ETSI TS 101 952-2 V1.1.1 (2010-11)

Technical Specification

Access, Terminals, Transmission and Multiplexing (ATTM); Access network xDSL splitters for European deployment; Part 2: Generic specification of xDSL over ISDN splitters and xDSL universal splitters

Reference
RTS/ATTM-06011

Keywords
ADSL, ADSL2, ADSL2plus, ISDN, POTS, splitter
VDSL, VDSL1, VDSL2

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

Important notice

Individual copies of the present document can be downloaded from:
http://www.etsi.org

The present document may be made available in more than one electronic version or in print. In any case of existing or perceived difference in contents between such versions, the reference version is the Portable Document Format (PDF). In case of dispute, the reference shall be the printing on ETSI printers of the PDF version kept on a specific network drive within ETSI Secretariat.

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at
http://portal.etsi.org/tb/status/status.asp

If you find errors in the present document, please send your comment to one of the following services:
http://portal.etsi.org/chaircor/ETSI_support.asp

Copyright Notification

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, Terminals, Transmission and Multiplexing (ATTM).

The present document is **part 2** of a multi-part deliverable covering Access network xDSL Transmission Filters, as identified below:

Part 1: "Generic specification of xDSL over POTS splitters";

Part 2: "Generic specification of xDSL over ISDN splitters and xDSL universal splitters";

Part 3: "Generic specification of distributed filters for xDSL over POTS";

Part 4: "Additional specification for dynamic distributed filters for xDSL over POTS" (under study).

NOTE 1: The present document is derived by merging and complementing 3 older, existing specifications, which were numbered according to the older structure of the splitter documents. Before the publication of the 3 or 4 parts as described above, the TS 101 952 was composed of 2 parts, which discriminated between ADSL and VDSL, with several subparts. For reasons of simplicity the TS is now restructured as a set of only 3 (potentially 4) documents, intended for both ADSL and VDSL when applicable. The older structure of the documents is explained in informative Annex B.

NOTE 2: Useful information on splitter tests may be found in TR 101 953-1-1 [i.3], TR 101 953-1-2 [i.4], TR 101 953-1-3 [i.5], TR 101 953-2-1 [i.6], TR 101 953-2-2 [i.7] and TR 101 953-2-3 [i.8]. These documents are linked to the previous versions of the splitter specifications. The TR 101 953 multi-part [i.3], [i.4], [i.5], [i.6], [i.7] and [i.8] e.g. describe the combination of the AC testing conditions of the test set-ups with the DC conditions controlled via feeding and loading bridges. The TR 101 953 multi-part [i.3], [i.4], [i.6] and [i.7] are intended for splitter over POTS, but also applicable to universal splitters. TR 101 953-1-3 [i.5] and TR 101 953-2-3[i.8] are intended for splitters over ISDN. If there is a discrepancy between the present document and the older TR 101 953 series of documents, the present document prevails.

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 covers all xDSL system variants, such as ADSL1, ADSL2, ADSL2plus, VDSL1 and VDSL2. It is applicable at the Local Exchange (LE) (i.e. network) side of the line at the LE or at the cabinet and at the Terminal Equipment (TE) (i.e. user) side of the line. A number of limitations and remarks should be listed:

1) The use of the present document is extended to splitters at the cabinet for both the POTS case (universal splitters) and the ISDN-only case, as explained in Annex C. However, this extension has to be applied with care in the case of ISDN. But, as explained in Annex C also, there is evidence that the splitters tested according to the present document will perform satisfactorily when used at the cabinet.

2) The present document covering the xDSL over ISDN or the Universal splitters was gained from the experience with passive and static xDSL splitters, the original state of the art for this application. Furthermore, 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. However, in the note under table A.3 an optional diversification between splitters requirements at the two sides of the line is described. For the TE side splitters an *optional* variant could be allowed with better downstream protection, with less IL in the upstream band and more IL in the downstream band. Similar differentiation between LE and TE is possible for the balance requirements; see the note under table A.10.

3) The present document covering xDSL over POTS splitters is limited to passive and static splitters. 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/dynamic splitters require different and additional requirements and test methods to be specified. The full specification of requirements for active/dynamic splitters is F.F.S. (for further study).

4) For certain static properties in the present document it is possible to relax the requirements and prove in dynamic tests that the splitter performs sufficiently well. These dynamic tests are compiled in TR-127, by the Broadband Forum. The use of the TR-127 methodology for this purpose is outside the scope of this version of the present document. The TR-127 could prove useful to introduce splitters with reduced complexity, or active and/or dynamic splitters. The TR-127 methodology for POTS splitters is now published [i.16]. A tutorial text on TR-127 is given in informative Annex H. Finalizing splitter tests in the present document based on TR-127 for ISDN signals and for ISDN and DSL interaction is F.F.S., as the version for ISDN splitters is still under definition in the Broadband Forum.

5) To test distortion, noise and other requirements in the present document the TR-127 methodology is sometime a superior methodology, or even the only feasible method at an acceptable complexity. Indeed, TR-127 will prove that a splitter works correctly in a worst case xDSL test environment, including POTS and ISDN signals. The use of the TR-127 [i.16] methodology for this purpose is introduced for certain clauses in the present document. With such tests, based on actual xDSL transceiver results, one can avoid requirements are either inadequate or potentially unnecessarily strong.

6) The majority of requirements in the present document are generic and applicable to all splitters for xDSL over ISDN or universal splitters over both ISDN and POTS. In the case where any requirements are applicable to only one particular flavour of xDSL, this is clearly indicated in the clause describing the requirement. The relevant information about requirements for specific xDSL system variants is given in Annex A.

1 Scope

The present document specifies requirements and test methods for the low pass and high pass parts of xDSL over ISDN splitters and for xDSL over "ISDN or POTS universal" splitters.

- The xDSL over ISDN splitters allow only ISDN underlying the broadband xDSL band.
- The xDSL over "ISDN or POTS universal" splitter shall support either POTS or ISDN transmission underlying the broadband xDSL band.

These splitters are intended to be installed at the Local Exchange (LE or network) side of the local loop, either at the LE 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" (also called "master splitter") that is intended for use at the demarcation point of the customer premises.

The present document covers the following xDSL variants: ADSL, ADSL2, ADSL2plus, VDSL1 and VDSL2, defined in the relevant ITU-T documents listed in informative references and the bibliography.

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

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

2.1 Normative references

The following referenced documents are necessary for the application of the present document.

