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Technical Specification

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

Reference

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Contents

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Foreword

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

The present document is part 2, sub-part 1 of a multi-part deliverable covering Access network xDSL transmission filters, as identified below:

Part 1: "ADSL splitters for European deployment";

Part 2: "VDSL splitters for European deployment";

Sub-part 1: "Specification of the low pass part of VDSL/POTS splitters";

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

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

Sub-part 4: "Specification of VDSL/"Other services" splitters".

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

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.

1 Scope

The present document specifies requirements and test methods for the low pass part of "VDSL over POTS" splitters. These splitters are intended to be installed at the Local Exchange side of the local loop and at the user side near the NTP. In the case of splitters at the user side, the present document specifies the master splitter that is intended for use at the demarcation point of the customer premises. Distributed splitters are not within the scope of the present document.

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 baseband termination unit (e.g. POTS line card), however this is outside of the scope of the current 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.

[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 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] 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".

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

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

3 Definitions 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

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

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 there are multiple TE present at the customer end of the loop, then only when all of these are on-hook shall the TE be considered to be on hook from the perspective of testing the splitter.

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 Abbreviations

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

AC Alternating Current
CLI Caller Line Identification
CO Central Office (Local Exchange)
DC Direct Current
HPF High Pass Filter
ITU International Telecommunication Union
LE Local Exchange (Central Office)
NTP Network Termination Point
POTS Plain Old Telephone Service
PSTN Public Switched Telephone Network
TE Terminal Equipment (e.g. Telephone, Fax, voice band modem etc.)
THD Total Harmonic Distortion
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 DSL 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.

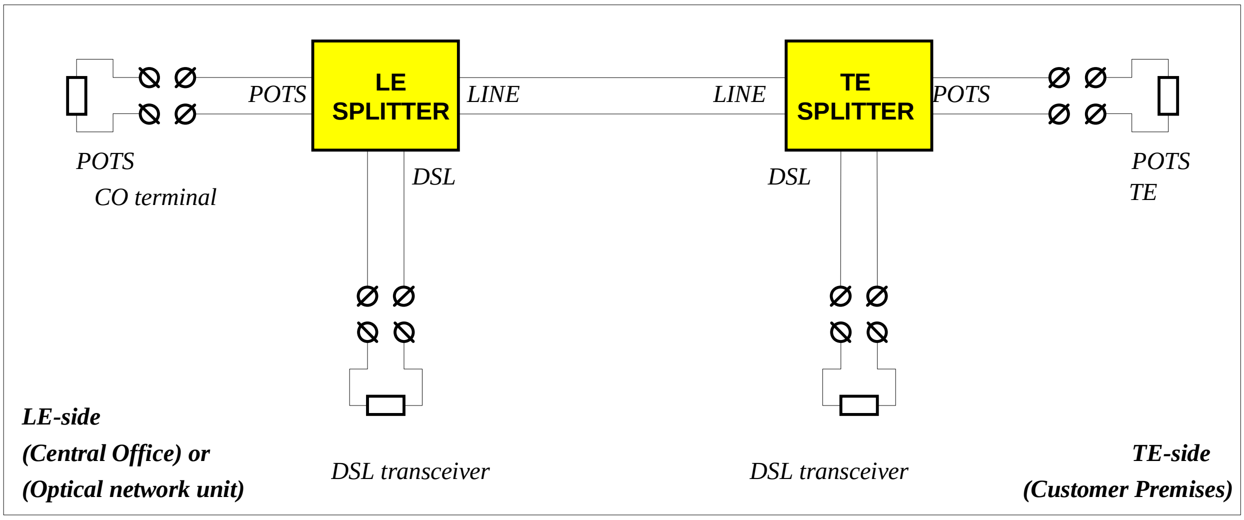


Figure 1: Functional diagram of the DSL splitter configuration

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.
- 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 2 of TS 101 952-1-2).

