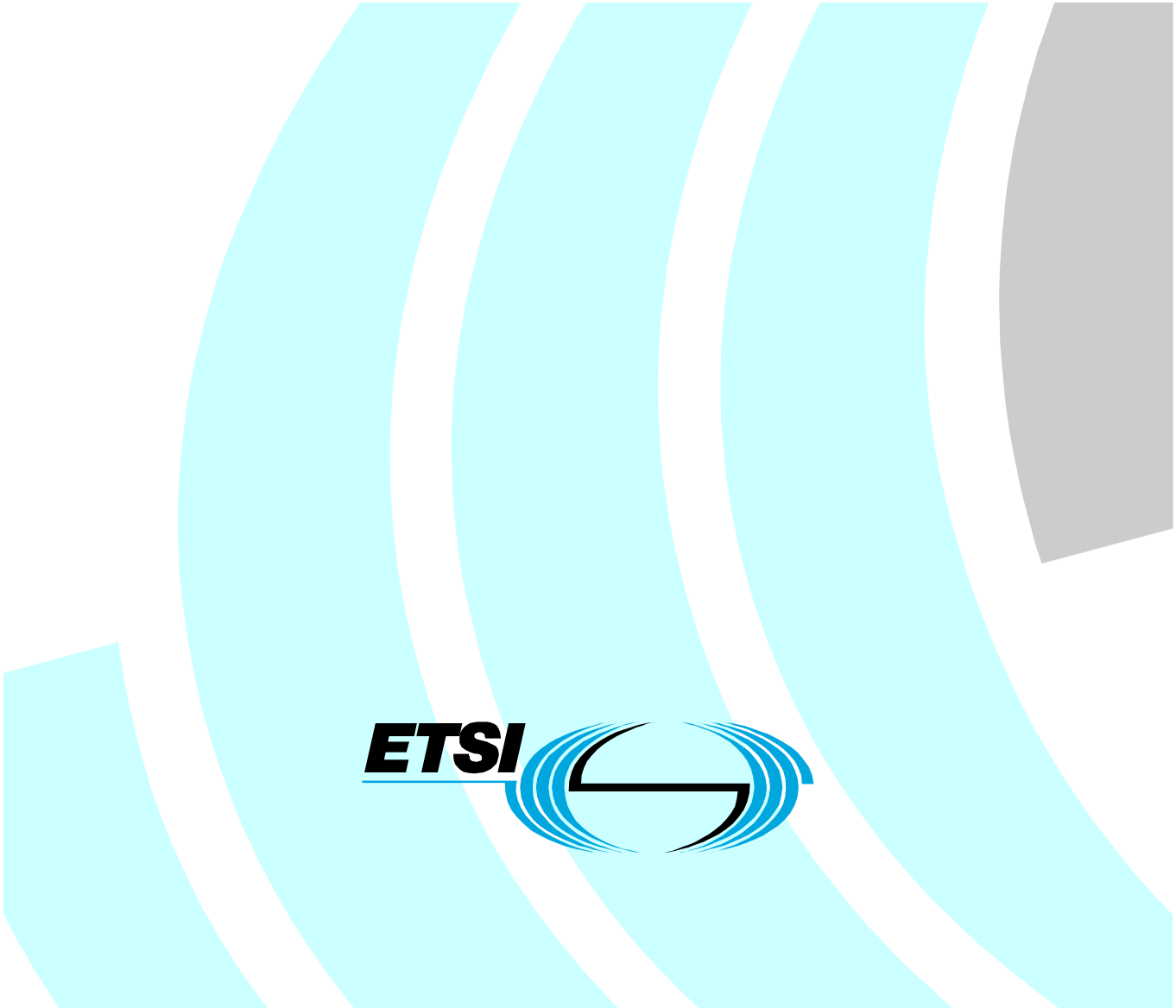
ETSI TS 101 952-1-1 V1.2.1 (2004-12)

Technical Specification

Access network xDSL transmission filters;
Part 1: ADSL splitters for European deployment;
Sub-part 1: Generic specification of the low pass part of DSL over POTS splitters
including dedicated annexes for specific xDSL variants



Reference
RTS/AT-010111-01-01

Keywords
ADSL, VDSL, POTS, splitter

ETSI

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

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

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

Contents

Intellectual Property Rights

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

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

Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Access and Terminals (AT).

The present document is part 1, sub-part 1 of a multi-part deliverable covering Access Network xDSL Transmission Filters, as identified below:

Part 1: "ADSL splitters for European deployment";

Sub-part 1:"Generic specification of the low pass part of DSL over POTS splitters including dedicated annexes for specific xDSL variants";

Sub-part 2: "Specification of the high pass part of ADSL/POTS splitters";

Sub-part 3: "Specification of ADSL/ISDN splitters";

Sub-part 4: "Specification of ADSL over "ISDN or POTS" universal splitters";

Sub-part 5: "Specification for ADSL over POTS distributed filters".

Part 2: "VDSL splitters for European deployment".

NOTE 1: The choice of a multi-part format for the present document is to facilitate maintenance and future enhancements.

NOTE 2: The sub-parts 1 and 2 must be considered together to both specify and test the low pass and the high pass parts of a splitter: Use the present document together with TS 101 952 part 1 sub-part 2 [19] and TS 101 952 part 2 sub-part 2 [20]. We also recommend to use the present document together with the documents on splitter tests TR 101 953 part 1 sub-part 1 [15] and TR 101 953 part 2 sub-part 1 [17] TR 101 953 part 1 sub-part 2 and TR 101 953 part 2 sub-part 2 (see bibliography).

NOTE 3: Before the publication of the present document, Part 1 covered splitters for ADSL, while part 2 covered splitters for VDSL. As the present document covers all DSL over POTS variants, the TS 101 952-2-1 will be made historical, as its updated content has become part of the present document. As listed above the sub-parts 2 to 5 of part 1 are still limited to ADSL, while the part 2 sub-parts 2 and 3 are limited to VDSL. However, in line with the present document, which became a generic version, it is the intention to combine the sub-parts 2 and 3 of part 1 and part 2 in generic version for all types of DSL. This work will be done by the committees TM6 and AT-A. When this is achieved, part 2 can be made historical.

The present document is fully in line with initiative "eEurope 2002 - An Information Society For All", under "The contribution of European standardization to the eEurope Initiative, A rolling Action Plan" especially under the key objective of a cheaper, faster and secure Internet.

Introduction

Remarks on and limitations of the present document

The present document is derived from a previous specification of a lowpass splitter for ADSL over POTS, applicable at the LE (i.e. network) side at the Local Exchange (LE) and at the Terminal Equipment (TE) (i.e. user) side of the line, for which there was not made any distinction in functionality and requirements at the LE and at the TE side. To make the document more generic, it is now extended for other DSL systems, such as VDSL. However, a number of limitations and remarks should be listed:

1) In the present document, the requirements are specified for the LE side splitters at the LE and for the corresponding splitter at the TE side. The requirements for splitters at the LE side, but located at the remote cabinet and for the corresponding splitters at the TE side are for further study.

2) The present document does not contain the requirements for splitters, which can handle both POTS and ISDN. These so-called ADSL over "ISDN or POTS" universal splitters are specified in a separate document.

3) The present document of the DSL over POTS splitter was gained from the experience with passive and static DSL splitters, the original state of the art for this application. Also the experience was gained with identical requirements at either side of the line. Therefore, the requirements in the present document are primarily intended for passive and static filters, with identical requirements for the LE side and the TE side of the line. A diversification between splitters requirements at either side of the line should be possible in the future.

4) Moreover, there are other classes of filters possible, besides passive and static splitters. Such active and/or dynamic filters are composed of other elements than passive components. Active splitters might require different requirements and test methods to be specified. Indeed, the dynamic behaviour of the splitter could allow the requirements to differ depending on the state of the line, e.g. requiring isolation, attenuation, rejection and insertion loss values to be adapted to the on-hook and the off-hook state of the line. This is for further study.

5) Furthermore, this version of the DSL splitter requirements is conceived for so-called ADSL EC (Echo Cancelled), which has spectra, with the upstream overlapping the downstream. However, ADSL with FDD (Frequency Division Duplexing) is often preferred as the only ADSL variant for deployment. Similarly VDSL only uses FDD. The FDD variant may allow less splitter isolation from POTS to the DSL system, in certain DSL bands where no local receiver is present, but only TX DSL signals are generated.

1 Scope

The present document specifies requirements and test methods for the low pass part of DSL over POTS splitters. These splitters are intended to be installed at the LE (i.e. network) side of the local loop, either at the local exchange or at a remote cabinet, and at the TE (i.e. user) side near the NTP. In the case of splitters at the TE side, the present document specifies the central splitter that is intended for use at the demarcation point of the customer premises. Splitters with a distributed topology, called distributed filters, are not within the scope of the present document.

The majority of requirements in the present document are generic and applicable to all DSL over POTS central splitters. In the case where any requirements are applicable to only one particular flavour of DSL, this is clearly indicated in the clause describing the requirement. The relevant information about requirements for specific DSL systems is given in annex A.

The splitter filter, as specified by the present document, may be implemented as an independent unit, separately from the DSL transceiver, or may be integrated with the DSL termination unit. The splitter may also be integrated with the base band termination unit (e.g. POTS line card), however this is outside of the scope of the present document.

2 References

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 and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

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

[1] ETSI TBR 038: "Public Switched Telephone Network (PSTN); Attachment requirements for a terminal equipment incorporating an analogue handset function capable of supporting the justified case service when connected to the analogue interface of the PSTN in Europe".

[2] ETSI TR 102 139: "Compatibility of POTS terminal equipment with xDSL systems".

[3] ITU-T Recommendation O.42: "Equipment to measure non-linear distortion using the 4-tone intermodulation method".

[4] ETSI TBR 021: "Terminal Equipment (TE); 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".

[5] ETSI TR 101 728: "Access and Terminals (AT); Study for the specification of low pass filter section of POTS/ADSL splitters".

[6] ITU-T Recommendation O.41: "Psophometer for use on telephone-type circuits".

[7] ITU-T Recommendation O.9: "Measuring arrangements to assess the degree of unbalance about earth".

[8] Void.

[9] ETSI ES 201 970: "Access and Terminals (AT); Public Switched Telephone Network (PSTN); Harmonized specification of physical and electrical characteristics at a 2-wire analogue presented Network Termination Point (NTP)".