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

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

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

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

NOTE: Additional references to ITU-T documents can be found in the Bibliography.

[5] 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)".

[6] ETSI ES 203 021-3: "Access and Terminals (AT); Harmonized basic attachment requirements for Terminals for connection to analogue interfaces of the Telephone Networks; Update of the technical contents of TBR 021, EN 301 437, TBR 015, TBR 017; Part 3: Basic Interworking with the Public Telephone Networks".

NOTE: ETSI TBR 021 has been made historical.

[7] ETSI TS 101 952-1: "Access network xDSL splitters for European deployment; Part 1: Generic specification of xDSL over POTS splitters".

[8] ETSI TS 101 388: "Access Terminals Transmission and Multiplexing (ATTM); Access transmission systems on metallic access cables; Asymmetric Digital Subscriber Line (ADSL) - European specific requirements [ITU-T Recommendation G.992.1 modified]".

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TR 102 139: "Compatibility of POTS terminal equipment with xDSL systems".

[i.2] ETSI TR 101 728: "Access and Terminals (AT); Study for the specification of low pass filter section of POTS/ADSL splitters".

[i.3] 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".

[i.4] 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".

[i.5] ETSI TR 101 953-1-3: "Access network xDSL transmission filters; Part 1: ADSL splitters for European deployment; Sub-part 3: Testing methods for ADSL/ISDN splitters".

[i.6] 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".

[i.7] 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".

[i.8] ETSI TR 101 953-2-3: "Access network xDSL transmission filters; Part 2: VDSL splitters for European deployment; Sub-part 3: Specification of Testing methods for VDSL/ISDN splitters".

[i.9] ITU-T Recommendation G.992.1: "Asymmetric digital subscriber line (ADSL) transceivers".

[i.10] ITU-T Recommendation G.992.3: "Asymmetric digital subscriber line transceivers 2 (ADSL2)".

[i.11] ITU-T Recommendation G.992.5: "Asymmetric Digital Subscriber Line (ADSL) transceivers - Extended bandwidth ADSL2 (ADSL2plus)".

[i.12] ITU-T Recommendation G.993.1: "Very high speed digital subscriber line transceivers".

[i.13] ITU-T Recommendation G.993.2: "Very high speed digital subscriber line transceivers 2 (VDSL2)".

[i.14] ETSI TS 101 952-3: "Access, Terminals, Transmission and Multiplexing (ATTM); Access network xDSL splitters for European deployment; Part 3: Generic specification of distributed filters for xDSL over POTS".

NOTE: TS 101 952-3 is under construction.

[i.15] ETSI TS 101 952-4: "Access, Terminals, Transmission and Multiplexing (ATTM); Access network xDSL splitters for European deployment; Part 4: Additional specifications for dynamic distributed filters for xDLS over POTS (under study)".

NOTE: TS 101 952-4 is F.F.S.

[i.16] Broadband Forum TR-127: "Dynamic Testing of Splitters and In-Line Filters with xDSL Transceivers", Issue 1.

NOTE: Available at: http://www.broadband-forum.org/technical/download/TR-127.pdf.

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

central splitter: splitter that is used to isolate xDSL frequencies from POTS or ISDN frequencies at a single point (often called NTP) at the customer premises (it is also called a master splitter)

dynamic splitter: a splitter changing its transfer behaviour dynamically, e.g. based on the state of the POTS connection

master splitter: See central splitter.

Network Termination Point (NTP): demarcation point between the access pair and the in-house wiring, where often the central splitter (or master splitter) is placed

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 ES 203 021-3 [6]. In the case where multiple TEs are present at the customer end of the loop, then the TE is considered to be off-hook from the perspective of testing the splitter when one terminal is off-hook.

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: See ES 203 021-3 [6]. In the case where multiple TEs are present at the customer end of the loop, then the TE is 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

signature network: circuitry included at the POTS port (called TELE port in the present document) 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

universal splitter: xDSL splitter which can be used with as underlying service either ISDN or POTS below the xDSL signals

xDSL: this term is an abbreviation, limited to the present document. It covers ADSL and VDSL only. E.g. SDSL is not covered by this abbreviation

3.2 Symbols

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

NOTE: Check also the clause 3.3 with abbreviations, and note that some symbols might be only used in figures.

Att_{DB}	Attenuation in the xDSL Band (LINE port to xDSL port or reversed)
C_{DCB}	DC Blocking capacitor as the optional high pass of first order
C_{DSL}	The capacitor C, part of the Z_{DSL-i}
CMRR	Common Mode Rejection Ratio
f_H	Highest of the used frequencies in the xDSL Band
f_L	Lowest of the used frequencies in the xDSL Band
f_{M1}	intermediate frequency, e.g. at the US to DS edge for ADSL
f_{Max}	maximum frequency above xDSL band for measurements
IL_{DBOffH}	Insertion Loss xDSL Band Off-Hook
IL_{IB}	Insertion Loss ISDN Band
IL_{PBOffH}	Insertion Loss POTS Pass Band Off-Hook
IL_{PBOnH}	Insertion Loss POTS Pass Band On-Hook
IL_{TBOffH}	Insertion Loss Transition Band, only measured in Off-Hook
IMD_{PB}	InterModulation Distortion in the POTS Band
IMD_{IB}	InterModulation Distortion in the ISDN Band
IMD_{DB}	InterModulation Distortion in the xDSL Band
LCL	Longitudinal Conversion Loss
$LCL_{LINEport}$	LCL at the LINE port (with either TELE port or xDSL port tied to ground)
$LCL_{TELEport}$	LCL at the TELE port
$LCL_{xDSLport}$	LCL at the xDSL port
LCTL	Longitudinal Conversion Transfer Loss
$LCTL_{TELEtoLINE}$	LCTL from TELE port to LINE port
L_{DSL}	The inductance L, part of the Z_{DSL-i}
N_{DB}	Noise in the xDSL band
N_{IB}	Noise in the ISDN band
N_{PB}	Noise in the POTS band (psophometric)
$R_{A\ to\ B\ wire}$	DC resistance between A and B wire
R_{DC}	DC Resistance of a splitter for POTS current
R_{DSL}	The resistive R part of the Z_{DSL-i} ($R_{DSL} \equiv Z_{RefDSL}$)
R_{FEED}	Variable DC feed resistor in figure 3
RL_{IB}	Return Loss in the ISDN Pass Band
R_{LOAD}	Variable DC load resistor in figure 4
RL_{PBOffH}	Return Loss POTS Pass Band Off-Hook
$R_{to\ Earth}$	Resistance to Earth
S_{DSL}	Switch to connect xDSL impedance Z_{DSL-i} to the test set-up
THD_{Ring}	Total Harmonic Distortion of the ringing signal
UaE	Unbalance about Earth
V_{RD}	V Ring-Drop
Z_{AC}	Generic name for the AC POTS impedance models
Z_{AUX}	Auxiliary AC POTS impedance used in figures F.1 and F.2
Z_{DSL-i}	Impedance model of the input filter of a particular xDSL over ISDN
Z_{DSL-i2}	Alternative impedance model of the input filter of xDSL over ISDN
Z_{InRing}	The input impedance of the splitter at the ringing frequencies
Z_L	Impedance modelling Line impedance for ISDN purposes
Z_{LINE}	Impedance modelling Line impedance for ISDN and POTS purposes in the xDSL band
Z_{LOAD}	Load impedance, symbol used in figures in clause 5 with test set-ups

