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Access network xDSL transmission filters; Part 1: ADSL splitters for European deployment; Sub-part 5: Specification for ADSL over POTS distributed filters

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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 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: "Specification of the low pass part of ADSL/POTS splitters";

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/POTS distributed splitters";

Part 2: "VDSL splitters for European deployment".

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 "ADSL over POTS" distributed filters. These filters at the user side of the local loop in the customer premise.

NOTE: It is also recognized that distributed filters may be used in deployments where higher frequency services are present, such as home networking signals or VDSL. Notes in the text of the present document refer to the appropriate modification of the electrical requirements necessary to accommodate these high frequency services.

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] 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 300 659-1: "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; Part 1: On-hook data transmission".

[11] ETSI ES 200 778-1: "Analogue access to the Public Switched Telephone Network (PSTN); Protocol over the local loop for display and related services; Terminal Equipment requirements; Part 1: On-hook data transmission".

[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".

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

active filters: filters whose filtering function is implemented using some active components, not including exclusively passive filter implementations containing line state detection circuitry

distributed filter: 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.

dual state filters: filters whose transfer function varies significantly depending on some external influence (e.g. the presence of line current)

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.

passive filters: filters 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

single state filters: filters whose transfer function does not display significant dependence on external influences (e.g. the presence of line current)

3.2 Abbreviations

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

AC	Alternating Current
ADSL	Asymmetric Digital Subscriber Line
CLI	Caller Line Identification
DTMF	Dual Tone Multi-Frequency
DC	Direct Current
DSL	Digital Subscriber Line
DUT	Device Under Test
HPF	High Pass Filter
ITU	International Telecommunication Union
NTP	Network Termination Point
POTS	Plain Old Telephone Service
PSTN	Public Switched Telephone Network
SLIC	Subscriber Line Interface Circuit
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 ADSL over POTS distributed filters

The main purpose of the ADSL over POTS distributed filter is to protect voice band terminal equipment 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 ADSL service due to fluctuations in impedance and linearity that occur when telephones change operational state (e.g. from off-hook to on-hook). The differences between a distributed filter and a master splitter (the latter being specified in sub part 1-1 of this multi-part) are defined more by the location of the filter rather than the function. Master splitters are designed to be located at the demarcation point of the customer premise, and provide separation of POTS and ADSL signals at a single location. Distributed filters on the other hand are placed in series with each piece of voice grade terminal equipment. Thus distributed filters are two port devices, as seen in figure 1 (master splitters have three ports). Hence the ADSL signals are delivered over the entire premise wiring and voice grade equipment is protected by distributed filters. Multiple filters will typically be used in a customer premise, as shown in figure 1.

4.1 Functional diagram

The functional diagram for distributed filters is given in figure 1. The filters specified by the present document are intended to be connected only in series with the POTS TE. Operation is not specified for serial stacking (i.e. connecting one distributed filter in series with another distributed filter).

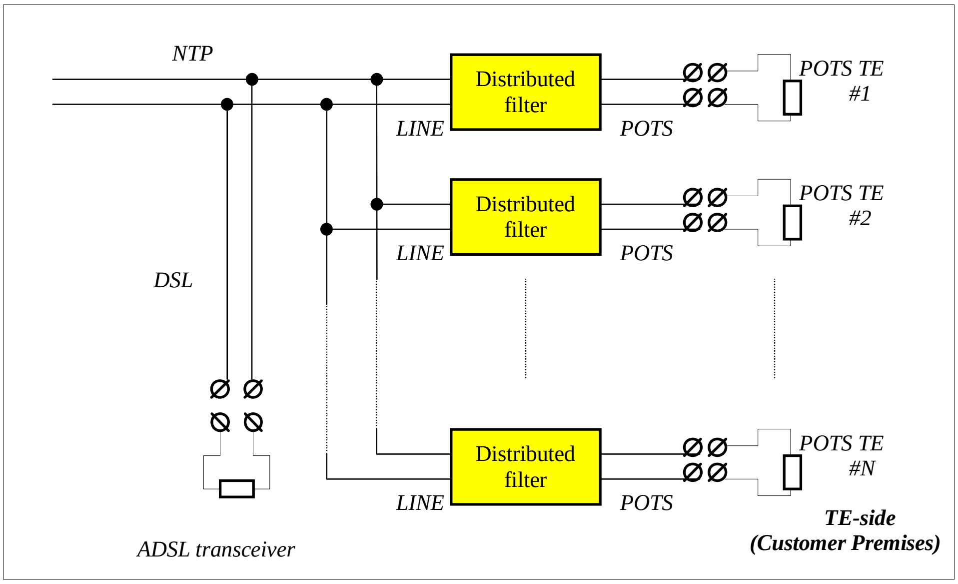


Figure 1: Functional diagram of the DSL splitter configuration

The transfer function between the POTS port and LINE port (and vice-versa) of each filter is that of a low pass 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).