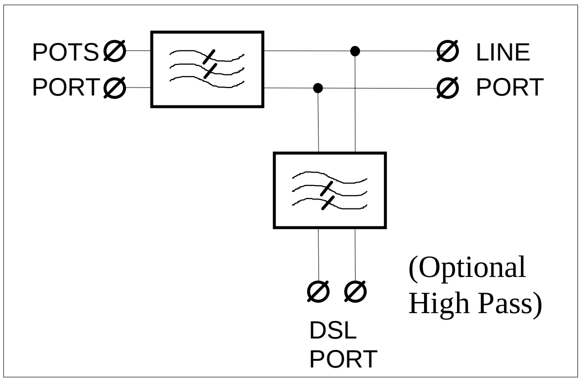


Figure 2: Structure of the DSL splitter filter

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 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.

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).

On-hook voiceband electrical requirements shall be met with a DC feeding voltage of 50 V, and using the impedance model Z_{ON}, as given in clause 5.2.4 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 distributed filter. In this case an impedance model of 600 Ω is used to terminate the LINE and POTS port of the distributed filter at voice frequencies.

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

Testing conditions for transitional requirements are specified in clause 6.13 of the present document.

5.2 Terminating impedances

5.2.1 Z_{VDSL-1} and Z_{VDSL-2}

NOTE: It is assumed in this clause that the input impedance of the VDSL modem is such that only signals below approximately 25 kHz are blocked. In the case where the modem also blocks higher frequency signals, (e.g. those between 25 kHz and 138 kHz, or indeed if it has a higher passband frequency), then an alternative model of Z_{VDSL} would be appropriate. Such an alternative model could significantly reduce the complexity of the filter. This issue is currently under study.

In many of the tests with voice frequencies, the VDSL port of the low pass filter is terminated with an impedance called Z_{VDSL-1}. This impedance model represents the input impedance of the VDSL transceiver (with the HPF), as seen from the low pass filter. This substitute circuit shown in figure 3 is a model which shall be applied to a POTS splitter when verifying requirements of the low pass filter. The model is intended for splitter specification in the context of the present document. The purpose of this model impedance is for splitter specification, it is not a requirement on the input impedance of the VDSL transceiver.

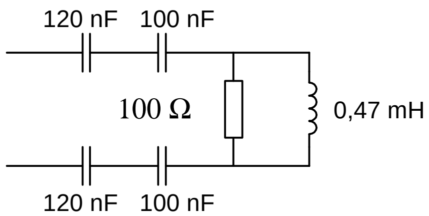


Figure 3: Schematic diagram of the impedance Z_{VDSL-1}

From the perspective of practical testing, the impedance model of figure 3 is valid for the case where the splitter does not contain blocking capacitors or a third order high pass filter. In the case where either of these are present, the impedance network of figure 4 shall be used to terminate the VDSL port of the splitter.

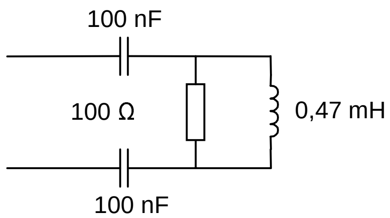


Figure 4: Schematic diagram of Z_{VDSL-2} for the case where there is a high pass filter or blocking capacitors present in the splitter unit

NOTE: The impedance Z_{VDSL} is used in the present document in the case where either Z_{VDSL-1} or Z_{VDSL-2} may be applicable, depending on whether there is a high pass filter or blocking capacitors present in the splitter.

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} is used to terminate the POTS port or the Line port. Z_R is the European harmonized complex impedance as defined in ES 201 970 [9] and TBR 021 [4] , Z_{SL} is an impedance used in TBR 038 [1] to simulate a short line terminated in 600 Ω.

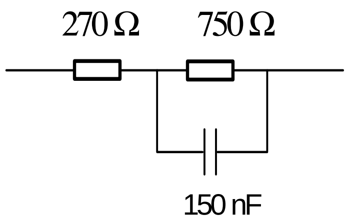


Figure 5: Impedance Z_R

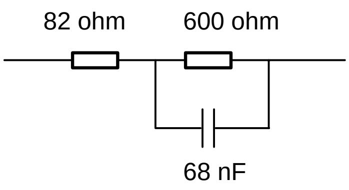


Figure 6: Impedance Z_{SL}

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 VDSL 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 7.