[10] ETSI EN 300 659 (all parts): "Access and Terminals (AT); Analogue access to the Public Switched Telephone Network (PSTN); Subscriber line protocol over the local loop for display (and related) services".

[11] ETSI ES 200 778 (all parts): "Access and Terminals (AT); Analogue access to the Public Switched Telephone Network (PSTN); Protocol over the local loop for display and related services; Terminal equipment requirements".

[12] ETSI EN 300 001: "Attachments to the Public Switched Telephone Network (PSTN); General technical requirements for equipment connected to an analogue subscriber interface in the PSTN".

[13] ETSI ES 201 729: "Public Switched Telephone Network (PSTN); 2-wire analogue voice band switched interfaces; Timed break recall (register recall); Specific requirements for terminals".

[14] ETSI ES 201 187: "2-wire analogue voice band interfaces; Loop Disconnect (LD) dialling specific requirements".

[15] ETSI TR 101 953-1-1: "Access and Terminals (AT); Unified and Generic Testing Methods for European Specific DSL splitters; Part 1: ADSL splitters for European deployment; Sub-part 1: Specification of Testing methods for Low Pass part of ADSL/POTS splitters".

[16] Void.

[17] ETSI TR 101 953-2-1: "Access network xDSL transmission filters; Part 2: VDSL splitters for European deployment; Sub-part 1: Specification of Testing methods for low pass part of VDSL/POTS splitters".

[18] Void.

[19] ETSI TS 101 952-1-2: "Access network xDSL transmission filters; Part 1: ADSL splitters for European deployment; Sub-part 2: Specification of the high pass part of ADSL/POTS splitters".

[20] ETSI TS 101 952-2-2: "Access network xDSL transmission filters; Part 2: VDSL splitters for European deployment; Sub-part 2: Specification of the high pass part of VDSL/POTS splitters for use at the Local Exchange (LE) and the user side near the Network Termination Point (NTP)".

[21] Void.

[22] Void.

[23] Void

3 Definitions, symbols and abbreviations

3.1 Definitions

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

A-wire and B-wire: wires in the 2-wire local loop connection provided from the exchange to the NTP

active splitters: splitters containing some active components, including splitters with "on/off-hook detection" circuitry

distributed filter: a low pass filter that is added in series with each of the parallel connected POTS TEs

NOTE: Each of these parallel connected filters (in the in-house cabling) is known as a distributed filter. These filters are also known as In-line filters or microfilters.

far end echo: speech that is fed back to the talker in a telephony connection with a round trip delay (i.e. the delay between talking and hearing the feedback), of greater than 5 ms, resulting in a distinguishable echo

off-hook: state of the POTS equipment at either end of a loop connection when the NTP terminal equipment is in the steady loop state

NOTE: See TBR 021 [4].

on-hook: state of the POTS equipment at either end of a POTS loop connection when the NTP terminal equipment is in the quiescent state

NOTE 1: See TBR 021 [4].

NOTE 2: In the case where multiple TEs are present at the customer end of the loop, then the TE shall be considered to be on-hook from the perspective of testing the splitter only when all of terminals are on-hook.

passive splitters: splitters containing exclusively passive components

sidetone: speech that is fed back to the talker in a telephony connection with a round trip delay (i.e. the delay between talking and hearing the feedback), of less than approximately 5 ms, making it indistinguishable from the original utterance

signature network: circuitry included at the POTS port of the splitter, the values and configuration of which may be operator dependent, which has the purpose of enabling network operator's remote line testing equipment to determine the presence of a splitter on a line

3.2 Symbols

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

Att_{DSLB}	Attenuation in the DSL band (clause 6.9)
C_{DSL}	Customer DSL
f_A	lower frequency
f_H	higher frequency
f_L	lower frequency
f_{M1}	intermediate frequency
f_{M2}	intermediate frequency
f_{Max}	maximum frequency
IL_{DBOffH}	Insertion Loss DSL Band Off-Hook
IL_{PBOffH}	Insertion Loss POTS Pass Band Off-Hook
IL_{PBOnH}	Insertion Loss POTS Pass Band On-Hook
IS_{DBOnH}	Isolation DSL Band On-Hook
L_{DSL}	Line DSL
N_{DSL}	Noise in the DSL band
RL_{PBOffH}	Return Loss POTS Pass Band Off-Hook
V_{rd}	$V_{ring\text{-}drop}$
Z_{DSL}	Impedance model of the input filter of a particular DSL
Z_{OnHI}	Impedance modelling POTS On-hook with high impedance
Z_{OnLI}	Impedance modelling POTS On-hook with low impedance
Z_R	European harmonized complex reference POTS impedance
Z_{RefDSL}	Nominal Reference Design Impedance of a particular DSL
Z_{RHF}	Complex POTS impedance by extending Z_R to higher frequencies, see [2]
Z_{ring}	Impedance modelling the load represented by ringer circuits
Z_{SL}	Impedance modelling a short line terminated on 600 Ω
Z_{trip}	Impedance modelling a telephone for the transient on to off-hook

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply, indicating relevant clauses:

AC	Alternating Current
ADSL	Asymmetric Digital Subscriber Line
ADSL2	Asymmetric Digital Subscriber Line version 2, revision by ITU
ADSL2+	Asymmetric Digital Subscriber Line "Plus", revision by ITU, ADSL extended to 2,2 MHz
BW	Bandwidth
C_{DCB}	Direct Current Blocking
CLI	Caller Line Identification
CMRR	Common Mode Rejection Ratio
CO	Central Office (Local Exchange)
CP	Customer Premise
DC	Direct Current
DSL	Digital Subscriber Line
EC	Echo Cancelled
emf	Electro-Magnetic Force
F.F.S.	For Further Study
FDD	Frequency Division Duplexing
HPF	High Pass Filter
ISDN	Integrated Services Digital Network
ITU	International Telecommunication Union
LE	Local Exchange (Central Office)
NTP	Network Termination Point
POTS	Plain Old Telephone Service (used throughout instead of PSTN)
PSTN	Public Switched Telephone Network
RL	Return Loss
RMS, rms	Root Mean Square
RT	Remote Terminal
SLIC	Silicon Line Interface Circuit
TE	Terminal Equipment (e.g. Telephone, Fax, voice band modem etc.)
THD	Total Harmonic Distortion
UaE	Unbalance about Earth
VDSL	Very high speed Digital Subscriber Line

4 General functional description of DSL over POTS splitters

The main purpose of the DSL over POTS splitter is to separate the transmission of POTS signals and DSL signals, enabling the simultaneous transmission of both services on the same twisted pair. The splitter also serves to protect POTS from interference due to egress (and ingress) from DSL signals. Equally it protects the DSL transmission from transients generated primarily during POTS signalling (dialling, ringing, ring trip, etc.), and it must also prevent interference to the DSL service due to fluctuations in impedance and linearity that occur when telephones change operational state (e.g. from off-hook to on-hook). Information on various implementations of ADSL over POTS splitters is given in TR 101 728 [5]. Insertion of a splitter filter in existing POTS lines shall only have a low impact on the performance of this service.

4.1 Functional diagram

The functional diagram for the splitter combination is given in figure 1.

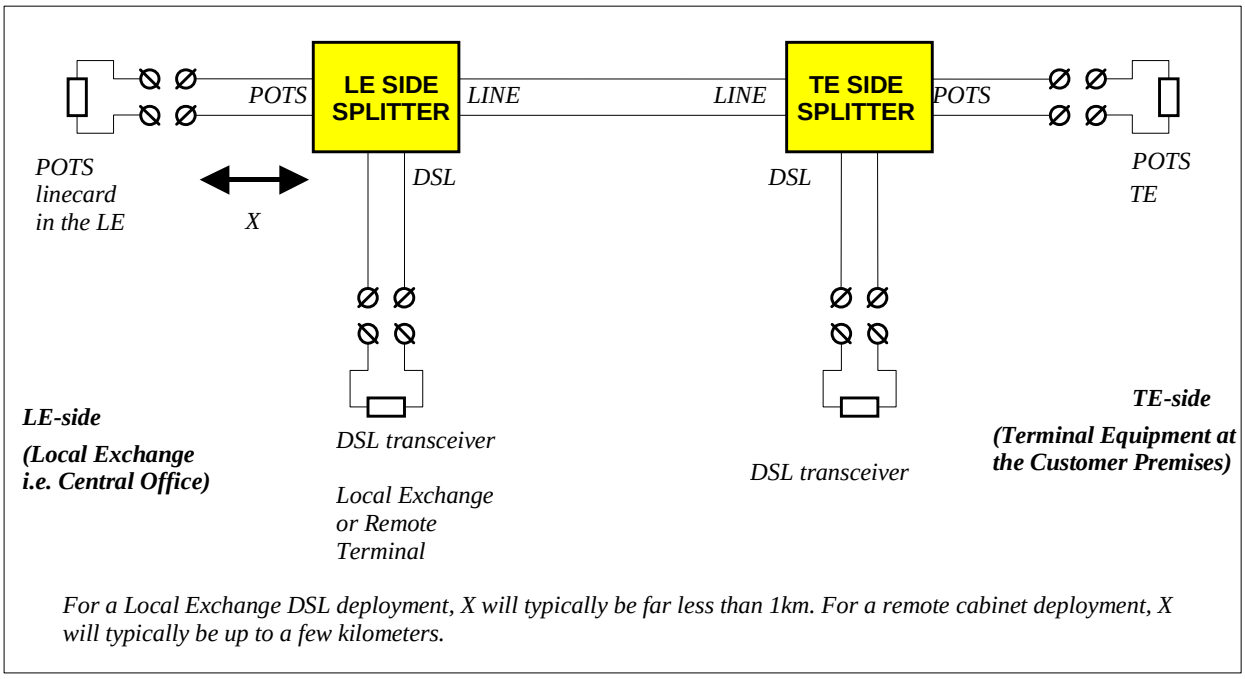


Figure 1: Functional diagram of the DSL splitter configuration

The transfer functions between the different ports of the splitter can be understood as follows:

- The transfer function from the POTS port to the LINE port and vice-versa is that of a low-pass filter.
- A high level of isolation is required from the DSL port to the POTS port to prevent undesirable interaction between the DSL transmission and any existing narrowband services, i.e. in both directions.
- The transfer function from the DSL port to the LINE port and vice-versa is either that of a high-pass filter, or it may be all pass in nature, in the case where the full high pass filter function is implemented in the DSL transceiver (see TS 101 952-1-2 [19] and TS 101 952-2-2 [20]).