Z_{OnHI}	Impedance modelling POTS On-hook with High Impedance
Z_{OnHo}	Impedance modelling multiple parallel on-hook phones
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 xDSL ($Z_{RefDSL} \equiv R_{DSL}$)
Z_{RHF}	Complex POTS impedance, extending Z_R to higher frequencies,[i.1]
Z_{Ring}	Impedance modelling the load represented by ringer circuits
Z_{SL}	Impedance Z Short Loop, modelling a short line terminated on 600 Ω
Z_{SOURCE}	Source impedance, symbol used in figures in clause 5 with test set-ups
Z_T	Impedance modelling the impedance at the TELE port for ISDN purposes

3.3 Abbreviations

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

NOTE: Check also the clause 3.2 with symbols, and note that some abbreviations are only used in the figures.

2B1Q Baseband linecode for ISDN-BRA (4-PAM)

NOTE: See annex A of TS 102 080 [1].

4B3T (also called MMS43) Alternative ISDN-BRA baseband linecode with higher frequency spectrum than 2B1Q

NOTE: See annex B of TS 102 080 [1].

AC Alternating Current
ADSL Asymmetric Digital Subscriber Line
ADSL1 ADSL limited to 1,1 MHz

NOTE: See ITU-T Recommendation G.992.1 [i.9].

ADSL2 ADSL revision 2

NOTE: See ITU-T Recommendation G.992.3 [i.10].

ADSL2plus ADSL revision "2Plus", extended to 2,2 MHz

NOTE: See ITU-T Recommendation G.992.5 [i.11].

CLIP Calling Line Identification Presentation
CMRR Common Mode Rejection Ratio
CO Central Office (≡ Local Exchange ≡ LE)
CPE Customer Premise Equipment (≡ Terminal Equipment ≡ TE)
CRC Cyclic Redundancy Check
DC Direct Current
DCB DC Blocking
DS Downstream, i.e. from LE side to TE side
DSL Digital Subscriber Line
DSLAM DSL Access Module, equipment at the LE side with multiple DSL transceivers
DUT Device Under Test
e.m.f. Electro-Magnetic Force
F.F.S. For Further Study
FDD Frequency Division Duplexing
HPF High Pass Filter
IL Insertion Loss
IMD InterModulation Distortion
ISDN Integrated Services Digital Network
ISDN-BRA ISDN-Basic Rate Access, 2B + D-channel service with 2B1Q or 4B3T linecode
ITU International Telecommunication Union
LCL Longitudinal Conversion Loss

LCTL	Longitudinal Conversion Transfer Loss
LE	Local Exchange (≡ Central Office ≡ CO)
LPF	Low Pass Filter
LT	Line Termination
MMS43	≡ 4B3T (an ISDN-BRA baseband linecode)
N.A.	Not Applicable
NT	Network Termination
NTP	Network Termination Point (also see clause 3.1 with definitions.)
PAM	Pulse Amplitude Modulation
POTS	Plain Old Telephone Service

NOTE: The abbreviation POTS is used in the text of the present document instead of PSTN.

PSTN	Public Switched Telephone Network

NOTE: The abbreviation PSTN is replaced by POTS in the text of the present document.

RL	Return Loss
RMS, rms	Root Mean Square
SDSL	Symmetric DSL
SLIC	Subscriber Line Interface Circuit
TE	Terminal Equipment (≡ CPE) (e.g. Telephone, Fax, voice band modem etc.)
TELE	Telephone Equipment, i.e. POTS or ISDN telephone equipment. The TELE port is where ISDN and optionally POTS equipment is connected at either side of a line
THD	Total Harmonic Distortion
UaE	Unbalance about Earth
US	Upstream, i.e. TE to LE side
US0	Upstream "0" band, the lowest VDSL upstream band

NOTE: See ITU documents [i.12] and [i.13] in the informative references and in the bibliography (Annex N).

VDSL	Very high speed Digital Subscriber Line
VDSL1	VDSL variant defined in ITU-T Recommendation G.993.1 [i.12]
VDSL2	VDSL variant defined in ITU-T Recommendation G.993.2 [i.13]
xDSL	See under clause 3.1 definitions.

4 General functional description of xDSL over ISDN splitters and universal splitters

A tutorial on the transmission and separation of POTS, ISDN and xDSL signals is in Annex I.

Merging and separating xDSL and ISDN signals by an xDSL over ISDN splitter or a universal splitter

When ISDN is underlying the xDSL, the main purpose of the xDSL splitter filter is to separate the transmission of ISDN-BRA signals, and xDSL band signals, enabling the simultaneous transmission of both services on the same twisted pair. The splitter also serves to protect ISDN from interference due to ingress from xDSL signals. Equally it protects the xDSL transmission from interference due to the underlying ISDN service.

Insertion of a splitter filter in existing ISDN-BRA lines shall have a limited impact on the performance of the ISDN-BRA service. The allowed impact is specified in TS 101 388 [8].