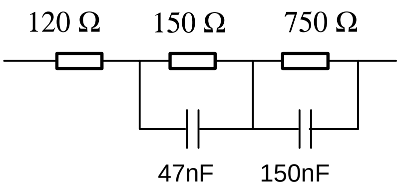


Figure 7: Impedance Z_{RHF}

5.2.4 Z_{ON}

For some on-hook requirements (as defined in clause 5.1.2) described in the present document, the terminating impedance Z_{ON} is used.

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

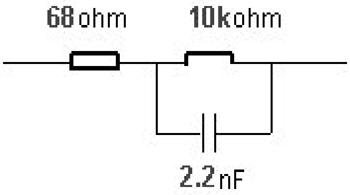


Figure 8: Impedance model to be used for some on-hook requirements

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 setup is valid. This test set-up is given in figures 9 and 10, for measurements at the LINE port and POTS port respectively.

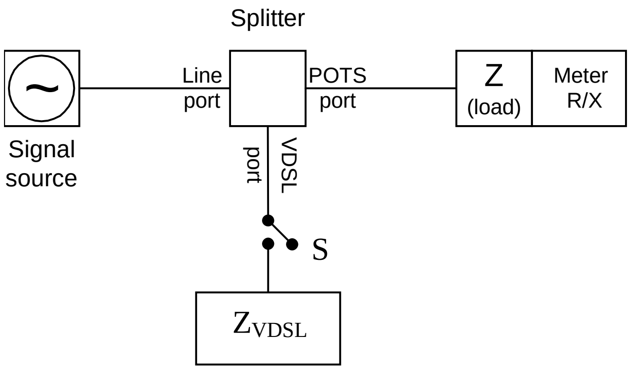


Figure 9: Test set up for transmission testing from LINE to POTS

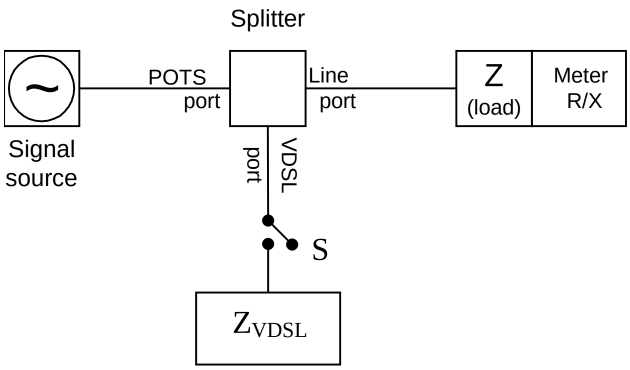


Figure 10: Test set up for transmission testing from POTS to LINE

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. The clauses in question are that specifying pass band return loss requirements in the off-hook state (clause 6.6), and that concerning off-hook isolation (clauses 6.9.2 and 6.10.2).

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

- 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 VDSL interference to the POTS service) motivate a requirement of very high level of isolation.

6.1.2 Option B splitters

- 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 moderate 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

The DC resistance from 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 50 Ω.

NOTE: The issue of defining a V-I characteristic in order to fully specify the DC behaviour of the splitter is currently under study.

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 38V to 78V 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 [12]);
- Reversals in polarity (commonly used in many networks to signal various events to the TE);
- Loop disconnect dialling (specified in ES 201 187 [13]), although DTMF signalling is preferred in combination with ADSL;
- K-break referred to in ES 201 970 [9], clause 14.6;
- CLI and other enhanced signalling, according EN 300 659 [10]; and
- ES 200 778 [11] may also be associated to some special DC signals.

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

6.3 Ringing frequency requirements

The DC feeding conditions of clause 5.1.2 are not applicable to these requirements.

6.3.1 Voltage drop at 25 Hz and 50 Hz

Ringing signals with frequencies of 25 Hz and 50 Hz shall be used.