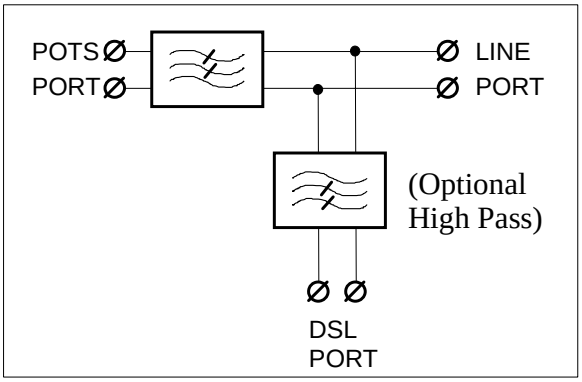


Figure 2: Structure of the DSL splitter filter

5 Testing conditions

5.1 DC testing conditions

5.1.1 Polarity independence

The splitter shall conform to all the applicable requirements of the present document for both polarities of the DC line feeding voltage and for both directions of the DC line current provided by the local exchange.

This may not apply in the case where a "signature network" is used, as this may be polarity dependant. For the definition of a signature network, see clause 3.1.

5.1.2 DC feeding conditions (on/off-hook)

The electrical requirements in the present document can be classified as follows:

- On-hook requirements, when the POTS terminal equipment is in the on-hook state.
- Off-hook requirements, when the POTS terminal equipment is in the off-hook state.
- Transitional requirements, when the POTS terminal equipment is in the transition between the on-hook and off-hook state (in either sense).

NOTE 1: These transitional requirements are for further study.

On-hook voice band electrical requirements shall be met with a DC feeding voltage of 50 V, and using the impedance model Z_{ON}, in a high impedance Z_{OnHI} and low impedance Z_{OnLI} variant as given in clauses 5.2.4 and 5.2.5 of the present document.

Additionally in certain networks there may be on-hook signalling requiring a DC loop current in the range of 0,4 mA to 2,5 mA flowing through the splitter. In this case an impedance model of Z_{OnLI} is used to terminate the LINE and POTS port of the splitter at voice frequencies.

Off-hook electrical requirements shall be met with a DC current of 13 mA to 80 mA.

NOTE 2: It is recognized that in some networks DC feeding currents in steady state up to 100 mA or higher can occur. Similarly there are networks in which the maximum DC feeding current is limited, e.g. by the SLIC. This might allow designs adapted to these specific conditions.

Testing conditions for transitional requirements are specified in clause 6.13. This clause is for further study.

5.2 AC Terminating impedances

The impedances in this clause are intended for AC only. The DC feeding conditions of the line shall be controlled separately, e.g. by inserting the appropriate DC feeding and loading bridges.

5.2.1 Z_{RefDSL} and Z_{DSL}

In many of the tests with voice frequencies, the DSL port of the low pass filter is terminated with impedances called Z_{RefDSL} and Z_{DSL}. Z_{RefDSL} is the nominal design impedance of the DSL system and Z_{DSL} is an impedance model representing the input impedance of the DSL transceiver (with the HPF), as seen from the low pass filter.

Both these substitute circuits, Z_{RefDSL} and Z_{DSL} are models, which shall be applied to a POTS splitter when verifying requirements of the low pass filter. These models are intended for splitter specification in the context of the present document. The purpose of these model impedances is for splitter specification; it is not a requirement on the input impedance of the DSL transceiver.

Depending on the type of DSL involved, different values of Z_{RefDSL} and Z_{DSL} are applicable. They are given in clause A.1.1.

5.2.2 Z_R and Z_{SL}

For most requirements relating to voice band frequencies described in the present document, either the terminating impedances Z_R or Z_{SL} are used to terminate the POTS port or the Line port. Z_R is the European harmonized complex impedance as defined in ETSI ES 201 970 [9] and ETSI TBR 21 [4] and is shown in figure 3; Z_{SL} is an impedance used in TBR 038 [1] to simulate a short line terminated in 600 Ω and is shown in figure 4.

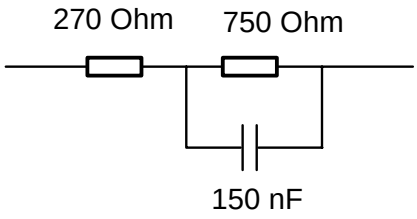


Figure 3: Impedance Z_R

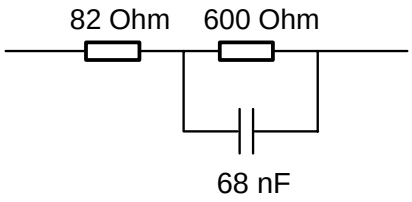


Figure 4: Impedance Z_{SL}

NOTE: In the case of splitters to be deployed in some networks, alternative models of reference impedances instead of Z_R are currently used when matching the splitter requirements.

5.2.3 Z_{RHF}

For requirements relating to DSL frequencies described in the present document, the terminating impedance Z_{RHF} is used to terminate POTS and line ports of the low pass filter. This is the European harmonized complex impedance Z_R with the modification proposed in TR 102 139 [2]. This network is shown in figure 5.

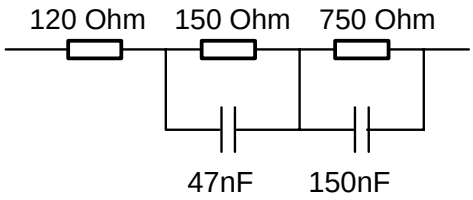


Figure 5: Impedance Z_{RHF}

5.2.4 Z_{OnHI}

For some on-hook requirements as defined in clause 5.1.2 in the present document, the terminating impedance is assumed to have a high impedance value and Z_{OnHI} is used.

Actual impedances will vary greatly especially over the DSL frequency range and thus the impedance model adopted here is just intended for the verification of splitters. It is not intended to be an equivalent circuit for a POTS TE.

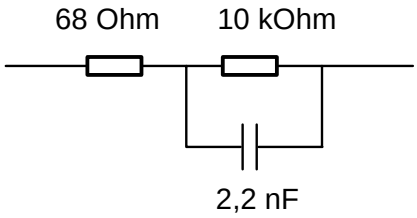


Figure 6: Impedance Z_{OnHI}

5.2.5 Z_{OnLI}

For some on-hook requirements, as defined in clause 5.1.2 in the present document, the terminating impedance is assumed to be a low AC impedance in the voice band and Z_{OnLI} is used.

Actual impedances can vary greatly and thus the impedance model adopted here is just intended for the verification of splitters. Z_{OnLI} shall be 600 Ω.

5.2.6 Z_{ring}

For some on-hook requirements in the presence of ringing signals, as defined in clause 6.3 in the present document, the terminating POTS impedance Z_{ring} is used, modelling the terminal equipment on-hook. This impedance represents the minimum ringing load of the customer premises equipment that any network is assumed to be able to support. The Z_{ring} impedance is dependent on the ringing frequency. The following applies:

- A ringing frequency of 25 Hz implies Z_{ring} = 2,7 kΩ + 2,2 µF.
- A ringing frequency of 50 Hz implies Z_{ring} = 2,7 kΩ + 1,0 µF.

5.2.7 Z_{trip}

NOTE: This POTS impedance is to be used for the on-hook to off-hook transient tests, which are addressed in clause 6.13. The value is under study. In the older version of the transient test, which is kept in annex B for information only, the phone was modelled as a short circuit. This is clearly not a realistic value.

5.3 General transmission test set-up

For many of the transmission related tests that are specified in the present document, a common general test set-up is valid. This test set-up is given in figures 7 and 8, for measurements at the LINE port and POTS port respectively.

These measurements are done with the switch S either open or closed, i.e. with the DSL impedance absent or present.

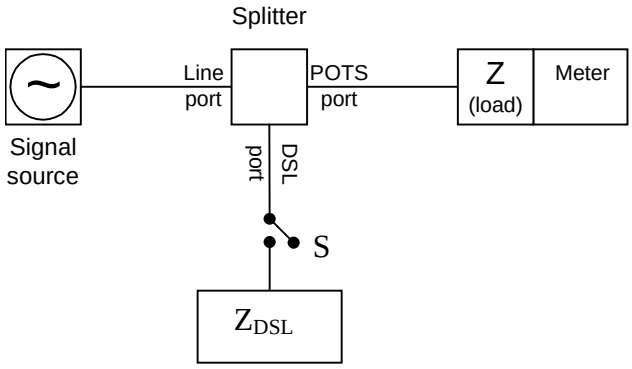


Figure 7: Test set up for transmission testing from LINE to POTS

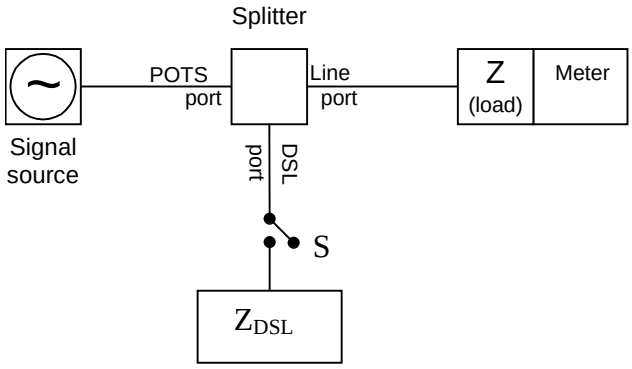


Figure 8: Test set up for transmission testing from POTS to LINE

Furthermore, other transmission related tests require generating a signal at the POTS port, but measuring at the DSL port or generating a signal at the DSL port and measuring at the POTS port.

Finally some transmission related tests require a signal to be generated at the DSL port and measured at the Line port and for a signal to be generated at the Line port and measured at the DSL port. It would appear that these last two tests are testing the high pass part of the splitter. However, these tests performed via the high pass filter must be done in the presence of the low pass filter, to prove that this low pass filter does not affect the DSL signals unnecessarily, i.e. does not attenuate, distort or add noise.

In all cases in which signal is injected or measured at the DSL port, the switch S in figures 7 and 8 will be closed.

NOTE: In a splitter without a series high pass filter, the line port and the DSL port are galvanicly coupled and electrically the same.

6 Splitter requirements

6.1 Options for splitter requirements

The electrical requirements in the present document are divided into two categories, option A and option B. In a practical sense, the requirements for Option A and Option B are identical with the exception of two clauses: clause 6.6 specifying pass band return loss requirements in the off-hook state, and clause 6.9.2 concerning off-hook isolation.

