reduce the spectral overlap between upstream and downstream signals are ***for further study***. There purpose is to reduce the NEXT.

7.5. Cluster 5 transmission equipment (broadband 0.3..30MHz)

This category is intended for future transmission equipment up to tens of Mb/s on a single wirepair.

7.5.1. Category 5a: VDSL

This category covers VDSL transmission equipment on a single wire-pair. This is technology that can be combined with POTS or ISDN services on the same wire-pair. The service is expected to be asymmetrically or symmetrically and can cover only relatively short ranges.

VDSL is currently under study for standardisation within ETSI and ANSI. The functional requirements and various different masks for PSD limits are specified in [15], but the issue of frequency allocation hasn't been solved yet. Future updates of these Technical Requirements shall be in line with the expected requirements for category 5 equipment.

It is expected that most impairment noise that will harm VDSL signals is generated from coexistent ADSL and VDSL systems.
It is also expected that EMC aspects, such as egress of VDSL signals, will play an important role in the acceptance of new categories. The metallic shield of most underground cables will prevent most of this egress, but this shield is usually lacking in the central office, in customer end of the network or arial cables
VDSL will have the ability to notch the transmitted spectrum at (programmable) frequencies. This can avoid that VDSL interferes with dedicated radio frequencies, so the rules about these notches might become an essential part of these Technical Requirements.

A subdivision of VDSL into several categories is to be expected, to distinct between
- symmetrical versus asymetrical bitrates.
- VDSL deployed from a cabinet or from the local exchange
- PSD's with notches or not

*Reference [19]: **ETSI-TS 101 270-1 V1.1.1 (1998-04)** Part 1: Functional requirements*

8. References

<POTS & ANALOGUE>

[1] **ETSI-TBR21** "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 Technical Basis for Regulation TBR21, final draft, October 1997.

[2] **ETSI-EG 201 188** "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 ATA, final draft, Sept 1999.

[3] **ETSI-ETS300/001**, "Attachments to Public Switched Telephone Network (**PSTN**); General technical requirements for equipment connected to an analogue subscriber interface in the PSTN" ETSI, European Telecommunication Standard, Edition 4, January 1997 (in particular Chapter 4: Transmission characteristics, sub clause 4.4)

[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-ETR 152:** "Transmission and Multiplexing (TM); High bit rate Digital Subscriber Line (**HDSL**) transmission system on metallic local lines; HDSL core specification and applications for 2 048 kbit/s based access digital sections", ETSI, European Telecommunication Standard, Edition 3, December 1996

[10] **ETSI-TS 152:** "Transmission and Multiplexing (TM); High bitrate digital subscriber line (**HDSL**) transmission system on metallic local lines; HDSL core specification and applications for 2048 kbit/s based access digital sections", ETSI, European Telecommunication Standard, draft Edition 4, November 1997

<SDSL>

[*] **ETSI**

<ADSL>

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

[12] **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

[13] **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.

[14] **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)

[*] **ITU-T G.992.2**

<VDSL>

[15] **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

[16] **ANSI-T1.VDSL**: "Very high-speed Digital Subscriber Lines (**VDSL**)", ANSI, Draft Technical report, revision 12 T1E1.4/97-131R3, may 1997.
[17] **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
[18] **ETSI-TS 101 270-1 V1.1.1 (1998-04)** Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Very high speed Digital Subscriber Line (VDSL); Part 1: Functional requirements
[19] **ETSI WG TM6**, 980p09a0, Permanent Document TM6(98)9, Rev. 1, Living List for DTS/TM-06011-1

<EMC & UNBALANCE>
[20] **ITU-T Recommendations 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)
[21] **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>
[22] **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.
[23] **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.
[24] **ETSI STC TM6, TD 42** meeting, 21-25 September 1998, Vienna, Austria, 984t42a0**,** Specification of crest distribution mask for noise in performance tests.