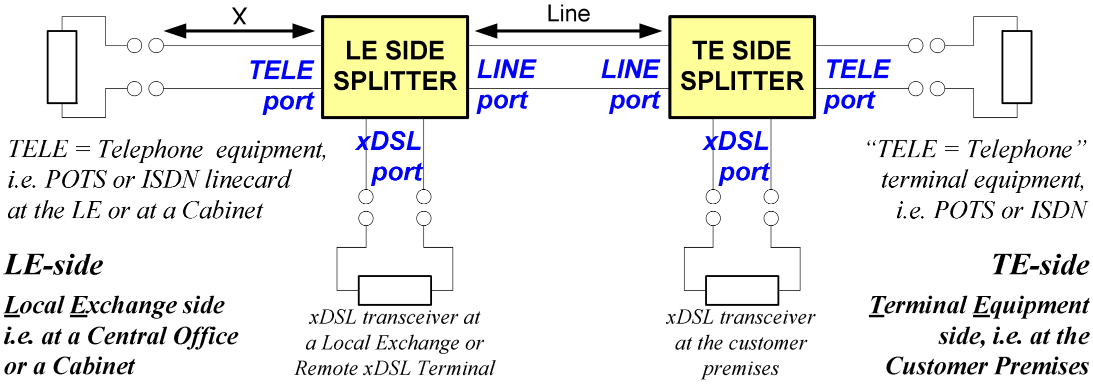
Merging and separating xDSL and POTS signals by a universal splitter

When POTS is underlying the xDSL, the main purpose of the xDSL universal splitter (i.e. over either ISDN or POTS) is to separate the transmission of POTS signals and xDSL signals, enabling the simultaneous transmission of both services on the same twisted pair. The splitter also serves to protect POTS from interference due to ingress from xDSL signals. Equally it protects the xDSL transmission from transients generated primarily during POTS signalling (dialling, cadenced ringing, ring trip, etc.), and it must also prevent interference to the xDSL service due to fluctuations in impedance and linearity that occur when telephones change operational state (e.g. from off-hook to on-hook). Insertion of a splitter filter in existing POTS lines shall only have a low impact on the performance of this service. Information on various implementations of xDSL over POTS splitters (also useful for universal splitters) is given in TR 101 728 [i.2].

4.1 Functional diagram

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

The "ISDN or POTS" port of the splitter is referred to as the "**TELE**" port, (i.e. the port where the ISDN **tele**phone equipment and optionally the POTS **tele**phone equipment are connected to the splitter at the LE or at the TE side).



NOTE: For a Local Exchange xDSL deployment, the length "X" in this figure will typically be far less than 1 km. For a remote xDSL terminal deployment, the length "X" can be up to several kilometres.

Figure 1: Functional diagram of the xDSL over ISDN or POTS universal splitter configuration

The types of transfer functions between the different ports of the splitter are shown in figure 2 and can be understood as follows:

- The transfer function from the "TELE" port to the "LINE" port and vice versa is that of a low pass filter.
- A high level of isolation is required from the "xDSL" port to the "TELE" port to prevent undesirable interaction between xDSL transmission and any existing baseband services, i.e. in both directions.
- The transfer function from the xDSL port to the LINE port and vice versa will be that of a first order high pass filter (i.e. a DC blocking function at the LE side and the TE side).

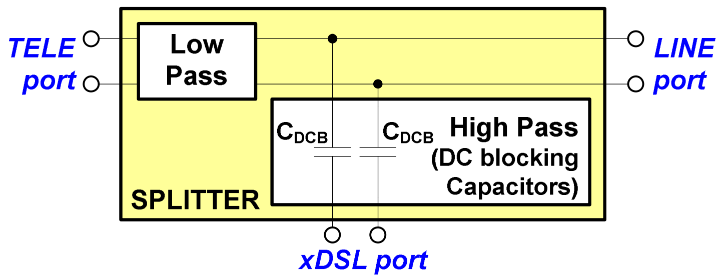


Figure 2: Structure of the xDSL over ISDN or POTS universal filter

Regarding the High Pass function (i.e. the DC blocking capacitors C_{DCB}) two cases are possible:

1) For systems in which the cooperating xDSL transceiver and the ISDN/Universal splitter are not allocated in the same physical rack, the DC blocking function, realized with capacitors between the LINE and the xDSL interface, is mandatory.

2) For other systems the DC blocking function can be accomplished by the input capacitor of the high pass part of the xDSL transceiver. In this case, the C_{DCB} capacitors (see figure 2) are merged with the input capacitors of the impedance Z_{DSL-i} at the entrance of the xDSL transceiver.

NOTE 1: In case the mandatory blocking capacitors are merged with the input capacitors of the Z_{DSL-i}, then those input capacitors are adjusted accordingly. More explanation is given in clause A.1.

NOTE 2: The splitters designed according to the present document are expected to be adequate under a wide range of operational conditions. The issue of general interoperability between ISDN equipment and splitters is under study at the Broadband Forum. The TR-127 [i.16] methodology will allow testing dynamic interaction of ISDN and xDSL in either sense and the effect of splitters on ISDN transmission. See also the remarks 4) and 5) in the Introduction. A tutorial text on TR-127 and its extension for ISDN is given in Annex H.

4.2 High pass filter

The high pass filter, as referred to in the present document, is the series high pass filter that is located in the splitter unit. It is distinct from the input high pass filter of the xDSL modem, which is located in the xDSL transceiver.

Reasons for including a series high pass filter in the LE splitter unit include the following:

- Safety to uncouple the ISDN or POTS line from damage due to the xDSL service.
- DC decoupling, to avoid "stealing" ISDN or POTS service from the premises of an alternative operator.
- Some form of POTS privacy, when xDSL is supplied by an alternative operator, to avoid "listening".
- Reduction of the bridged tap effect of the line length between the xDSL port of the splitter and the xDSL transceiver. Without the series high pass filter this bridged tap may deteriorate the ISDN transmission more.

The high pass filter shall be a 1st order filter made up of two DC blocking capacitors C_{DCB}, which can be merged with the input capacitors of the Z_{DSL-i} as explained under clause 4.1 in paragraph marked as case "2)".

5 Circuit definitions, testing conditions and methods

5.1 DC and ringing 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 voltage and current

The requirements in the present document for xDSL over ISDN splitters only are valid for a DC current of 0 mA to 60 mA. The voltages are network dependent, but can be as high as 120 V.

The POTS related requirements in the present document for xDSL universal splitters are valid for a DC current of 0 mA to 80 mA. The ISDN related requirements for universal splitters are valid for a DC current of 0 mA to 60 mA.

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

- On-hook requirements, when all POTS terminals are in the on-hook state.
- Off-hook requirements, when (at least) one POTS terminal is in the off-hook state.
- Transitional requirements, when one POTS terminal is in the transition from the on-hook to the off-hook state or vice versa.