Although one of the purposes of the present document is to present a harmonized set of requirements for European networks, it has become apparent during the development of the present document that the relative importance of certain key requirements varies considerably between networks in Europe. For this reason it is felt necessary to define two options for the splitter. These can be broadly considered as in clauses 6.1.1 and 6.1.2.

6.1.1 Option A splitters

NOTE: Option A is appropriate for networks where the terminals and LE variants have several different reference impedance values (e.g. 600 Ω, harmonized European reference impedance Z_R and other complex impedances), and one single reference impedance is insufficient to accommodate the needs of all terminals and LE variants. Option A splitters have the potential for increased degradation of POTS service when compared to Option B splitters.

- Option A splitters will meet return loss requirements for two reference impedances, which is appropriate for networks where the population of existing terminals or network presentations includes equipment designed against several different reference impedance values.
- Conversely, this option assumes that potential sidetone and far end echo effects can be adequately accounted for with relatively moderate return loss requirements.

- In addition option A splitters are considered to be appropriate to networks where concerns of potential interference between services (e.g. audible DSL interference to the POTS service) necessitate very high levels of isolation.

6.1.2 Option B splitters

NOTE: Option B is appropriate for networks that have one single reference impedance for all terminals and local exchanges.

- Option B splitters are considered to be appropriate to networks where concerns of sidetone and far end echo effects motivate a very high return loss requirement.
- Additionally, this return loss requirement is only valid for one reference impedance, and thus option B splitters are appropriate for networks for which it is felt that one single reference impedance is sufficient to accommodate the needs of all terminals and network presentations.
- Conversely, this option assumes that potential interference between services can be adequately accounted for with relatively low isolation requirements.

6.2 DC requirements

6.2.1 DC resistance to earth

The DC resistance between each terminal (i.e. A-wire and B-wire) of the splitter and earth, when tested with 100 V DC, shall not be less than 20 MΩ.

This requirement only applies to splitters with a terminal directly connected to earth.

6.2.2 DC insulation resistance between A-wire and B-wire

The DC resistance between the A-wire and B-wire at both the LINE and POTS port of the splitter, when tested with 100 V DC, shall not be less than 5 MΩ.

In the case where the splitter is fitted with a signature network, measurement of the DC isolation resistance becomes more difficult. Possible solutions include a switching system in order to open circuit the signature network for the measurement, or indeed performing the measurement before the signature network is added to the splitter card. It is left to the individual operator to determine how this measurement should be carried out. Depending on the particular test methodology used, the requirement shall be set accordingly.

6.2.3 DC series resistance R_{DC}

The DC resistance between the A-wire to the B-wire at the LINE port with the POTS port shorted, or at the POTS port with the LINE port shorted shall be less than or equal to R_{DC} values specified in the tables A.2 and A.3 in annex A for each specific DSL system.

This requirement shall be met for the feeding conditions described in clause 5.1.2 for both on and off-hook conditions.

6.2.4 DC signalling

The PSTN line typically may, according ES 201 970 [9], have 38 V to 78 V DC powering the analogue TE. When the POTS terminal is off-hook, the voltage appearing across the splitter ports will normally be lower depending on the characteristics of the terminal and the line length.

The splitter shall not significantly affect any PSTN DC signalling in such a manner that would prevent it from performing its intended function.

The following DC signalling methods are commonly used:

- Register recall signalling (specified in ES 201 729 [13]).
- Reversals in polarity (commonly used in many networks to signal various events to the TE).
- Loop disconnect dialling (specified in ES 201 187 [14]), although DTMF signalling is preferred in combination with DSL.
- K-break referred to in ES 201 970 [9], clause 14.6.
- CLI and other enhanced signalling, according to part 1 and 2 of EN 300 659 [10].
- ES 200 778 [11] may also be associated to some special DC signals.

NOTE 1: Clause 14 of ES 201 970 [9] refers to these signalling methods.

NOTE 2: Although there is no clear test method given to prove this, by design a typical passive and static filter with sufficient bandwidth will not affect any of the POTS DC signalling methods above.

6.3 Ringing frequency requirements

The DC feeding current conditions of clause 5.1.2 are not applicable to these requirements. The specific DC feeding voltage conditions are specified in the remainder of this clause.

6.3.1 Ringing voltage drop at 25 Hz and 50 Hz

Ringing signals with frequencies of 25 Hz and 50 Hz shall be used. Other test conditions are in table 1.

The maximum voltage drop at the load impedance due to the insertion of one splitter, in the test set-up of figure 7 for the splitter at the TE side and figure 8 for the splitter at the LE side, shall be not more than V_{rd} (abbreviation of $V_{ring\text{-}drop}$), with a value specified in the tables A.2 and A.3 in annex A for each specific DSL system. This requirement is valid with the switch S in figures 7 and 8 both open and closed.

Table 1: Test conditions Voltage drop at 25 Hz and 50 Hz

Impedance of signal source	850 Ω (resistive)
Impedance of the load, dependent of the ringing frequency	Z_{ring} (defined in clause 5.2.6)
Open voltage of the AC test signal source	35 Vrms
Level of the DC feeding voltage	60 V DC

6.3.2 Impedance in the presence of ringing at 25 Hz and 50 Hz

The POTS port and the LINE port of the splitter shall have an impedance (when measured between the A-wire and the B-wire) at 25 Hz and 50 Hz greater than 40 kΩ. When testing at either the POTS port or the LINE port, all other ports are open circuit.

6.3.3 Total harmonic distortion at 25 Hz and 50 Hz

The splitter shall be able to transfer the ringing signals to the AC-load without significant distortion. This is tested with two sets of source and feeding voltages, as given in table 2. The test shall be carried out at 25 Hz and 50 Hz. With those voltages applied, the total harmonic distortion of the AC signal shall be less then 10 %. The test set-up is given in figure 7 for the TE side splitter and in figure 8 for the LE side splitter. This requirement is valid with the switch S in figures 7 and 8 both open and closed.

Table 2: Test conditions THD at 25 Hz and 50 Hz

	test 1	test 2
Open voltage of the AC test signal source	100 Vrms	50 Vrms
Level of the DC feeding voltage	50 V DC	78 V DC
Frequency of the signal source	25 Hz and 50 Hz	
Impedance of signal source	850 Ω (resistive)	
Impedance of the load, dependent of the ringing frequency	Z_{ring} (defined in clause 5.2.6)	

6.4 POTS pass band loss requirements (on-hook)

In the present document, this test is specified only for the LE side splitters at the LE and the corresponding splitter at the TE side. The test impedances and the requirements for splitters at the cabinet are for further study.

6.4.1 On-hook requirement for the case of high impedance termination

The magnitude of the voltage gain of the splitter in the range 200 Hz to 2,8 kHz shall be within the range -4 dB to +4 dB for the on-hook case with high impedance termination. A DC voltage of 50 V shall be used. The test set-ups are given in figures 7 and 8. This requirement is valid with the switch S in figures 7 and 8 both open and closed.

The test shall be executed with the combinations of source and load impedances presented in table 3.

NOTE: Different test set-ups are used in the case where the splitter is for the LE-side or TE-side.

Table 3: Impedances and test set-ups for the on-hook voltage gain test

Splitter Type	Test set-up reference	Impedance of signal source	Impedance of the load (modelling line +phone)	DC feeding voltage
LE side	Figure 8	Z_R (POTS port)	Z_{OnHI} (Line port)	50 V
TE side	Figure 7	Z_R (Line port)	Z_{OnHI} (POTS port)	50 V

Level of the test signal = -4 dBV emf. Z_R and Z_{OnHI} are defined in clause 5.2.2 and 5.2.4.

6.4.2 On-hook requirement for the case of low impedance termination

The requirements of this clause are only applicable to certain networks (see clause 5.1.2). The on-hook pass band insertion loss and loss distortion shall be measured according to figures 7 for the TE side splitter and according to figure 8 for the LE side splitter.

In either case of the LE side or of the TE side splitter, both the source and load impedance shall be Z_{OnLI} in the voice band. This requirement is valid for a DC current required in clause 5.1.2, i.e. from 0,4 mA to 2,5 mA..

This requirement is valid with the switch S in figures 7 and 8 both open and closed.

6.4.2.1 Low impedance on-hook POTS pass band insertion loss

The insertion loss of one splitter in the pass band while on-hook (IL_{PBOnH}) shall be less than the value specified in tables A.2 and A.3 in annex A for each specific DSL system at 1 kHz.

6.4.2.2 Low impedance on-hook POTS pass band insertion loss distortion

The absolute difference between the insertion loss at any frequency in the range 200 Hz to 2,8 kHz and the insertion loss at 1 kHz shall be less then 1 dB.

6.5 POTS pass band loss requirements (off-hook)

In the present document, the loss requirement is specified only for the LE side splitters at the LE and the corresponding splitter at the TE side. The loss requirements for splitters at the cabinet and for the corresponding splitters at the TE side are for further study.

The test set-ups are described in clause 5.3. The off-hook pass band requirements shall be measured in each direction, i.e. according to figures 7 and 8 for both the LE side and the TE side splitter. The off-hook DC feeding current is specified in clause 5.1.2 with the level of the test signal = -4 dBV emf. The test shall be executed with both combinations of source and load impedances presented in table 4.

Table 4: Combinations of source and load impedances for the pass band loss requirements

Source/Load combination	Impedance of signal source	Impedance of the load
Combination 1	Z_R	Z_R
Combination 2	600 Ω	600 Ω

The requirements in this clause shall be validated with the switch S in figures 7 and 8 both open and closed.

6.5.1 Off-hook POTS pass band insertion loss

The insertion loss in the pass band while off-hook (IL_{PBOffH}) of one splitter shall be less than the value specified in the tables A.2 and A.3 in annex A for each specific DSL system at 1 kHz.

6.5.2 Off-hook POTS pass band insertion loss distortion

The absolute difference between the insertion loss at any frequency in the range 200 Hz to 4 kHz and the insertion loss at 1 kHz shall be less then 1 dB.

6.6 POTS pass band return loss requirements (off-hook)

In the present document, the return loss requirement is specified only for the LE side splitters at the LE and for the corresponding splitter at the TE side. The return loss for splitters at the cabinet and for the corresponding splitters at the TE side is for further study.