The maximum voltage drop at the load impedance due to the insertion of one splitter, in the test set-up of figure 9, shall be not more than 2 Vrms. This requirement is valid with the switch S in figure 9 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	2,7 kΩ + 2,2 µF at 25 Hz 2,7 kΩ + 1,0 µF at 50 Hz
Open voltage of the AC test signal source	35 Vrms
Level of the DC feeding voltage	60 V DC

6.3.2 Impedance 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 of not less 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 setup is given in figure 9. This requirement is valid with the switch S in figure 9 both open and closed.

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

Impedance of signal source	850 Ω (resistive)
Impedance of the load	2,7 kΩ + 2,2 µF at 25 Hz 2,7 kΩ + 1,0 µF at 50 Hz
Open voltage of the AC test signal source (test 1)	100 Vrms
Level of the DC feeding voltage (test 1)	50 V DC
Open voltage of the AC test signal source (test 2)	50 Vrms
Level of the DC feeding voltage (test 2)	78 V DC

6.4 Pass band loss requirements (on-hook)

6.4.1 On hook requirement for the case of high impedance injection

The magnitude of the voltage gain of the splitter in the range 200 Hz to 2 800 Hz shall be within the range -4 dB to +4 dB for the on-hook case with high impedance injection. A DC voltage of 50 V shall be used. The test set ups are given in figures 9 and 10. This requirement is valid with the switch S in figures 9 and 10 both open and closed.

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

NOTE: Different test set-ups are used in the case where the splitter is for the LE-side or TE-side (as defined in figure 1).

Table 3: Impedances and test setups for the on hook voltage gain test

Splitter Type	Test setup reference	Impedance of signal source	Impedance of the load
LE	Figure 10	Z_R	Z_{ON}
TE	Figure 9	Z_R	Z_{ON}

Level of the test signal = -4 dBV emf.

6.4.2 On hook requirement for the case of low impedance injection

The requirements of this clause are only applicable to certain networks (see clause 5.1.2).

6.4.2.1 On-hook insertion loss

The insertion loss of one splitter shall be less then 1 dB at 1 kHz for the on-hook case with low impedance injection.

The on-hook pass band insertion loss shall be measured according to both figures 9 and 10 for either an LE or and TE splitter. In either case both the source and load shall be set at 600 Ω. This requirement is valid for DC current in the range from 0,4 mA to 2,5 mA.

This requirement is valid with the switch S in figures 9 and 10 both open and closed.

6.4.2.2 On-hook insertion loss distortion

The absolute difference between the insertion loss at any frequency in the range 200 Hz to 2 800 Hz and the insertion loss at 1 kHz shall be less then 1 dB.

The on-hook pass band insertion loss distortion shall be measured according to both figures 9 and 10 for either an LE or a TE splitter. In either case both the source and load shall be set at 600 Ω. This requirement is valid for DC current in the range 0,4 mA to 2,5 mA.

This requirement is valid with the switch S in figures 9 and 10 both open and closed.

6.5 Pass band loss requirements (off-hook)

6.5.1 Off-hook pass band insertion loss

The insertion loss of one splitter shall be less then 1 dB at 1 kHz.

The test set ups are given in figures 9 and 10. The off-hook passband insertion loss shall be measured according to both figures 9 and 10 for either an LE or a TE splitter. This requirement is valid with the switch S in figures 9 and 10 both open and closed.

Level of the test signal = -4 dBV emf.

The test shall be executed with both combinations of source and load impedances in table 4. The off-hook DC feeding current is specified in clause 5.1.2.

Table 4: Combinations of source and load impedances for the insertion loss test

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

6.5.2 Off-hook passband insertion loss distortion

The absolute difference between the insertion loss at any frequency in the range 200 Hz to 4 000 Hz and the insertion loss at 1 kHz shall be less then 1 dB. The test shall be executed with both combinations of source and load impedances in table 4. The test set-ups are described in figures 9 and 10, the off-hook DC feeding current is specified in clause 5.1.2. This requirement is valid with the switch S in figures 9 and 10 both open and closed.