POTS on-hook voice band electrical requirements shall be met with a DC feeding voltage of 50 V without DC current, and using the **On**-hook impedance model, in a **H**igh **I**mpedance Z_{OnHI} and **L**ow **I**mpedance Z_{OnLI} variant as given in clauses 5.2.6 and 5.2.7 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 TELE port of the splitter at voice frequencies.

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

NOTE 1: Dynamic behaviour at switch-on of ISDN systems can result in DC currents beyond 60 mA being present in the loop during short periods of time (< 50 ms).

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.

NOTE 3: The transitional requirements (for ISDN and POTS DC currents, on-hook/off-hook transitions, for ringing, cadenced ringing and for ISDN signal transitions) are introduced in clause 6.12.

5.1.3 DC feeding and loading bridges

To inject a DC voltage and control the DC current separately from the AC impedances, a feeding circuit is used at the LE side and a loading (or holding) circuit at the TE side. These circuits, which we will call bridges throughout the text, have an equivalent electrical circuit as shown in the figures 3 and 4. For balance C and L should be well matched.

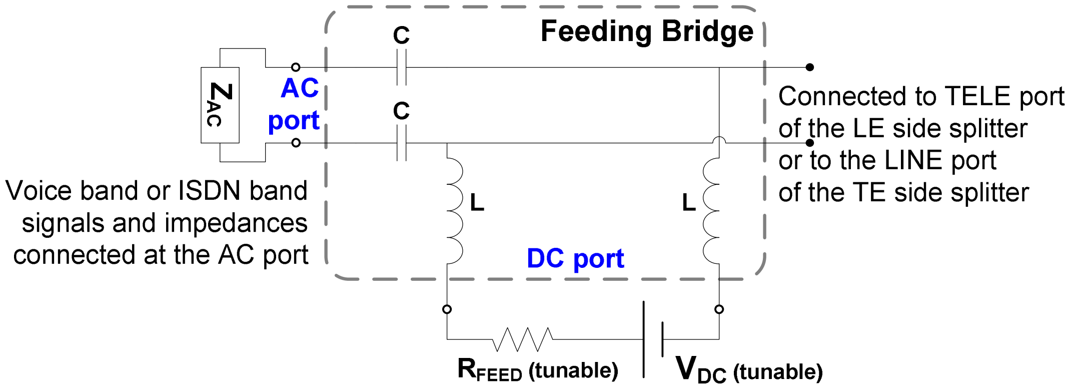


Figure 3: Schematic diagram of a Feeding Bridge

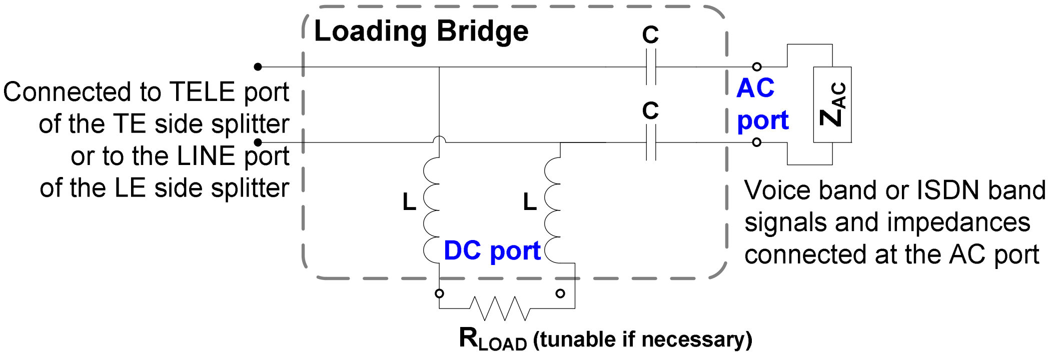


Figure 4: Schematic diagram of a Loading Bridge

NOTE 1: It is necessary to combine these feeding and loading bridges with the splitter test circuit diagrams of clauses 5.4 to 5.7. How this is done, is one aspect of the TR 101 953 [i.3], [i.4], [i.5], [i.6], [i.7] and [i.8], which were already mentioned in the foreword in, note 2. However, to clarify the combination of feeding and loading bridges with the diagrams of clause 5.4, a few examples are also shown in Annex G.

NOTE 2: The properties of the feeding and loading bridges should be sufficiently good, to prevent that measurements of splitter properties are affected by these bridges. E.g. in note 2 of clause 5.5.3 it is stated that their balance should be sufficiently good. Balance can be improved by using transformers. Testing above 1 MHz is not expected to be feasible with the same bridges which are used for the POTS frequency range. Further information on building bridges particularly for higher frequencies is contained in Annex J.

5.1.4 Ringing signals and the DC added to the ringing

NOTE: For consistency the ringing test signals and the DC voltages superimposed to the 25 Hz or 50 Hz ringing should be defined in this clause. However, for historical reasons the clause 6.2 on ringing itself contains this particular information. Therefore, the levels of both the AC ringing and the associated DC are not defined here.

5.2 AC Terminating impedances Z_{AC}

The impedances Z_{AC} 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 modelling ISDN or POTS DC conditions, as explained in clause 5.1.3.

When used for testing purposes, the precision of components in the different Z_{AC} impedances shall be better than 1 %.

5.2.1 Z_{RefDSL} and Z_{DSL-i} (xDSL transceiver related)

In many of the tests the xDSL port of the splitter is terminated with impedances called Z_{RefDSL} and Z_{DSL-i}. Z_{RefDSL} is the nominal design impedance of the xDSL system and Z_{DSL-i} is an impedance model representing the input impedance of the xDSL transceiver (which implements a HPF). To simplify the measurements above 1 MHz, the source or load termination with Z_{DSL-i} can be replaced by Z_{RefDSL}, see clause A.1.

Both these substitute circuits, Z_{RefDSL} and Z_{DSL-i} are models, which shall be applied to an ISDN splitter or universal splitter when verifying certain requirements. These models are intended for splitter specification in the context of the present document. The purpose of these model impedances is for splitter specification; they are not a requirement on the input impedance of the xDSL transceiver.

Depending on the type of xDSL involved, different values of Z_{RefDSL} and Z_{DSL-i} are applicable. They are described in clause A.1.