The return loss (RL) at both the POTS and LINE port of the splitter shall be measured according to figure 9. The definition of RL is also given in figure 9. The return loss requirements are valid with the switch S both open and closed. As Z_{LOAD} the appropriate Z values of table 5 shall be connected, as indicated specifically in the remaining parts of this clause. Z_{DSL} is defined in clause A.1.1 in annex A for different DSL variants.

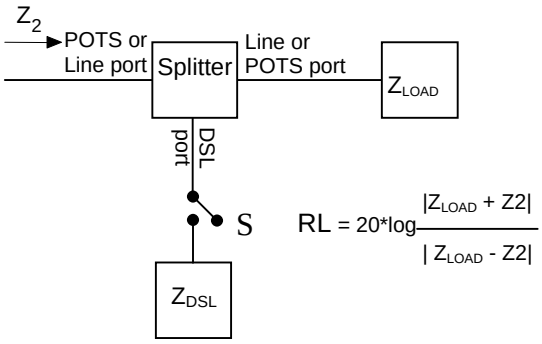


Figure 9: Definition of return loss, R_L, at either the Line or the POTS port

There are two options for return loss testing. The following test set-ups and requirements are equally applicable to the LE side and TE side splitters. Return loss testing is to be carried out under the off-hook DC feeding current of clause 5.1.2.

The pass band return loss requirements in off-hook condition are not depending on the type of DSL. Therefore, they are specified in the main body of the present document and not in the annex A. Return loss requirements are measured according to two options A and B as explained under clause 6.1.

6.6.1 POTS pass band return loss requirements, option A

The device shall meet all the return loss requirements specified in table 5.

Table 5: Return loss requirements, option A

Test #	Value of Z_{LOAD}	Frequency range	Minimum Return Loss
Test 1	Z_{SL}	300 Hz to 3,4 kHz	12 dB
Test 2	Z_{SL}	3,4 kHz to 4 kHz	8 dB
Test 3	Z_R	300 Hz to 3,4 kHz	12 dB
Test 4	Z_R	3,4 kHz to 4kHz	8 dB
NOTE 1: A value of 14 dB for the minimum Return Loss instead of 12 dB is desirable. NOTE 2: Z_R and Z_{SL} are defined in clause 5.2.2, in figures 3 and 4 respectively.			

6.6.2 POTS pass band return loss requirements, option B

For the case of option B, Z_{LOAD} in figure 9 shall be Z_R. The device shall meet the return loss requirements specified in figure 10.

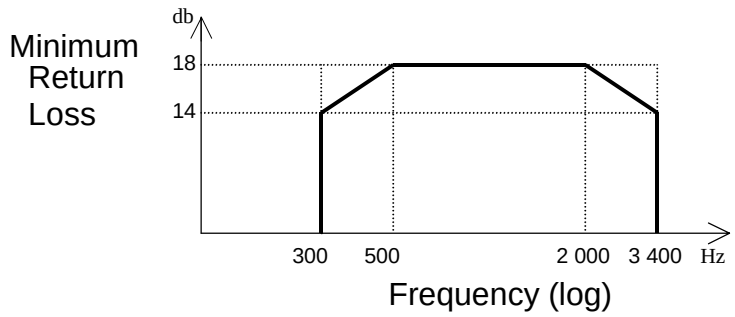


Figure 10: Minimum return loss template for option B

6.7 Requirements relating to metering pulses at 12 kHz or 16 kHz (optional)

In the case where pulse metering signals are deployed on the same lines as DSL, the insertion loss due to the splitter shall be measured at the frequency of the metering pulse. Due to the country specific nature of the rationale of this requirement, the required insertion loss shall be operator specific. A maximum insertion loss requirement in the range of 3 dB to 5 dB per splitter should be suitable for many European networks.

The test set up of figures 7 and 8 shall be used, using the condition of table 6. The level of the test signal is 3,5 V_{RMS} emf. This requirement is valid only for the off-hook condition, with DC current as specified in clause 5.1.2. This requirement is valid with the switch S in figures 7 and 8 both open and closed.

Table 6: Conditions for insertion loss test at 12 kHz or 16 kHz

Level of source voltage	Impedance of signal source	Impedance of the load (Z in figures 7 and 8)	Impedance at the DSL port
3,5 V_{RMS} emf	200 Ω	200 Ω	Z_{DSL}

NOTE: This optional requirement can increase the complexity of the low pass filter implementation.

6.8 Unbalance about Earth

NOTE: The POTS splitter low pass can influence the unbalance about earth of the Line port and the DSL port. This is not addressed in the present document. This requirement is specified in TS 101 952-1-2 [19] and in TS 101 952-2-2 [20].

The basic test set-up for measuring Unbalance about Earth (UaE) at the POTS port is shown in figure 11. In the case of measuring at the LINE port, the test set-up of figure 11 is used, however with the POTS and LINE terminations reversed. The test shall be carried out for the combinations described in table 7. Note that the source and measurement are always at the same port. This requirement is applicable for both the on-hook and off-hook case. The DC feeding is as specified in clause 5.1.2. In the case of performing measurements at frequencies above the voice band, for reasons of practical testing 150 Ω impedance should be used in series with the longitudinal source (i.e. S1 in figure 11 should be open).

Table 7: Unbalance about earth, test set-ups

Test set-up #	Source and Measurement	Location of S2	State of S2
1	POTS side	LINE side	open
2	POTS side	LINE side	closed
3	LINE side	POTS side	closed

The DSL port shall be terminated with a Z_{RefDSL} resistor for all unbalance tests described in the present document. The value of Z_{RefDSL} is dependent on the DSL involved. Specific values are given in table A.1.

For each of the test set-ups described above, the splitter shall meet the unbalance about earth requirements as specified in table 8. The value of f_{Max} in table 8 is dependent on the DSL involved. Specific values are given in tables A.2 and A.3.

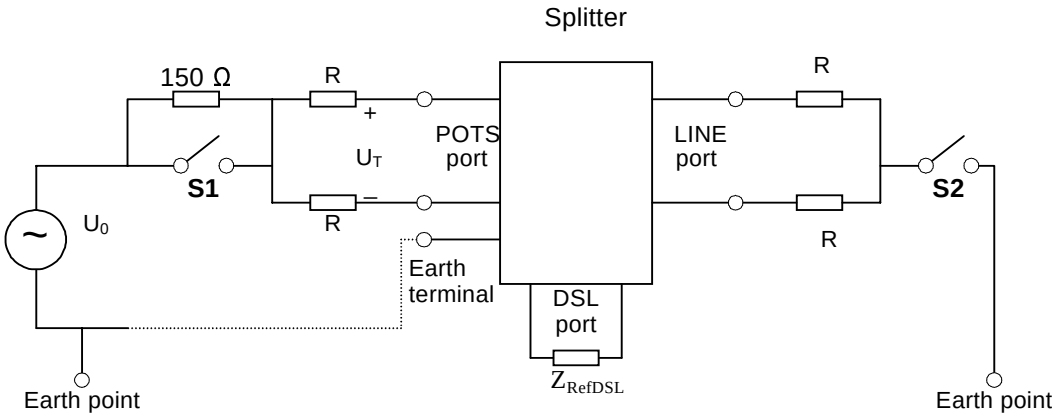
Table 8: Unbalance about earth, minimum values

Frequency range	State of S1	Value of R	Minimum Unbalance value
50 Hz to 600 Hz	Closed	300 Ω	40 dB
600 Hz to 3,4 kHz	Closed	300 Ω	46 dB
3,4 kHz to 4 kHz	Closed	300 Ω	40 dB
4 kHz to f_L	Open	$Z_{RefDSL}/2$	40 dB
f_L to f_H	Open	$Z_{RefDSL}/2$	See annex A
f_H to f_{Max}	Open	$Z_{RefDSL}/2$	See annex A

Values of the unbalance above f_L can be found in the tables A.2 and A.3 in annex A for each DSL variant.

The unbalance about earth is calculated by using the following equation:

$$\text{Unbalance} = 20\log_{10}\left|\frac{U_0}{U_T}\right| \quad (\text{dB})$$



NOTE 1: The dotted circuit is only used if the splitter has an earth terminal.
NOTE 2: The DC current feeding circuitry is not shown. Care should be taken that this circuitry is implemented in such a way as not to have significant influence on the accuracy of the measurement.
NOTE 3: For resistances R an equivalent circuit according to ITU-T Recommendation O.9 [7] can be used.
NOTE 4: If the splitter has no earth terminal, the test should be performed while the splitter is placed on an earthed metal plate of a sufficiently large size.

Figure 11: Unbalance about earth test set-up

6.9 DSL band requirements

In the present document, the DSL band requirements are specified only for the LE side splitters at the LE and for the corresponding splitter at the TE side. The requirements for splitters at the cabinet and for the corresponding splitters at the TE side are for further study.

NOTE 1: Insertion loss caused by the POTS splitter low pass on DSL signals (Att_{DSLB}) between the Line port and the DSL port and vice versa are not addressed in the present document. This requirement is specified in TS 101 952-1-2 [19] and in TS 101 952-2-2 [20].

The isolation (attenuation or insertion loss) should be measured between the POTS port and both the line and the DSL port. Noises of the POTS LE circuits (ringing with noisy 25 to 60 Hz AC generators, ring-relays, out-of-band aliasing of 4 kHz voice audio, etc.) and of the POTS phone circuits (pulse dialling, off/on-hook, ring trip, etc.) should not reach the DSL port or the line, because they will travel to the remote DSL Receiver via the line. This means that the attenuation should be measured between the POTS port and both the DSL port and the line port.

Furthermore, there is a need to prevent DSL signals from reaching the POTS port. This means that measurements shall be performed in both directions, i.e. isolation (attenuation or insertion loss) from DSL port to POTS port and from the remote DSL via the line port to POTS port.

NOTE 2: In a splitter without a series high pass filter, there is no difference between line port and DSL port. In a splitter with the extra series capacitors, or even a higher order high pass filter, the attenuation between POTS port and DSL port will be greater than the attenuation between POTS port and the line port.

6.9.1 DSL band on-hook isolation between DSL and POTS

NOTE: It is recognized that the values in this clause are sufficient to provide protection of the POTS service against the DSL signals. Higher values may be required to provide adequate protection of the DSL service against POTS transients. This last issue is for further study.

The set-up for the test from DSL port into the POTS port is given in figure 12. The test has to be executed in the opposite direction also, by reversing the signal source and load. The on-hook DC feeding conditions are specified in clause 5.1.2. As the isolation in the DSL band is almost identical at both DSL and line port, we measure the isolation in on-hook only at the DSL port. The isolation in on-hook needs not to be measured from POTS port tot line port and vice versa.