5.1.2.1 DC feeding for single state filters

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.

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.

5.1.2.2 DC feeding for dual state filters

DC feeding for active splitters is specified in annex A. Due to the potential degradation in filter performance due to the loading effect of parallel filters, dual-state devices may be used (i.e. devices whose transfer characteristic depends on the state of the attached TE). For this reason the conditions of DC feeding for distributed filters are critical. DC feeding conditions are detailed in annex A.

5.2 Terminating impedances

5.2.1 Z_{DSL-1}

In many of the tests with voice frequencies, an impedance called $Z_{DSL-1}$is used. This impedance model represents the input impedance of the DSL transceiver (with the HPF), as seen from the low pass filter. This substitute circuit shown in figure 2 is a model which shall be applied to a distributed filter when verifying electrical requirements. The model is intended for filter specification in the context of the present document. This is not a requirement on the input impedance of the DSL transceiver.

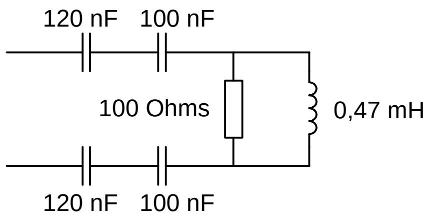


Figure 2: Schematic diagram of the impedance Z_{DSL-1}

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} 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 21 [4], Z_{SL} is an impedance used in TBR 038 [1] to simulate a short line terminated in 600 Ω.

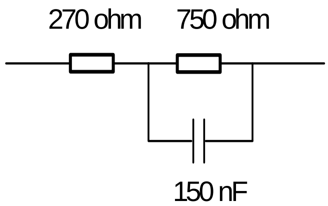


Figure 3: Impedance Z_R

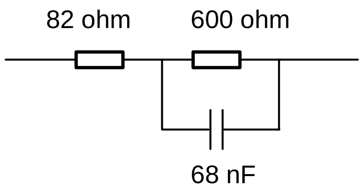


Figure 4: Impedance Z_{SL}

NOTE: In the case of filters 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 ADSL frequencies described in the present document, the terminating impedance Z_{RHF} is used to terminate POTS and LINE ports of the distributed 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.

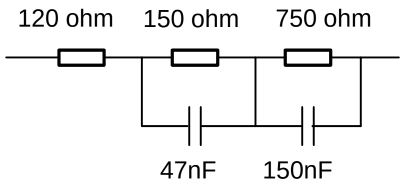


Figure 5: Impedance Z_{RHF}

5.2.4 Z_{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. This impedance is valid at AC frequencies only.

Actual impedances will vary greatly especially over the ADSL 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.

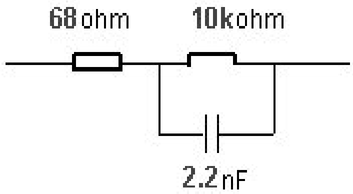


Figure 6: Impedance model to be used for some on-hook requirements

5.3 General transmission test setup

For many of the transmission related tests that are specified in the present document, a common general test setup is valid. This test setup is given in figures 9 and 10, for measurements at the LINE port and POTS port respectively.

The number of parallel filters to be used in the test setups is N-1. The maximum number of parallel filters that can be connected, for which the electrical requirements of the present document are fulfilled, shall be specified by the manufacturer.