6.6 Passband return loss requirements (off-hook)

The return loss at both the POTS and LINE port of the splitter shall be measured according to figures 9 and 10. The definition of return loss (for the case of a measurement at the POTS port) is given in figure 11. The return loss requirements are valid with the switch S in figures 9 and 10 both open and closed.

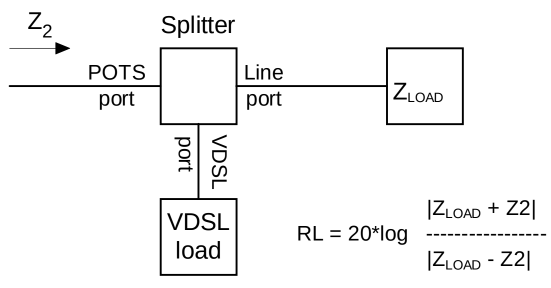


Figure 11: Definition of return loss at the POTS port

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

6.6.1 Return loss requirements options A and B

6.6.1.1 Return loss requirements, option A

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

NOTE: Option A is appropriate for networks where the population of existing terminals or network presentations includes equipment designed against several different reference impedance values (e.g. 600 Ω, harmonized European reference impedance Z_R, other complex impedances), such that it is felt that one single reference impedance is insufficient to accommodate the needs of all terminals and network presentations. Due to the wide range of impedances which are accommodated, the degree of potential degradation of the POTS service introduced by an option A splitter may not be as well controlled as in the case of option B.

Table 5: Return loss requirements, option A

Test #	Value of Z_{LOAD}	Frequency range	Minimum Return Loss
test 1	Z_{SL}	300 Hz to 3 400 Hz	12 dB
test 2	Z_{SL}	3 400 Hz to 4 000 Hz	8 dB
test 3	Z_R	300 Hz to 3 400 Hz	12 dB
test 4	Z_R	3 400 Hz to 4 000 Hz	8 dB
NOTE: A value of 14 dB for the minimum Return Loss instead of 12 dB is desirable.			

6.6.1.2 Return loss requirements, option B

The device shall meet the return loss requirements specified in figure 12.

NOTE: Option B is 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.

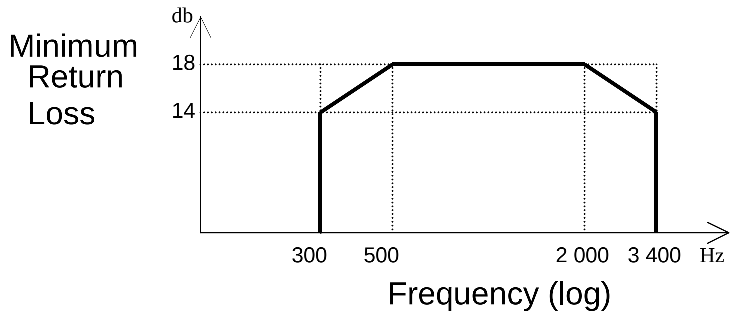


Figure 12: Minimum return loss template for option B

For the case of option B, Z_{LOAD} in figure 11 shall be Z_R.

6.7 Requirements relating to metering pulses at 12 kHz or 16 kHz

In the case where pulse metering signals are deployed on the same lines as VDSL, 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 of in the range 3 dB to 5 dB per splitter should be suitable for many European networks.

The test set up of figures 9 and 10 shall be used, using the condition of table 6. The level of the test signal is 3,5 Vrms. 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 9 and 10 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 9 and 10)	Impedance at the VDSL port
3,5 Vrms	200 Ω	200 Ω	Z_{VDSL}

NOTE: This is an optional requirement, and can increase the complexity of the low pass filter implementation.

6.8 Unbalance about Earth

The basic test set-up for measuring unbalance at the POTS port is shown in figure 13. In the case of measuring at the LINE port, the test set-up of figure 13 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 on hook and off hook cases. DC feeding is as specified in clause 5.1.2. In the case of performing measurements at frequencies above the voiceband, for reasons of practical testing a 150 Ω impedance should be used in series with the longitudinal source (i.e. S1 in figure 13 should be open).