The minimum values of the isolation in the DSL band on-hook (IS_{DBOnH}) and the frequency ranges are found in the tables A.2 and A.3 in annex A for each specific DSL system. The impedance values are in table 9. Editorial NOTE: some values are still under debate. The level of the test signal = -6,0 dBV emf.

Table 9: Impedances applied for on-hook isolation

Test Direction	LE side splitter			TE side splitter		
	Line port Impedance	POTS port Impedance	DSL Port Impedance	Line port Impedance	POTS port Impedance	DSL Port Impedance
DSL to POTS	Z_{RHF}	Z_{RHF}	Z_{DSL}	Z_{RHF}	Z_{OnHI}	Z_{DSL}
POTS to DSL	Z_{RHF}	Z_{RHF}	Z_{DSL}	Z_{RHF}	Z_{RHF}	Z_{DSL}

In this case the isolation is defined as 20 log (V1/V2) where V1 is the source emf and V2 is the voltage appearing across the load. In figure 12 the case is shown with the load attached at the POTS port and the source at the DSL port. The test in the opposite direction will reverse source and load.

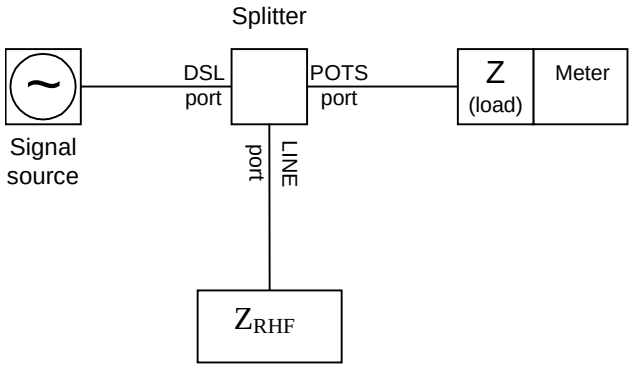


Figure 12: On-hook isolation test set-up, shown here from DSL port to POTS port

6.9.2 DSL band off-hook isolation between DSL and POTS

The minimum values of the isolation in the DSL band (when off-hook) are measured as an insertion loss (IL_{DBOffH}) and the frequency ranges are found in the tables A.2 and A.3 for each specific DSL system. The off-hook DC feeding conditions are specified in clause 5.1.2.

In the case where the return loss requirement of option A (see clause 6.6.1) is used in specifying the splitter, the off-hook insertion loss requirement of type A in tables A.2 and A.3 shall be fulfilled.

In the case where the return loss requirement of option B (see clause 6.6.2) is used in specifying the splitter, the off-hook insertion loss requirement of type B in tables A.2 and A.3 shall be fulfilled.

For the test between POTS port and line port, the test set-ups to be used are given in figures 7 and 8, i.e. the isolation is to be measured at both the POTS and LINE port. Switch S is always closed, because this type of isolation is only needed when DSL equipment is present.

The splitter shall also fulfil the requirements if the signal source is connected to the DSL port, the level meter connected to the POTS port and the LINE port terminated as shown in figure 12 and in the opposite direction from POTS port to DSL port.

The impedance values are contained in table 10. The level of the test signal is -6 dBV emf.

NOTE: It was decided to use Z_{RHF} to model the impedance at the POTS port at the TE and LE.

Table 10: Impedances applied for off-hook isolation

	LE side splitter			TE side splitter		
Test Direction	Line port Impedance	POTS port Impedance	DSL Port Impedance	Line port Impedance	POTS port Impedance	DSL Port Impedance
Line to POTS	Z_{RHF}	Z_{RHF}	Z_{DSL}	Z_{RHF}	Z_{RHF}	Z_{DSL}
POTS to Line						
DSL to POTS						
POTS to DSL						

6.10 Noise

The noise requirements of clause 6.10.1 are only valid for the off-hook condition. The noise requirements of clause 6.10.2 are valid for both the on-hook and off-hook condition. The DC feeding conditions are given in clause 5.1.2.

6.10.1 POTS band audible noise level

The psophometric noise power, as defined in ITU-T Recommendation O.41 [6], measured at the LINE port and the POTS port of a splitter, shall be less than -75 dBmp. The psophometer shall be referenced to Z_R. LINE port and POTS port should be terminated with Z_R. The DSL port is terminated with the Z_{DSL} load as defined in clause 5.2.1.

6.10.2 DSL band noise level

In the present document, the noise requirement is specified only for the LE side splitters at the LE and for the corresponding splitter at the TE side. The noise requirements for splitters at the cabinet and for the corresponding splitters at the TE side are for further study.

The test set-ups of figures 13 and 14 shall be used with the different splitters ports terminated with Z_{RefDSL} and Z_{DSL}, both defined in clause 5.2.1. The DSL port shall be terminated with Z_{DSL}. Specific values of Z_{DSL} are given in clause A.1.1 in annex A. Depending on the presence or absence of DC blocking capacitors or a higher order high pass filter in the splitter, the value of C_{DSL} will be adjusted according to clause A.1.1.

The noise shall be measured in the frequency range f_A to f_H. The value of f_A and f_H are dependent on the DSL involved. Specific values are given in tables A.2 and A.3. The frequency f_A represents the lower edge of the DSL band. The frequency f_H represents the higher edge of the DSL band.

The required maximum values of the noise will also depend on the DSL involved. The values are found in the tables A.2 and A.3 for each specific DSL system.

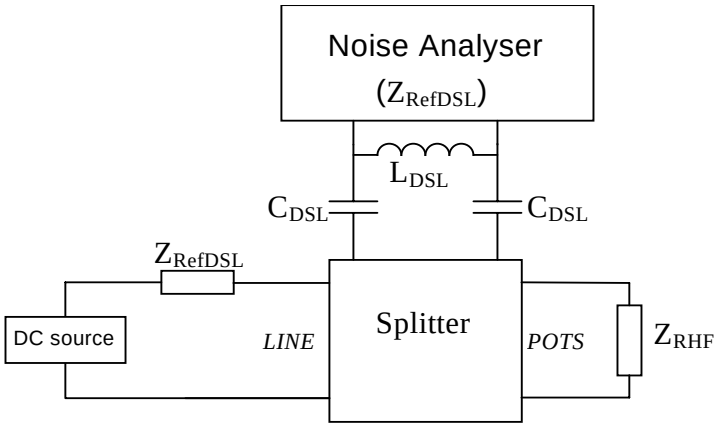


Figure 13: Test set-up for measuring DSL band noise at the DSL port

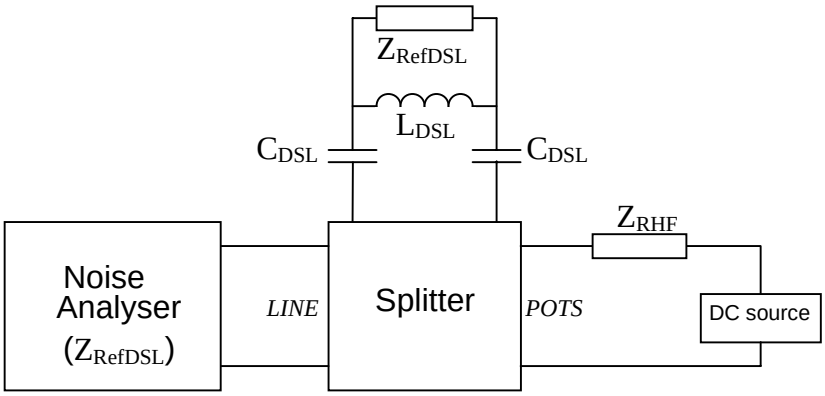


Figure 14: Test set-up for measuring DSL band noise at the LINE port

6.11 Distortion

6.11.1 POTS band intermodulation distortion

The test set-up to be used is given in figure 7. This requirement is valid with the switch S in figure 7 both open and closed. Both the source and load impedance used shall be equivalent to Z_R. This requirement is valid for both the on-hook and off-hook conditions. The DC feeding conditions are given in clause 5.1.2.

The test signal to be used is as according to ITU-T Recommendation O.42 [3].

Using the 4-tone method [3] at a level of -9 dBV, the second and third order harmonic distortion products shall be at least 57 dB and 60 dB, respectively below the received signal level.

The second and third order harmonics of the 4-tone signal are measured at POTS port.

NOTE: A methodology for performing this test in the presence of a DSL signal is available in [15] and [17]. This represents a more realistic scenario for splitter evaluation.

6.11.2 DSL band intermodulation distortion

NOTE: A methodology to test the intermodulation of splitters in the DSL band, due to the presence of DSL and/or POTS signals, is for further study.

6.12 Group delay distortion

The increase of the group delay distortion by inserting one splitter shall be measured relative to the lowest measured delay in the frequency range 300 Hz to 4 kHz. The required maximum values are contained in table 11.

Table 11: Group delay distortion, maximum values

Frequency range	Maximum value
200 Hz to 600 Hz	250 µs
600 Hz to 3,2 kHz	200 µs
3,2 kHz to 4 kHz	250 µs

Two tests shall be performed. Both tests shall use the same impedance as signal source and load impedance. A first test uses an impedance of 600 Ω. The second test uses Z_R as impedance. The level of the test signal is -10 dBV.

The set-up for measuring group delay distortion is given in figure 7. This requirement is valid with the switch S in figure 7 both open and closed. The DC feeding current is specified in clause 5.1.2. This requirement is valid for both the on-hook and off-hook conditions.

6.13 Requirements related to POTS transient effects

NOTE: To test how the transient signals caused by POTS affect the DSL system, a POTS transient test existed in previous versions of the present document. However, the need for this test and the test method are for further study. To keep a reference to the older version of this test, the complete text of this clause is put in the informative annex B.

6.14 Requirements for Common Mode rejection (optional)

Normally a splitter serves as shield for the DSL modem by suppressing differential mode noises, which are present on the POTS network in the building. However, also a common mode noise could be picked up on the POTS network. This common mode noise might pass the splitter low pass without any required attenuation. The common mode noise then reaches the DSL modem and the local cable were it will be partially converted into differential mode noise signals, which will enter the DSL receiver input stage and affect the DSL reception.

Therefore, splitters with measures to suppress common mode will reduce the effects of these noises on the DSL modem and will improve the DSL signal reception.

In the present document the requirements are limited to ADSL. A similar requirement for ADSL2+ and for VDSL is for further study, i.e. in the band above 1,1 MHz.