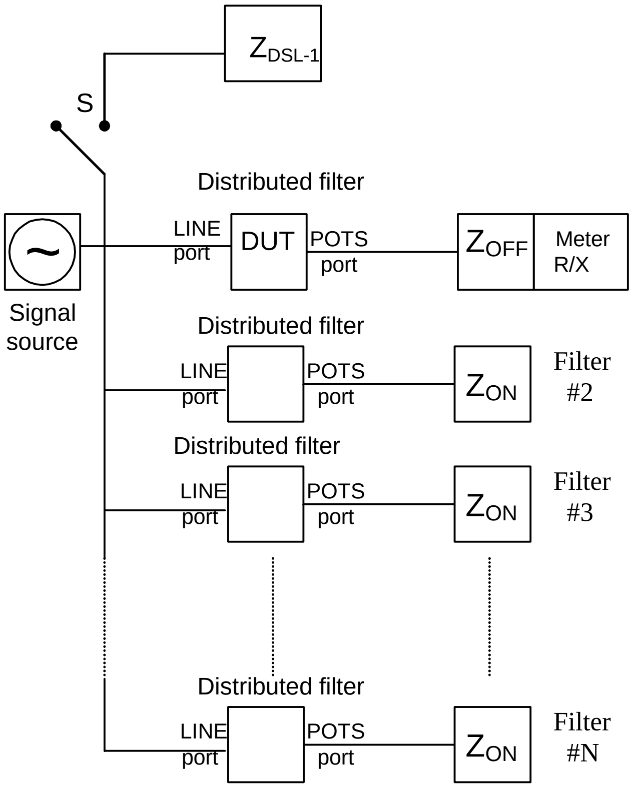


Figure 7: Test set up for transmission testing from LINE to POTS

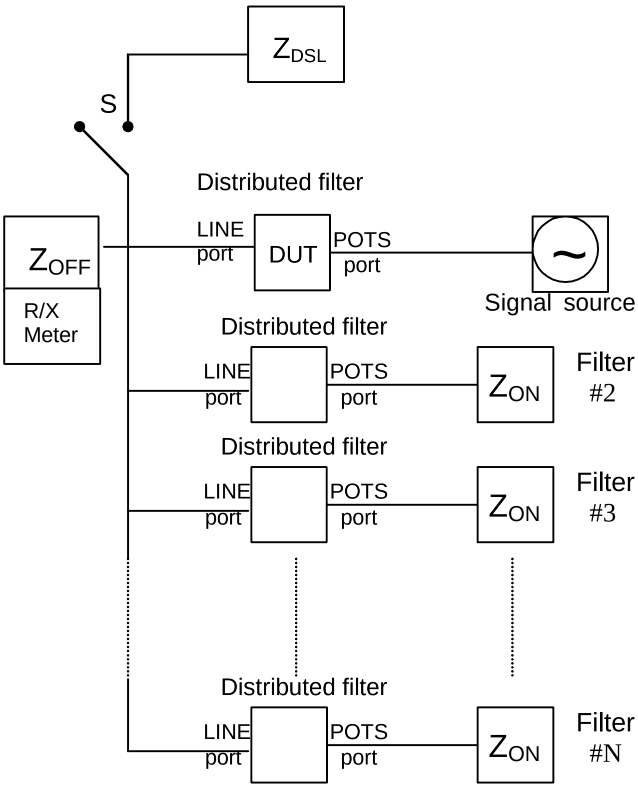


Figure 8: Test set up for transmission testing from POTS to LINE

6 Distributed filter requirements

6.1 Options for filter 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 (see clause 6.6), and that concerning off-hook isolation (see 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 distributed filter. These can be broadly considered as in clauses 6.1.1 and 6.1.2.

6.1.1 Option A distributed filters

- Option A filters 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 filters are considered to be appropriate to networks where concerns of potential interference between services (e.g. audible DSL interference to the POTS service) motivate a requirement of very high level of isolation.

6.1.2 Option B distributed filters

- Option B filters 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 filter and earth, when tested with 100 V DC, shall not be less than 100 MΩ.

This test should be performed while the filter is placed on an earthed metal plate of a sufficiently large size.

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 filter, when tested with 100 V DC, shall not be less than 25 MΩ.

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.

This requirement is applicable to distributed filters that contain only passive circuitry. In the case of dual state filters, this requirement is for further study.

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 strongly 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 200 778-1 [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: Detailed specification in this area is for further study.

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 filter, i.e. that marked "DUT" in the test setup of figure 7, shall be not more than 2 Vrms. This requirement is valid with the switch S in figure 7 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 filter 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 the other port is open circuit.

6.3.3 Total harmonic distortion at 25 Hz and 50 Hz

The filter 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 7. This requirement is valid with the switch S in figure 7 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 load

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. The DC feeding shall be as specified in clause 5.1.2 for the on-hook case. 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.

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

Test setup reference	Impedance of signal source	Impedance of the load
Figure 7	Z_R	Z_{ON}
NOTE: Level of the test signal = -4 dBV emf.		