NOTE: The load Z_{DSL-i} at the xDSL port differs, depending on whether the DC blocking capacitors are merged with Z_{DSL-i} or not, as introduced in note 2 in clause 4.1. This is explained in clause A.1, where it is stated that it is required that the total xDSL load seen at the LINE port is identical for a splitter with the C_{DCB} present in the splitter or with C_{DCB} merged with Z_{DSL-i}.

5.2.2 Z_T and Z_L (ISDN related)

For requirements relating to ISDN band frequencies described in the present document, the terminating impedance Z_T is used to terminate the TELE port, while Z_L is used to terminate the Line port. Z_T is defined as being equal to Z_L, and both shall follow the definitions of TS 102 080 [1], Annex A for 2B1Q (135 Ω), Annex B for 4B3T (150 Ω) ISDN-BRA.

5.2.3 Z_{Line} (POTS and ISDN related)

Z_{Line} is used in certain clauses to terminate the LINE port at xDSL frequencies and shall be equal to 135 Ω.

5.2.4 Z_R (POTS related)

When the splitter is to be used for POTS, the terminating **R**eference impedances Z_R as defined in ES 201 970 [5] and ES 203 021-3[6] is used. This impedance is specified in figure 5. The impedance of figure 5 can be used to terminate both the LINE port at low frequencies, and the TELE port.

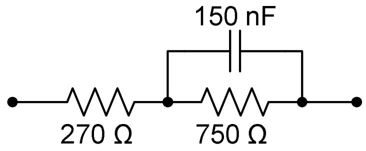


Figure 5: Schematic diagram of the impedance Z_R

NOTE 1: In the case of splitters to be deployed in some networks, alternative models of reference impedances instead of Z_R may be used when testing according to the splitter requirements in the present document.

NOTE 2: For regular POTS splitters (see part 1 TS 101 952-1 [7]) other reference impedances are possible, such as 600 Ω and the impedance Z_{SL}, which is modelling a 600 Ω termination resistance on a short loop. For universal splitters these 600 Ω related variants are normally not used as reference impedances.

5.2.5 Z_{RHF} (POTS related)

For requirements relating to xDSL frequencies described in the present document, the terminating impedance Z_{RHF} is used to terminate TELE port and LINE port of the splitter. This is the European harmonized complex reference impedance Z_R with the modification for **H**igh **F**requencies proposed in TR 102 139 [i.1]. This network is shown in figure 6.

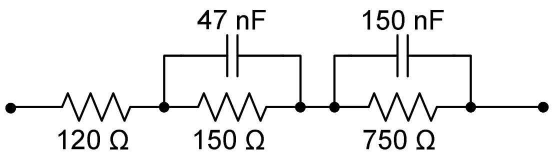


Figure 6: Schematic diagram of Impedance Z_{RHF}

For frequencies above 1 MHz it is known that it is difficult to source or to load the line with the Z_{RHF} impedance, particularly when equipment with a build-in 50 Ω impedance is used. In those cases a simple balun will load the line with an Ohmic impedance, rather than with the exact Z_{RHF}. To simplify the measurements at higher frequencies, the source or load termination with Z_{RHF} above 1 MHz may be replaced by the relevant resistive part, i.e. a 120 Ω resistor. Note that for certain other test cases Z_{LINE} was defined in clause 5.2.3, but at 135 Ω.

5.2.6 Z_{OnHI} (POTS related), Impedance On-hook High Impedance

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. "OnHI" stands for **On**-hook **H**igh **I**mpedance.

Actual impedances will vary greatly especially over the xDSL 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.

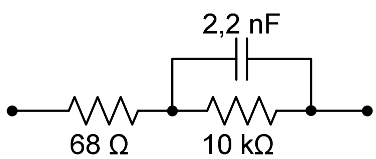


Figure 7: Schematic diagram of Impedance Z_{OnHI}

5.2.7 Z_{OnLI} (POTS related), Impedance On-hook Low Impedance

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. "OnLI" stands for **On**-hook **L**ow **I**mpedance.

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.

NOTE: For universal splitters the Z_{OnLI} impedance variants are rarely used as reference impedances.

5.2.8 Z_{OnHo} (POTS related), Impedance On-hook

To model multiple on-hook telephones in parallel with a single off-hook phone, Z_{OnHo} is used. It was shown that the Z_{OnHI} is inappropriate, due to its low impedance, which is a worst case situation. Z_{OnHo} is not used in the present document. It is added for completeness. It might be used for testing multiple parallel distributed filters in TS 101 952-3 [i.14] and TS 101 952-4 [i.15].

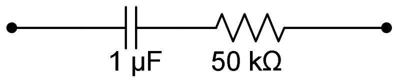


Figure 8: Schematic diagram of Impedance Z_{OnHo}

5.2.9 Z_{ring} (POTS related), Impedance load for ringing

For some on-hook requirements in the presence of ringing signals, as defined in clause 6.2, 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 circuits in figure 9 apply:

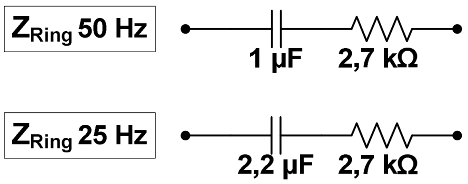


Figure 9: Schematic diagrams of Impedances Z_{Ring} for 25 Hz and 50 Hz ringing

5.3 High pass filter implementation

As stated in clause 4.2, the high pass part of the splitter, i.e. the filter between the LINE and xDSL ports, shall be made up of two DC Blocking capacitors C_{DCB}, as shown in figure 10, which make up a first order high pass filter.

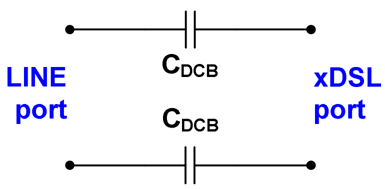


Figure 10: Implementation of the high pass filter

A tolerance of 5 % shall be allowed for the practical implementation of these capacitors across the frequency range. They shall be capable of withstanding the DC conditions of clause 5.1.2 and the AC ringing voltages of clause 5.1.4. Nominal values of C_{DCB} are listed in clause A.1 for different xDSL variants. The balance test of the high pass in clause 6.6.2 facilitates testing the matching of the two C_{DCB} capacitors. The loss caused by these capacitors on the xDSL signal is measured with the Att_{DB} of clause 6.7.2.