Table 7: Unbalance about earth, test setups

Test setup	Source and Measurement	State of S2
1	POTS	open
2	POTS	closed
3	LINE	closed

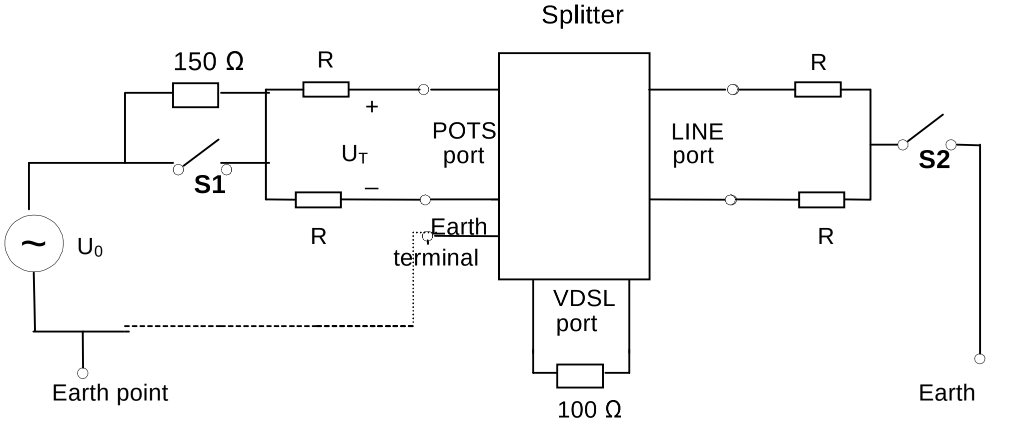
The VDSL port shall be terminated with a 100 Ω resistor for all unbalance tests described in the present document. For each of the test set-ups described above, the splitter shall meet the unbalance about earth requirements as specified in table 8.

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 3 400 Hz	Closed	300 Ω	46 dB
3 400 Hz to 4 000 Hz	Closed	300 Ω	40 dB
4 kHz to 30 kHz	Open	50 Ω	40 dB
30 kHz to 1 104 kHz	Open	50 Ω	45 dB
1 104 kHz to 12 MHz	Open	50 Ω	30 dB

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

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



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.

Figure 13: Unbalance about earth test set-up

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.

6.9 VDSL band requirements

6.9.1 On-hook loss for VDSL over POTS splitters

The value of f_L to be used shall be dependent on the lower corner frequency of the VDSL being deployed. This will be influenced by a number of factors, including whether the VDSL is being deployed from the exchange or a remote cabinet, and also the spectral regulation applicable to the particular network in question. For more information on f_L see clause 8.2 of TS 101 270-1 [8].

138 kHz is considered to be a common value of f_L , however it may be as low as 25 kHz, or may be near the upper VDSL 3dB frequency of 1 104 kHz. The value of f_L may have a very significant influence on the complexity of filter required.

Applying an input test signal of -6 dBV emf to the LINE port of the splitter, the maximum output voltage level measured over the load impedance shall be below the template of figure 14. The DC feeding conditions for the on-hook condition are given in clause 5.1.2.

The test setups are given in figures 9 and 10.

The test shall be executed with the combinations of source and load impedances in table 9.

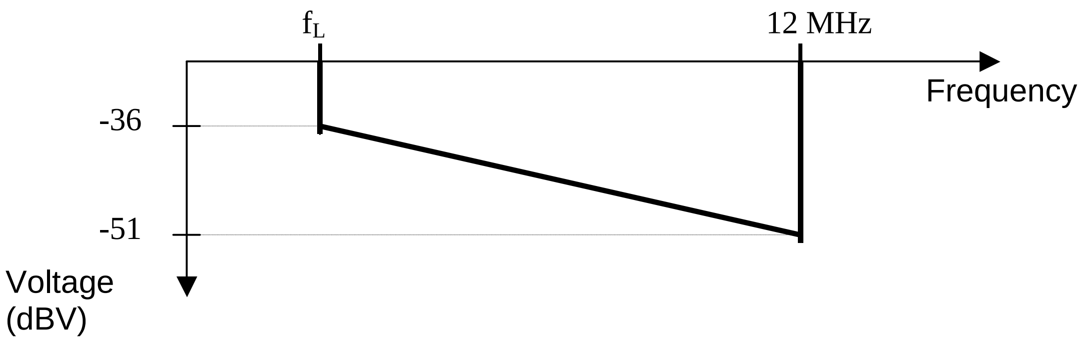


Figure 14: On-hook voltage gain template (maximum allowed output voltage with input of -6 dBV)