6.4.2 On hook requirement for the case of low impedance load

The requirements of this clause are only applicable to certain networks. These networks use DTMF transmission as specified in annex A of ES 200 778-1 [11]. In this case , considering a number of parallel receivers, the equivalent AC impedance could be as low as 600 Ω.

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 figure 7. Both the source and load shall be set at 600 Ω. The DC feeding shall be as specified in clause 5.1.2 for the on-hook case.

This requirement is valid with the switch S in figure 7 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 figure 7. Both the source and load shall be set at 600 Ω. The DC feeding shall be as specified in clause 5.1.2 for the on-hook case.

This requirement is valid with the switch S in figure 7 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 filter 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. 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

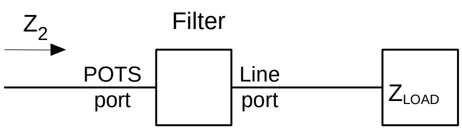
Source/Load combination	Impedance of signal source	Impedance of the load
Combination 1	Z_R	Z_R
Combination 2	600 Ω	600 Ω

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



$$RL = 20 \times \log \frac{|Z_{LOAD} + Z2|}{|Z_{LOAD} - Z2|}$$

Figure 9: Definition of return loss at the POTS port

There are two options for return loss testing. 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 filter 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 10.

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.

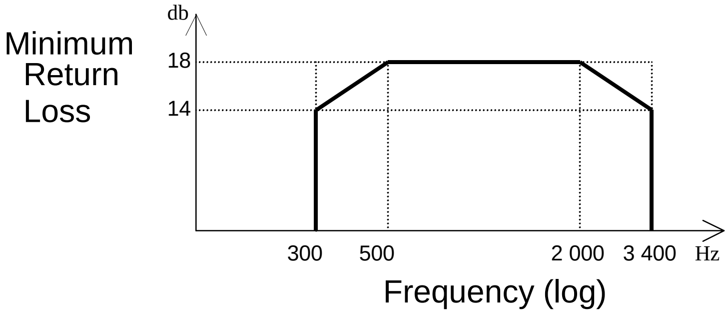


Figure 10: Minimum return loss template for Option B

For the case of Option B, Z_{LOAD} in figure 9 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 ADSL, the insertion loss due to the filter 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 3 dB to 5 dB per filter 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 the DC feeding 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 or16 kHz

Level of source voltage	Impedance of signal source	Impedance of the load (Z in figures 9 and 10)	Impedance at the ADSL port
3,5 Vrms	200 Ω	200 Ω	Z_{DSL}
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 setup for measuring unbalance at the POTS port is shown in figure 11. In the case of measuring at the LINE port, the test setup 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, with the DC feeding conditions 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 11 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

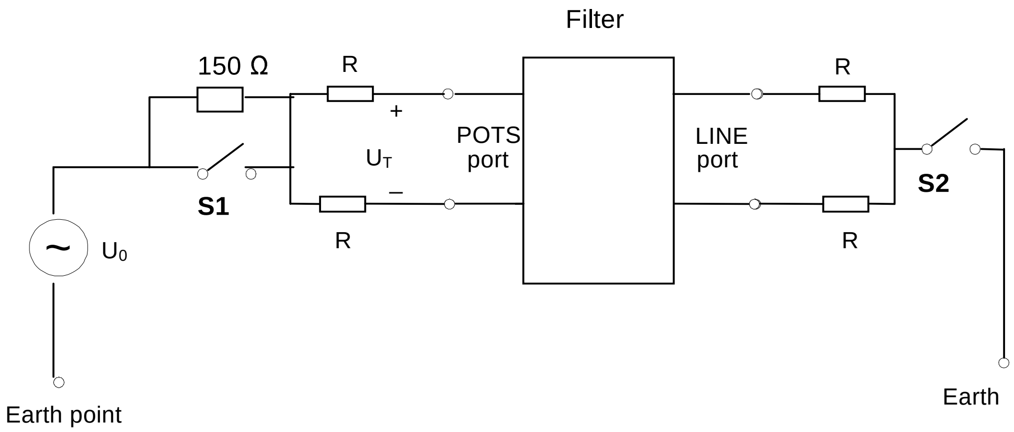
For each of the test setups described above, the splitter shall meet the unbalance about earth requirements as specified in table 8.

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 5 MHz	Open	50 Ω	30 dB
NOTE: In the case where the filter is to be used with high frequency services such as home networking signals or VDSL, the 30 dB minimum requirement for unbalance is valid up to at least 12 MHz.			