5.3.1 DCB capacitors as reference high pass filter

The reference high pass is composed of two DCB caps, with 5 % tolerance on the absolute value and a matching better than 1 %. E.g. for ADSL and ADSL2 over ISDN the DC blocking caps are 27 nF each. Details are in clause A.1.

The reference high pass filter is used in certain measurement cases, e.g. in the reference case of IL measurements from LINE port to xDSL port of clause 5.4.4, when the splitter contains the DC blocking capacitors (clause 5.3).

If the splitter contains no high pass part, because the DCB capacitors are merged with the input impedance of the xDSL transceiver (see note 2 of clause 4.1), then the reference high pass is still needed as explained in Annex L.

5.4 General transmission test set-ups

A tutorial on the "Optimal Transmission of POTS, ISDN and xDSL Signals and their Separation" is in Annex I.

For the transmission related tests specified in the present document, a number of general test set-ups apply.

Insertion Loss (IL):

To measure the propagation of certain signals with little loss or with some desirable strong attenuation from one port of the splitter to another port of the splitter the measurement of the insertion loss (IL) is used in almost all cases.

Return Loss (RL):

Another important property of the splitter in the POTS or ISDN band is the Return Loss (RL) at its TELE port and LINE ports. This property indicates the way the impedance of the telephone line or equipment at one port is altered when the splitter is inserted, when that impedance is measured at another port of the splitter. A high RL will result in less echoes being generated in the POTS telephone network or in both ISDN transceivers at each end of the subscriber line.

NOTE 1: All parts of the TS 101 952 (e.g. part 1 [7]) contain a similar clause, with tutorial information about the set-up of the transmission tests. They differ in essential points, so careful reading of this clause and its subclauses is required.

NOTE 2: It is necessary that a splitter fulfils certain requirements with and without xDSL load Z_{DSL-i} connected to the splitter, e.g. the IL, RL in the POTS band is measured this way. However, other requirements are only measured in the presence of Z_{DSL-i}, e.g. the IL in the DSL band. The presence or absence of Z_{DSL-i} is discussed in the clauses below and it is always mentioned in the requirement clauses in clause 6.

5.4.1 General definition of the Insertion Loss (IL) measurement

One of the transmission properties is the Insertion Loss (IL). For measuring IL the ratio is calculated between a voltage at the position of the **D**evice **U**nder **T**est (DUT) output, when the device is present and when it is absent. This means that we have to indicate the reference case (absence of the DUT). IL can indicate e.g. that a splitter attenuates a signal very little, e.g. between the LINE and the TELE port in the POTS or ISDN band or that it attempts to isolate, e.g. by attenuating the signals in both directions between the TELE port and the xDSL port or the LINE port, in the xDSL band.

NOTE 1: It should be noted that for passive splitters the IL is identical irrespective of the direction in which the IL is measured. This is the reciprocity theorem, which states that source and load can be interchanged for IL measurements. So in principle only one of the IL measurements is needed, or if both measurements are performed, the results should be identical, within the precision limits of the test.

NOTE 2: The source and the load impedances used in the IL measurements do not have to be identical, although this might be the case in many instances of the IL measurements in the present document.

NOTE 3: Measuring IL at higher frequencies requires care in the selection of the testing material, e.g. the BALUNs. Particularly care has to be taken regarding resonance effects between the splitter and the baluns, which can influence the results at high attenuation values. It was noted that this influence could be dependent on the impedance of the TELE port of the splitter in the xDSL band, which is undefined.

5.4.2 POTS or ISDN signal loss test set-up: IL LINE port to TELE port

To measure the loss effect of inserting the splitter on the POTS or ISDN signals the IL is measured between the LINE port and the TELE port (or in the opposite direction). Note that for measuring the IL of the low pass part of a splitter, the measurement is done for the splitter alone and for the combination of the splitter with the xDSL impedance attached to its xDSL port.

For measurements of the IL from the LINE port to the TELE port and for the inverse, the test set-ups are given in figures 11 and 12. These IL measurements are done with the switch S_{DSL} either open or closed, i.e. with the xDSL impedance Z_{DSL-i} absent or present. The IL is measured in the band of the low frequency telephonic equipment only, i.e. in the POTS band for POTS equipment and in the ISDN band for ISDN equipment.

NOTE: The IL measurement with the switch S_{DSL} closed will not represent the IL of the splitter low pass alone, but will include a loading effect of the Z_{DSL-i} impedance on the TELE signals. This means that part of the IL measured with the switch S_{DSL} closed is caused by the xDSL equipment. In Annex D the IL of the Z_{DSL-i}, i.e. the extra IL caused by the xDSL equipment is shown. This means that for measurements in the POTS or ISDN band the IL is enlarged adversely by the xDSL equipment. A similar effect exists for the RL (see clause 5.4.5), as explained in the same Annex D.

When the DC blocking capacitors are merged with the Z_{DSL-i} impedance, and there is no high pass section inside splitter, the load at the xDSL port must include the C_{DCB} capacitors as explained in clause A.1. The relevant schematics are shown in clause L.1.