Table 9: Load impedances for the on hook isolation test

Splitter Type	Test setup reference	Impedance of the load
LE	figure 9	Z_{ON}
TE	figure 10	Z_{ON}

6.9.2 Off-hook isolation

For the value of f_L see clause 6.9.2.

In the case where the return loss requirement of option A (see clause 6.6.1.1) is used in specifying the splitter, the off-hook isolation requirement of table 10 shall be fulfilled.

In the case where the return loss requirement of Option B (see clause 6.6.1.2) is used in specifying the splitter, the off-hook isolation requirement of table 11 shall be fulfilled.

The test setups to be used are given in figures 9 and 10, i.e. the isolation is to be measured at both the POTS and LINE ports. The off-hook DC feeding conditions are specified in clause 5.1.2. 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 with ZRHF.

Table 10: Isolation, minimum value in the case of return loss option A

Frequency range	Minimum value
f_L to 12 MHz	55 dB

Table 11: Isolation, minimum value in the case of return loss option B

Frequency range	Minimum value
f_L to 138 kHz (see note)	45 dB
138 kHz to 12 MHz	55 dB

NOTE: In the case where f_L is greater than or equal to 138 kHz, only the 55 dB requirement applies.

- Impedance of signal source = $Z_{RHF;}$
- impedance of the load = $Z_{RHF;}$
- level of the test signal = -6 dBV emf.

6.10 Noise

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

6.10.1 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 VDSL port is terminated with the VDSL load as defined in clause 5.2.1.

6.10.2 VDSL band noise level

In the case of a LE splitter, the noise in the frequency range f_L kHz to 12 MHz due to the splitter, measured at the both the DSL port and at the LINE port, should be less than -125 dBm/Hz measured in a bandwidth of 10 kHz.

In the case of a TE splitter, the noise in the frequency range f_L kHz to 12 MHz due to the splitter, measured at the both the DSL port and at the LINE port, should be less than -140 dBm/Hz measured in a bandwidth of 10 kHz.

The test set-ups of figures 15 and 16 shall be used.

NOTE: It assumed that the splitter contains no blocking capacitors or high pass filter. In the case where either of these is present, the termination at the VDSL port shall be modified according to figure 4.