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 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 2: For resistances R an equivalent circuit according to ITU-T Recommendation O.9 [7] can be used.

Figure 11: Unbalance about earth test setup

The test should be performed while the filter is placed on an earthed metal plate of a sufficiently large size.

6.9 ADSL band requirements

6.9.1 On-hook loss

The on-hook DC feeding conditions are specified in clause 5.1.2.

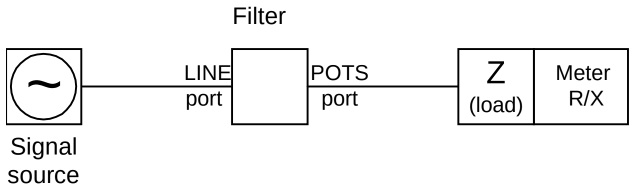
Table 9: Isolation, minimum values

Frequency range	Minimum value
32 kHz to 350 kHz	34 dB
350 kHz to 1 104 kHz	55 dB

The test setup is given in figure 12.

- Impedance of signal source = Z_{RHF};
- Impedance of the load = Z_{ON};
- Level of the test signal = -6,0 dBV emf.

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 at the POTS port.



NOTE: In the case where the filter is to be used with high frequency services such as home networking signals or VDSL, the on hook loss requirement is valid up to 12 MHz.

Figure 12: On-hook isolation test setup

6.9.2 Off-hook isolation

In the case where the return loss requirement of Option A (see clause 6.6.1.1) is used in specifying the filter, 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 filter, 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.

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

Frequency range	Minimum value
32 kHz to 1 104 kHz	55 dB

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

Frequency range	Minimum value
32 kHz to 138 kHz	45 dB
138 kHz to 1 104 kHz	55 dB

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

NOTE: In the case where the filter is to be used with high frequency services such as home networking signals or VDSL, the off hook loss requirement is valid up to 12 MHz.

6.9.3 Line side impedance

The low pass filter should present an impedance to the line side of at least 1 000 Ω for the frequency range 32 kHz to 1 104 kHz. This requirement should apply with the POTS port terminated in $Z_{RHF.}$

NOTE: In the case where the filter is to be used with high frequency services such as home networking signals or VDSL, the line side impedance requirement is valid up to 12 MHz.

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 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 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 filter, 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.

6.10.2 ADSL band noise level

The noise in the frequency range 26 kHz to 1 104 kHz due to the filter, measured at the LINE port, should be less than -140 dBm/Hz measured in a bandwidth of 10 kHz.

NOTE: In the case where the filter is to be used with high frequency services such as home networking signals or VDSL, the noise requirement of clause 6.10.2 is valid up to 12 MHz.

The test setup of figure 13 shall be used.

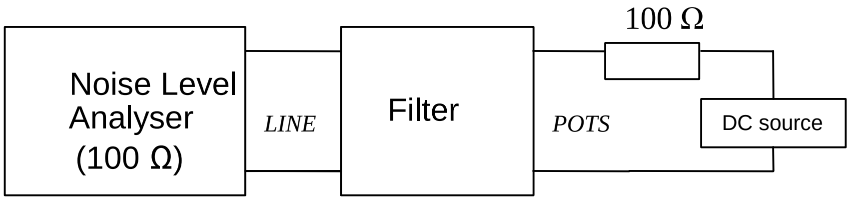


Figure 13: Test setup for measuring ADSL band noise at the LINE port

6.11 Distortion

6.11.1 POTS band intermodulation distortion

The test setup to be used is given in figure 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 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 ADSL signal is currently under study. This would represent a more realistic scenario for filter evaluation.

6.12 Group delay distortion

The increase of the group delay distortion by inserting one filter 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 12: 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.