The splitter shall have a Common Mode Rejection Ratio (CMRR) better than the boundaries shown in figure 15. This requirement is applicable for POTS DC feeding current in the range 0 to 80 mA. This DC current shall be purely differential. Indeed, it is noted that in an operational situation the DC currents in the a- and b- wire are always flowing in opposite directions.

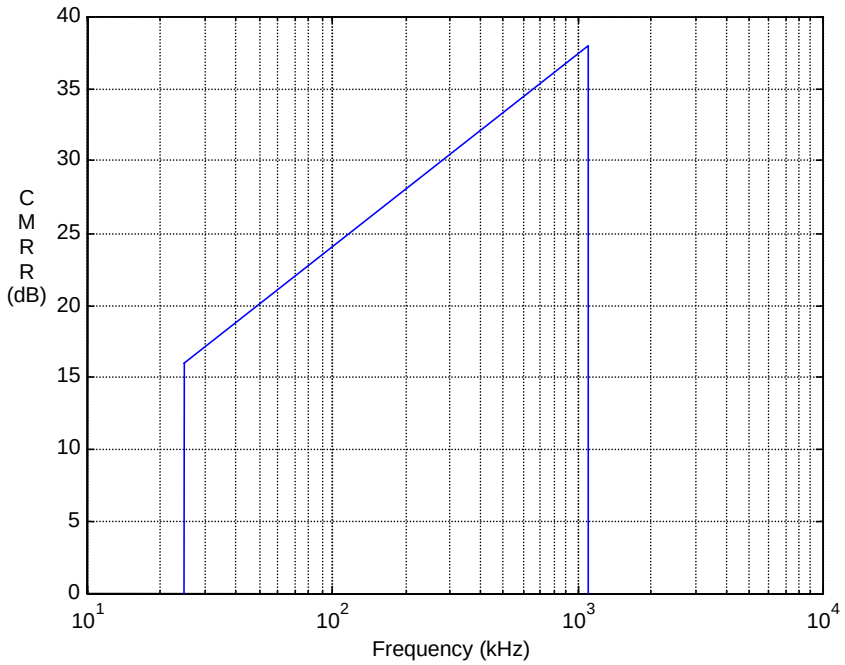


Figure 15: Mask of the minimum CMRR

NOTE 1: For frequencies up to 50 Hz the CMRR should preferably be low (< 6 dB). However this value is F.F.S.

NOTE 2: The vertical edges of the mask in figure 15 are at 25 kHz and at 1,104 MHz

The test set-up for measuring the CMRR of the splitter is in given figure 16. The test shall be done from POTS port to Line port and from POTS port to the DSL port.

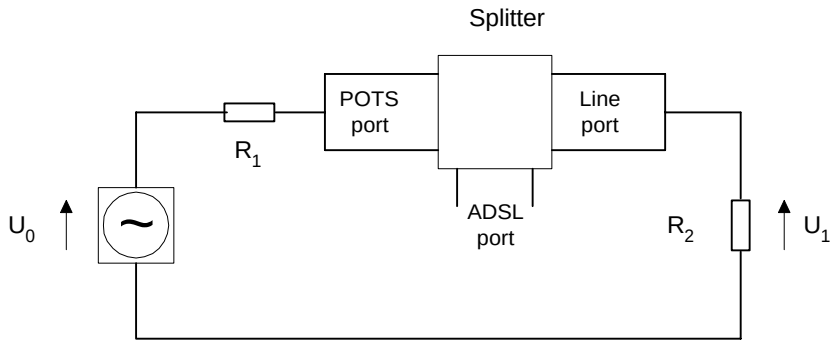


Figure 16: Test set-up for measuring the CMRR

In the set-up the following resistor values are used: R1 = R2 = Z_{RefDSL} = 100 Ω for ADSL.

The CMRR is calculated with the following formula:

CMRR= 20 x log (U_0 / U_1) (dB)

Annex A (normative): DSL specific information

A.1 Dedicated impedances for specific DSL over POTS variants

A.1.1 Generic definition of Z_{DSL}, using C_{DCB}, Z_{RefDSL}, C_{DSL}, L_{DSL}

For DSL over POTS, the values of Z_{DSL}, as defined in clause 5.2.1, is composed of Z_{RefDSL}, C_{DSL} and L_{DSL}, which results in the equivalent circuit of figure A.1.

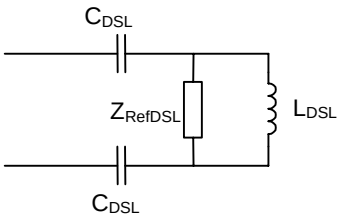


Figure A.1: Equivalent schematic of Z_{DSL}

Z_{RefDSL} is the design impedance of the DSL transceivers of a specific DSL variant, and is a resistor independent of the used frequency range.

L_{DSL} depends on the lower edge of the pass band of the DSL, and matches also the Z_{RefDSL} of the DSL at that lower edge.

The C_{DSL} depends also on the pass band of the DSL, but has 2 possible values for 2 distinct cases, i.e. when splitter includes a DC blocking capacitor (C_{DCB}) or not. If C_{DCB} is present, the value of the C_{DSL} will be larger to compensate the extra series impedance.

Table A.1: Values of elements of Z_{DSL} for different DSL systems

Impedance name	ADSL over POTS	ADSL2+ over POTS	European VDSL1 over POTS starting at 25 kHz	European VDSL1 over POTS starting at 138 kHz	European VDSL1 over POTS starting at 900 kHz	VDSL2 over POTS
Z_{RefDSL}	100 Ω	100 Ω	135 Ω	135 Ω	135 Ω	100 Ω Note 1
L_{DSL}	0,47 mH	0,47 mH	0,6345 mH	F.F.S.	F.F.S.	Note 2
C_{DCB}	120 nF	120 nF	120 nF	F.F.S.	F.F.S.	Note 2
C_{DSL} if C_{DCB} is present	100 nF	100 nF	60 nF	F.F.S.	F.F.S.	Note 2
C_{DSL} if C_{DCB} is absent	54,5 nF	54,5 nF	40 nF	F.F.S.	F.F.S.	Note 2

NOTE 1: There is ongoing work to harmonize the VDSL2 design impedance Z_{RefDSL} with ADSL at the universal value of 100 Ω.
NOTE 2: There is ongoing work to harmonize the VDSL2 input impedance with ADSL.

A.1.2 Specific values of Z_{RefDSL}, C_{DSL}, L_{DSL} and Z_{DSL} for ADSL over POTS

For ADSL in general and for ADSL over POTS specifically the value for Z_{RefDSL} is 100 Ω.

For ADSL over POTS L_{DSL} is 0,47 mH.

For ADSL over POTS C_{DSL} has 2 possible values, depending on the absence or presence of a high pass part in the splitter. This results in 2 possible values for Z_{DSL}.

For ADSL over POTS, when the splitter does not contain DC blocking capacitors or a higher order series high pass filter, the impedance model of figure A.2 shall be used to terminate the DSL port of the splitter.

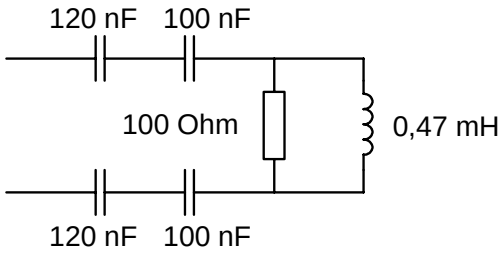


Figure A.2: Schematic diagram of the impedance Z_{DSL} for ADSL over POTS, if blocking capacitors or higher order series HPF are absent in the splitter filter

In the case where either DC blocking capacitors or a higher order series high pass filter are present, the impedance network of figure A.3 shall be used to terminate the DSL port of the splitter.

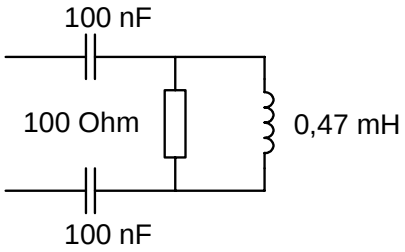


Figure A.3: Schematic diagram of the impedance Z_{DSL} for ADSL over POTS, if blocking capacitors or higher order series HPF are present in the splitter filter

A.1.3 Specific values of Z_{RefDSL} for European VDSL1 over POTS

For European VDSL1 in general and for European VDSL1 over POTS specifically the value for Z_{RefDSL} is 135 Ω.

A.1.4 Specific values of Z_{DSL} for European VDSL1 over POTS, starting at 25kHz

For European VDSL1 over POTS, starting at 25 kHz, i.e. using the lower U0 upstream band L_{DSL} is 0,6345 mH.

For European VDSL1 over POTS starting at 25 kHz, when the splitter does not contain DC blocking capacitors or a higher order series high pass filter, the impedance model of figure A.4 shall be used to terminate the DSL port of the splitter.

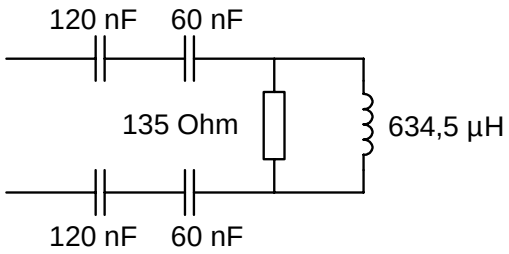


Figure A.4: Schematic diagram of the impedance Z_{DSL} for European VDSL1 over POTS, starting at 25 kHz if blocking capacitors or higher order series HPF is absent in the splitter filter

In the case where either DC blocking capacitors or a higher order series high pass filter is present, the impedance network of figure A.5 shall be used to terminate the DSL port of the splitter.

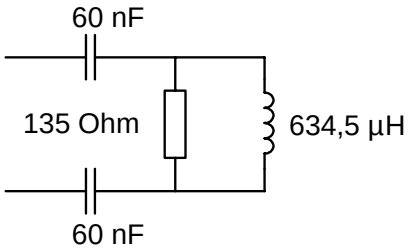


Figure A.5: Schematic diagram of the impedance Z_{DSL} for European VDSL1 over POTS, starting at 25 kHz if blocking capacitors or higher order series HPF are present in the splitter filter

A.1.5 Specific values of Z_{DSL} for European VDSL1 over POTS, starting at 138 kHz

These values are under study.

A.1.6 Specific values of Z_{DSL} for European VDSL1 over POTS, starting at 900 kHz

These values are under study.