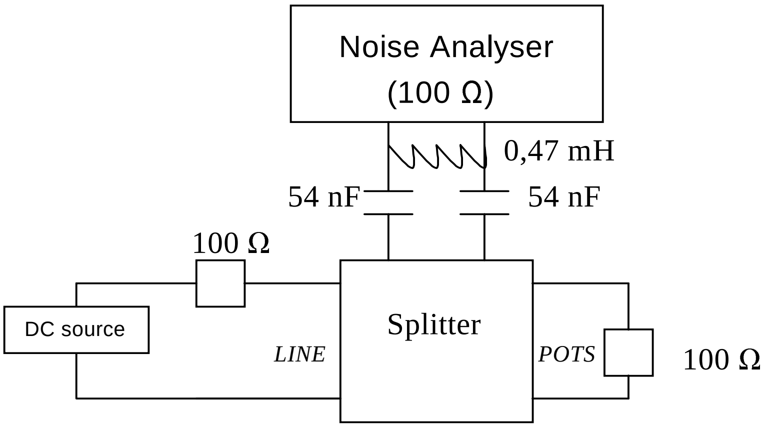


Figure 15: Test set-up for measuring VDSL band noise at the VDSL port

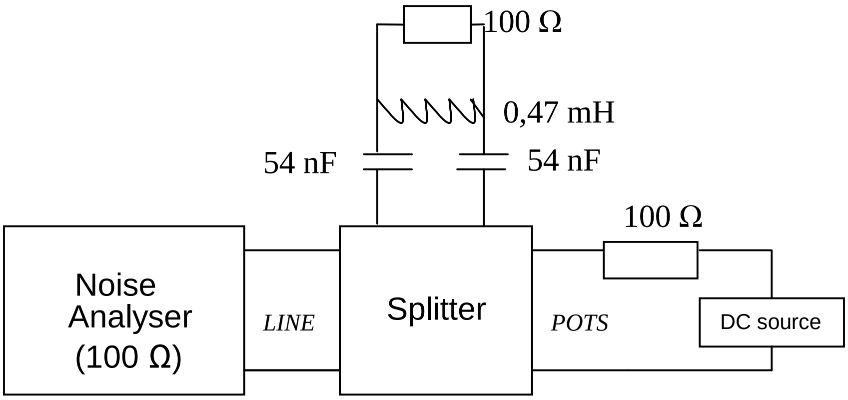


Figure 16: Test set-up for measuring VDSL band noise at the LINE port

6.11 Distortion

6.11.1 POTS band intermodulation distortion

The test setup to be used is given in figure 9. This requirement is valid with the switch S in figure 9 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 at a level of -9 dBm, 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 an VDSL signal is currently under study. This would represent a more realistic scenario for splitter evaluation.

6.12 Group delay distortion

The increase of the group delay distortion by inserting one splitter shall be less than the figures in table 12, relative to the lowest measured delay in the frequency range 300 Hz to 4 000 Hz.

Table 15: Group delay distortion, maximum values

Frequency range	Maximum value
200 Hz to 600 Hz	250 μs
600 Hz to 3 200 Hz	200 μs
3 200 Hz to 4 000 Hz	250 μs

- Impedance of signal source = 600 Ω (test 1)/Z_R (test 2);
- impedance of the load = 600 Ω (test 1)/Z_R (test 2);
- level of the test signal = -10 dBV.

The set-up for measuring group delay distortion is given in figure 9. This requirement is valid with the switch S in figure 9 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

The test set-up is shown in figure 17. It consists of a switch with an on/off transition time 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 1 000 Ω, 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 1: A possible implementation of switch S_1 is given in TR 101 728 [5].

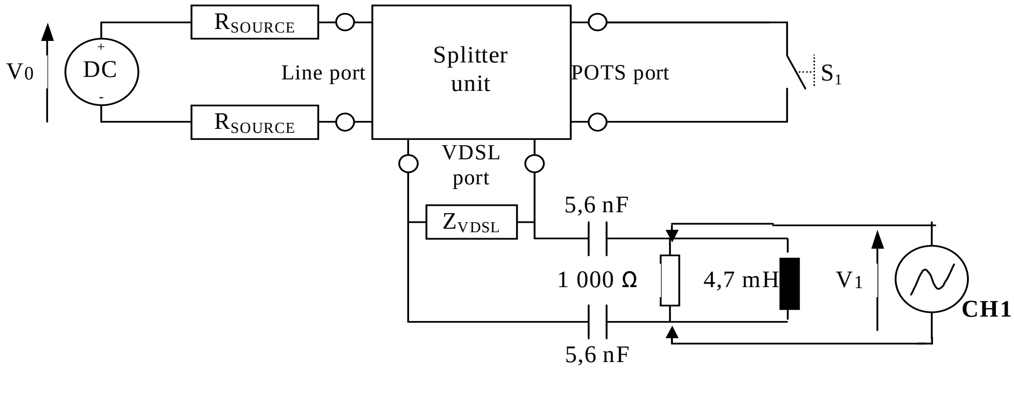


Figure 17: Test circuit for large signal test

NOTE 2: 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 A (informative): Bibliography

ITU-T Recommendation G.992.1: "Asymmetric Digital Subscriber Line (ADSL) transceivers".

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

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".

History

Document history		
V1.1.1	November 2002	Publication