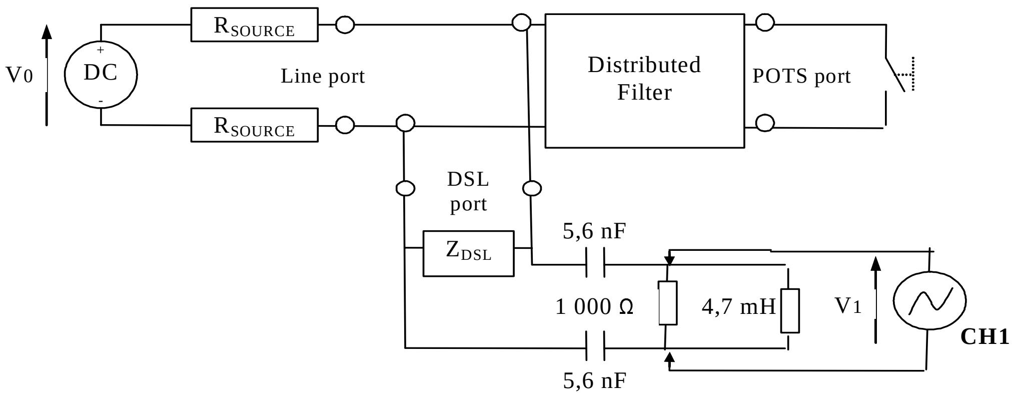
The setup for measuring group delay distortion is given in figure 7. This requirement is valid with the switch S in figure 7 both open and closed. The DC feeding current is specified in clause 5.1.2. This requirement is valid for both the on hook and off hook conditions.

6.13 Requirements related to POTS transient effects

The test setup is shown in figure 14. 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: A possible implementation of switch S_1 is given in TR 101 728 [5].



NOTE: 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.

Figure 14: Test circuit for large signal test

Annex A (normative): DC feeding and holding for dual state filters

In practice the DC feeding circuitry used by SLICs will generally be either resistive (i.e. a constant voltage source followed by feed resistances), or constant current. The technique actually used will depend both on the technology of the SLIC, and also on the length of the line (longer lines will use resistive feeding as the voltage required for constant current feeding can be insufficient to maintain the necessary biasing for the drivers in the SLIC). Many modern POTS line cards can provide either type of feeding.

It is necessary to test a dual state filter with both types of DC feeding due to the typically sensitive dependence of the filter characteristics on the DC signals present.

- The filter must be tested with resistive feeding in order to ensure that it will operate at in the lower DC current range.
- Conversely, although a filter may work well in the case of resistive feeding (where the effective operating point is a compromise between the feed and load characteristic), it could still present issues of stability with constant current feeding (where the operating point is effectively fixed by the feeding circuitry).

A.1 Case of resistive feeding

It is considered that a 50 V DC source is suitable for performing filter tests.

The DC behaviour of an on hook TE is modelled by a 1 MΩ resistor. For the off hook case, the DC behaviour of the TE is modelled by figure 3 of ITU-T Recommendation O.42 [3]. The capacitor of figure 2 is intended to model some transient switching effects.

In terms of the DC resistance of the line, this can be modelled by a variable resistor. Typical maximum DC resistance values for ADSL vary between networks, however 1,2 kΩ is considered to be an acceptable value of Europe.

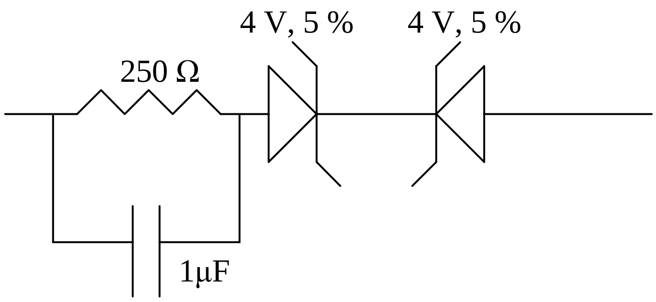


Figure A.1: Simplified model of the TE in the off hook case for the purpose of DC feeding

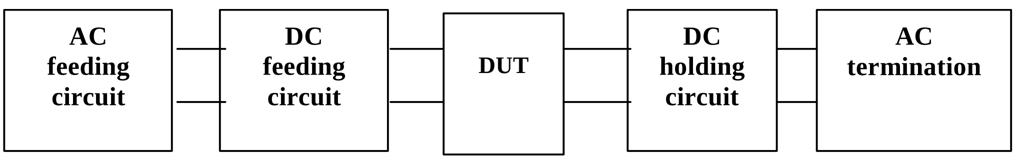


Figure A.2: Block diagram showing positioning of DC feed circuitry in a typical test setup

In the circuit of figure A.2, both the DC feeding circuits and holding circuits are functionally high pass filters with a very low cut-off frequency, the concept being to limit the DC current to the "inner loop" while being transparent at higher frequencies.

A.1.1 Resistive DC feeding for a distributed filter

The setups of figures A.3 and A.4 can (see note below) be used for DC feeding and holding circuitry (to be inserted in the full test setup as in figure A.2) for the case of a CPE filter.