A.1.7 Specific values of Z_{DSL} for Universal VDSL2 over POTS

These values are under study.

NOTE: The harmonization of the Z_{DSL} for VDSL2 with ADSL and its variants is under study.

A.2 Dedicated requirements for ADSL over POTS variants

Specific requirements for ADSL over POTS are listed in the following table. Symbols are explained under clause 3.2.

Table A.2: Dedicated requirements for ADSL systems

Clause number	**Requir-ement**	Meas. at freq	ADSL or ADSL2 over POTS	ADSL2+ over POTS deployed from the LE	ADSL FDD over POTS at the LE	ADSL FDD over POTS at the TE	ADSL2+ over POTS deployed from the cabinet
6.2.3	R_{DC}	DC	50 Ω	50 Ω	50 Ω	50 Ω	F.F.S.
6.3.1	V_{rd}	25 Hz 50 Hz	2 V	2 V	2 V	2 V	2 V
6.4.2.1	IL_{PBOnH}	1 kHz	1 dB	1 dB	1 dB	1 dB	1 dB
6.5.1	IL_{PBOffH}	1 kHz	1 dB	1 dB	1 dB	1 dB	1 dB
6.6	RL_{PBOffH}	Clause 6.6	Option A & B in clause 6.6	Option A & B in clause 6.6	Option A & B in clause 6.6	Option A & B in clause 6.6	Option A & B in clause 6.6
6.8	UaE	f_L - f_H	50 dB	50 dB	45 dB	45 dB	F.F.S.
		f_H - f_{Max}	30 dB	30 dB	30 dB	30 dB	F.F.S.
6.9	Att_{DSLB}	[19]	[19]	[19]	F.F.S.	F.F.S.	F.F.S.
6.9.1	IS_{DBOnH}	f_L - f_{M2}	34 dB	34 dB	F.F.S.	F.F.S.	F.F.S.
		f_{M2} - f_H	51 dB	51 dB	F.F.S.	F.F.S.	F.F.S.
6.9.2 option A	IL_{DBOffH}	f_L - f_H	55 dB	55 dB	F.F.S.	F.F.S.	F.F.S.
6.9.2 option B	IL_{DBOffH}	f_L - f_{M1}	45 dB	45 dB	F.F.S.	F.F.S.	F.F.S.
		f_{M1} - f_H	55 dB	55 dB	F.F.S.	F.F.S.	F.F.S.
6.10.2	N_{DSL} at TE	f_A - f_H	- 140 dBm/Hz in 10 kHz BW	- 140 dBm/Hz in 10 kHz BW	F.F.S.	F.F.S.	F.F.S.
	N_{DSL} at LE	f_A - f_H	- 125 dBm/Hz in 10 kHz BW	(- 125 dBm/Hz) in 10 kHz BW	F.F.S.	F.F.S.	F.F.S.
A.2	f_A	-	26 kHz	26 kHz	F.F.S.	F.F.S.	F.F.S.
A.2	f_L	-	32 kHz	32 kHz	F.F.S.	F.F.S.	F.F.S.
A.2	f_{M1}	-	138 kHz	138 kHz	F.F.S.	F.F.S.	F.F.S.
A.2	f_{M2}	-	350 kHz	350 kHz	F.F.S.	F.F.S.	F.F.S.
A.2	f_H	-	1 104 kHz	2 208 kHz	F.F.S.	F.F.S.	F.F.S.
A.2	f_{Max}	-	5 MHz	5 MHz (Note 1)	F.F.S.	F.F.S.	F.F.S.
NOTE: The value was kept at 5 MHz, similar to ADSL with 1,1 MHz bandwidth.							

A.3 Dedicated requirements for VDSL over POTS variants

Specific requirements for VDSL over POTS are listed in the following table. Symbols are explained under clause 3.2.

Table A.3: Dedicated requirements for VDSL systems

Clause number	**Requir-ement**	Meas. at freq	VDSL over POTS starting at 25 kHz (note 1)	VDSL over POTS starting at 138 kHz	VDSL over POTS starting at 900 kHz
6.2.3	R_{DC}	DC	50 Ω (note 1)	F.F.S.	F.F.S.
6.3.1	V_{rd}	25 Hz 50 Hz	2V (note 1)	F.F.S.	F.F.S.
6.4.2.1	IL_{PBOnH}	1 kHz	1 dB (note 1)	F.F.S.	F.F.S.
6.5.1	IL_{PBOffH}	1 kHz	1 dB (note 1)	F.F.S.	F.F.S.
6.6	RL_{PBOffH}	range	Option A & B in clause 6.6	F.F.S.	F.F.S.
6.8	UaE	f_L - f_H	45 dB (?)	F.F.S.	F.F.S.
	UaE	f_H - f_{Max}	30 dB	F.F.S.	F.F.S.
6.9	Att_{DSLB}	[20]	[20]	F.F.S.	F.F.S.
6.9.1	IS_{DBOnH}	f_L - f_{M2}	34 dB	F.F.S.	F.F.S.
		f_{M2} - f_H	51 dB	F.F.S.	F.F.S.
6.9.2 option A	IL_{DBOffH}	f_L - f_H	55 dB	F.F.S.	F.F.S.
6.9.2 option B	IL_{DBOffH}	f_L - f_{M1}	45 dB	F.F.S.	F.F.S.
		f_{M1} - f_H	55 dB	F.F.S.	F.F.S.
6.10.2	N_{DSL} at TE	f_A - f_H	- 140 dBm/Hz in 10 kHz BW	F.F.S.	F.F.S.
	N_{DSL} at LE	f_A - f_H	(- 125 dBm/Hz) in 10 kHz BW (note 2)	F.F.S.	F.F.S.
A.3	f_A	-	26 kHz	F.F.S.	F.F.S.
A.3	f_L	-	32 kHz	F.F.S.	F.F.S.
A.3	f_{M1}	-	138 kHz	F.F.S.	F.F.S.
A.3	f_{M2}	-	350 kHz	F.F.S.	F.F.S.
A.3	f_H	-	12 MHz	F.F.S.	F.F.S.
A.3	f_{Max}	-	F.F.S.	F.F.S.	F.F.S.

NOTE 1: The values for VDSL over POTS starting at 25 kHz were obtained by copying the values required for ADSL over POTS. However, this type of VDSL seems to be installed at the Local Exchange, which means that the POTS line length is essentially limited. This means that the requirements labelled with "note 1" are unnecessarily strong. Indeed, a VDSL splitter can add more insertion losses on a shorter POTS line. This will reduce the complexity of the device and/or improve the achievable performance.

NOTE 2: By the editor: The value of the noise at a VDSL upstream receiver in the LE (or in the cabinet at the LE side) has not yet been correctly defined.

Annex B (informative): Test related to POTS transient effects (see clause 6.13)

NOTE 1: The need for this test and test method is for further study. The remaining text including figure B.1 in this clause reflects a former version of this test, which is included for information only.

The test set-up is shown in figure B.1. It consists of a switch with an on/off transition time of less than 2 μs on the POTS port. The resistors R_{SOURCE} are set at 1 kΩ. The DC source is set to 48 V.

The signal V_1 measured across the 1 kΩ, due to each change of state of the switch S_1, should be less than 2 V p-p and the main lobe of the Fourier Transform of the transient has its peak at a frequency less than 15 kHz. This applies to both the on and off hook transitions of switch S_1.

NOTE 2: A possible implementation of switch S_1 is given in TR 101 728 [5].

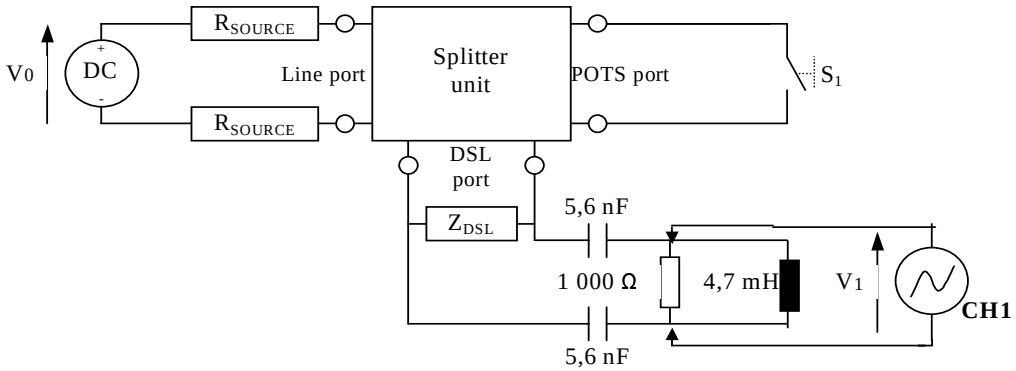


Figure B.1: Test circuit for large signal test

NOTE 3: In some cases there could be disturbances from POTS TE that could show a degree of asymmetry at higher frequencies, and therefore common mode suppression methods for splitters are under study.

Annex C (informative): Bibliography

ITU-T Recommendation G.117: "Transmission aspects of unbalance about earth".

ETSI EN 300 001: "Attachments to the Public Switched Telephone Network (PSTN); General technical requirements for equipment connected to an analogue subscriber interface in the PSTN".

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

ETSI TR 101 953-1-2: "Access network xDSL transmission filters; Part 1: ADSL splitters for European deployment; Sub-part 2: Testing methods for High Pass part of ADSL/POTS splitters".

ETSI TS 101 952-2-1: "Access network xDSL transmission filters: Part 2: VDSL splitters for European deployment; Sub-part 1: Specification of the low pass part of VDSL/POTS splitters".

ETSI TR 101 953-2-2: Access network xDSL transmission filters; Part 2: VDSL splitters for European deployment; Sub-part 2: Specification of testing methods for high pass part of VDSL/POTS splitters".

ETSI TS 102 080: "Transmission and Multiplexing (TM); Integrated Services Digital Network (ISDN) basic rate access; Digital transmission system on metallic local lines".

ITU-T Recommendation G.992.1: "Asymmetricaldigital subscriber line (ADSL) transceivers".

ITU-T Recommendation G.992.3: "Asymmetric digital subscriber line transceivers 2 (ADSL2)".

ITU-T Recommendation G.992.5: "Asymmetrical Digital Subscriber Line (ADSL) transceivers - Extended bandwidth ADSL2 (ADSL2+)".

History

Document history		
V1.1.1	May 2002	Publication
V1.2.1	December 2004	Publication