NOTE: The implementation of the feeding and holding circuits with inductive components is generally used for voice frequency testing. In the case of higher frequency testing, it may be necessary to use a variation on the feeding and holding circuitry shown (e.g. implementing the inductive component with multiple series magnetics). The issue of validation of the behaviour of these circuits in the frequency bands relevant to the electrical requirements on the filter is for further study.

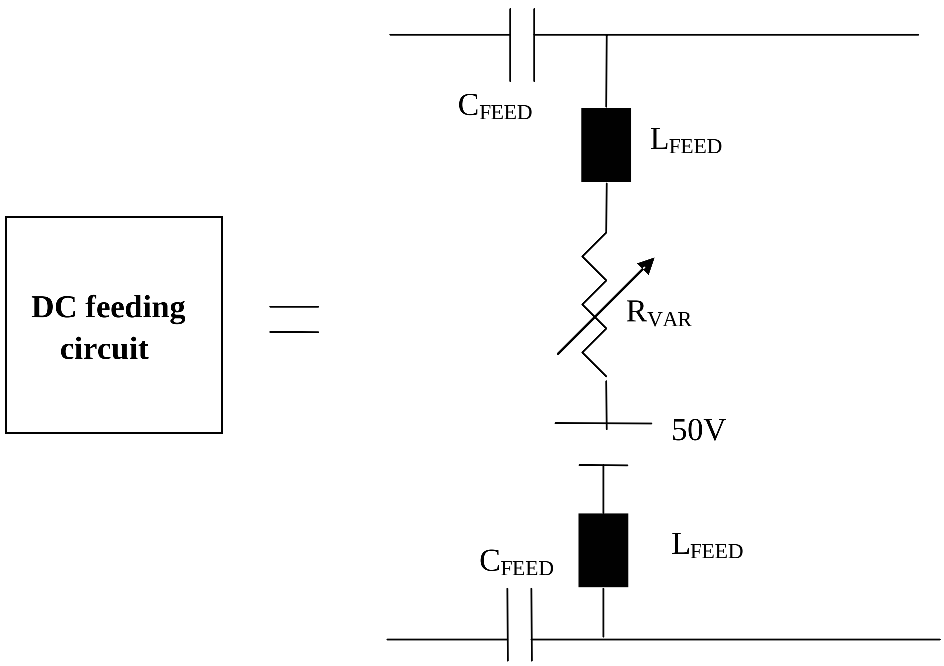


Figure A.3: DC feeding circuit for resistive feeding for a distributed filter

The DC resistance of the feed coils should be specified to be a nominal value, and the value of R_{VAR} should be set in order to model the pre-specified loop resistance. It is considered that 0 Ω to 1,2 kΩ would be an appropriate range of R_{VAR}.

L_{FEED} will typically be partially made up by an inductor be in the range 5 H to 10H [12].

C_{FEED} will typically be in the range 2 µF to 100 µF [12].

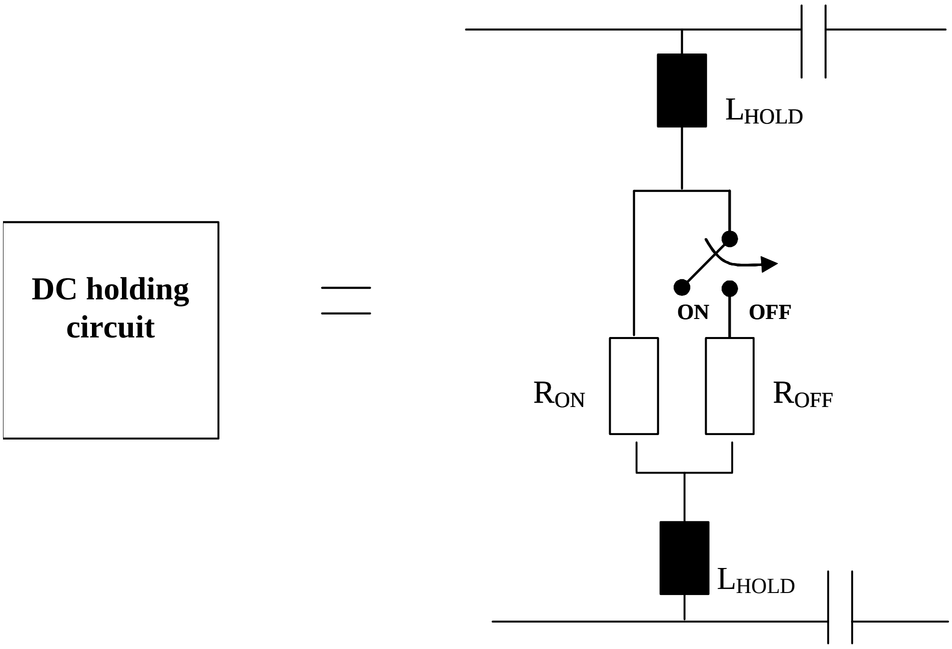


Figure A.4: DC holding circuit for resistive feeding for a distributed filter

The DC resistance of the hold coils should be specified to be a nominal value, and the value of R_{ON} should be set to give a total DC resistance (between the a-wire and the b-wire wire) of 1 MΩ when the switch is in the "ON" position. In practice a resistor of 1MΩ is suitable for R_{ON}, as the effect of the resistance of the hold coils should be negligible compared to this.

NOTE: The appropriate limits on the timing characteristics for the switch of figure A.4 can be found in clause 4.6.2 of TBR 21 [4].

The value R_{OFF} should be set to give a total DC resistance (between the a-wire and the b-wire wire) equal to that of figure 3 when the switch is in the "OFF" position.

A.2 Case of constant current feeding

In this case it is assumed that verification of the filter at one operating point is sufficient The DC feed circuitry in this case can be as shown in figure A.5.

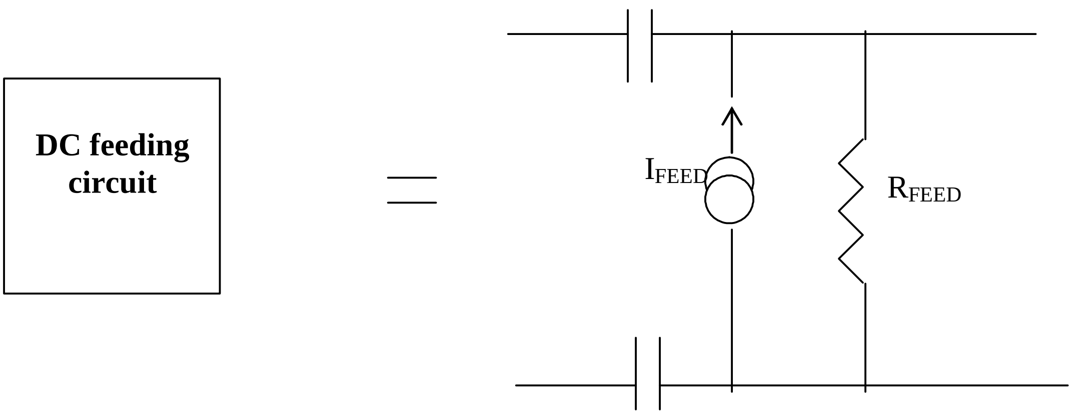


Figure A.5: Simplified DC representation of the DC feeding circuit for constant current feeding

Here the feed resistor should be around 10 kΩ, and the constant current source should be set to 40 mA. The holding circuit of figure A.4 (see note below) is also appropriate.

NOTE: The implementation of the feeding and holding circuits with inductive components is generally used for voice frequency testing. In the case of higher frequency testing, it may be necessary to use a variation on the feeding and holding circuitry shown (e.g. implementing the inductive component with multiple series magnetics). The issue of validation of the behaviour of these circuits in the frequency bands relevant to the electrical requirements on the filter is for further study.

A.3 Test method

The filter should first be connected to the DC feeding circuitry with the switch (in figure A.4) in the "ON" position. In order to verify off-hook behaviour, the switch of figures A.4 and A.5 should be moved to the "OFF" position and the relevant testing carried out. In order to verify the on-hook behaviour the switch of figure 3 should be moved back to the "ON" position and the relevant testing carried out. This method will remove ambiguity concerning the reliance of tests results on the pre-history of the test.

The resistive feeding tests should be performed with various values or R_{VAR}, and the current at each value (in both the on-hook and off-hook case) should be recorded. It needs to be ensured that this current complies with the relevant requirement on terminal equipment in ITU-T Recommendation O.42 [3]. For the constant current feeding, the current source should be set at 40 mA.

Annex B (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 ES 201 187: "2-wire analogue voice band interfaces; Loop Disconnect (LD) dialling specific requirements".

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	May 2003	Publication