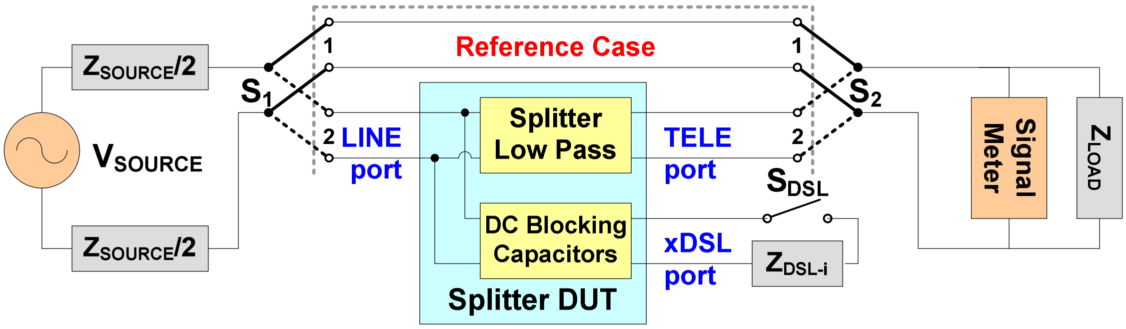


Figure 11: Test set-up for Insertion Loss from LINE port to TELE port

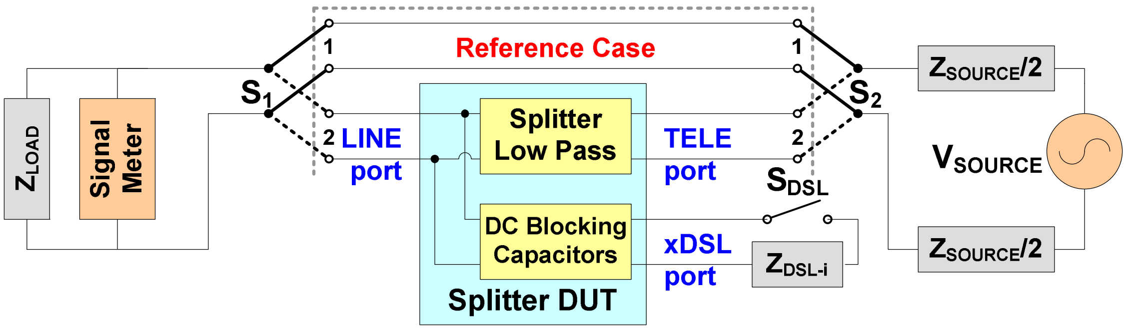


Figure 12: Test set-up for Insertion Loss from TELE port to LINE port

5.4.3 xDSL signal isolation: TELE port to xDSL port

NOTE 1: To measure xDSL signal isolation the testing method for ISDN and Universal splitters differs substantially from the POTS splitters, as explained in Annex M.

To measure the isolation of the ISDN splitter low pass section in the xDSL band, the loss effect resulting from the splitter insertion must be measured. The isolation is measured between the xDSL port and the TELE port and/or in the opposite direction. In the xDSL band the ISDN splitter isolation is **never** measured between LINE port and TELE port.

For the xDSL over ISDN splitters and for the Universal splitters the isolation is the measurement of the IL of serial connection of the low pass and the high pass of the splitter, as shown in figures 13 and 14.

For any of these IL cases the Z_{DSL-i} is present, because measuring the xDSL signal isolation in the absence of the xDSL transceiver is meaningless. The measurements are done over the relevant xDSL frequency ranges, i.e. in the xDSL pass band and optionally in the transition band.

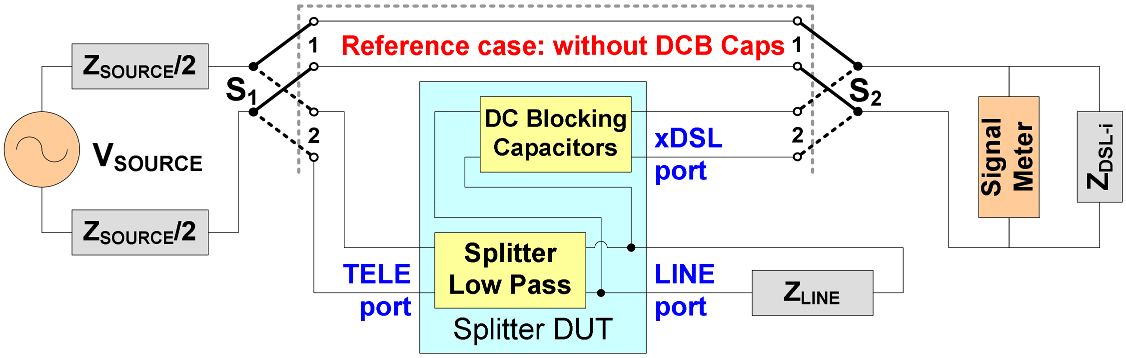


Figure 13: Test set-up for IL of low pass and high pass from TELE port to the xDSL port

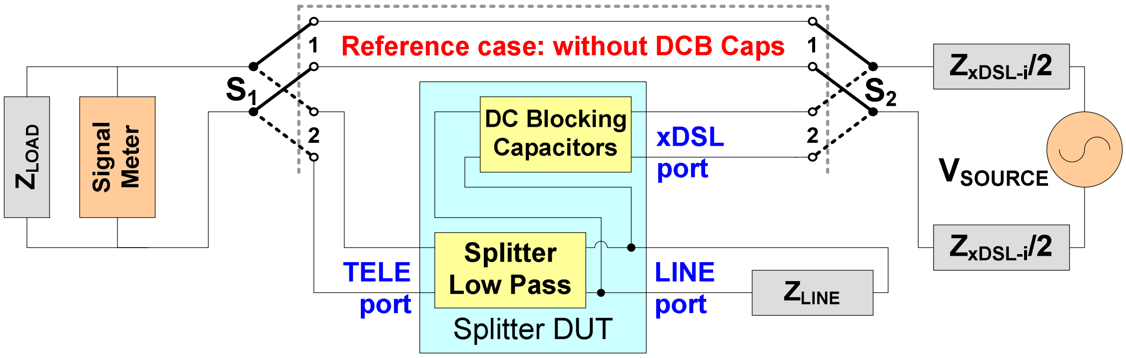


Figure 14: Test set-up for IL of low pass and high pass from xDSL port to TELE port

The results of the IL measured according to figures 13 and 14 will be identical for passive splitters, due to the passive nature of the signal path and the known reciprocity theorem, mentioned in note 1 of clause 5.4.1.

NOTE 2: Taking this approach enhances the IL with the extra blocking effect of the DC blocking caps.

A different approach (but with identical results) was documented in TR 101 953-1-3 [i.5] and TR 101 953-2-3 [i.8]. There the measurement is not taken at the xDSL port, but inside high pass block modelling the xDSL equipment, with the test set-ups as given in clause E.1. This annex shows how the injection of signal can be done from within the Z_{DSL-i} or the measurement of the signal can be done in series with the Z_{RefDSL} (= R_{DSL}) inside the Z_{DSL-i}. Furthermore, this can be done with circuits using a balun transformer.

Furthermore, when the DC blocking capacitors are merged with the Z_{DSL-i} impedance, and there is no high pass section inside splitter, the load at the xDSL port must include the C_{DCB} capacitors as explained in clause A.1. The IL schematic must be corrected as shown in clause L.2.

5.4.4 Insertion Loss test set-up LINE port to xDSL port

The final transmission tests are needed to measure the attenuation effect of the high pass and the low pass section on the xDSL signals, which normally transit from the LINE to the xDSL port, or in the inverse direction.

These transmission related tests require a signal to be generated at the xDSL port and measured at the LINE port or a signal to be generated at the LINE port and measured at the xDSL port.

It would appear that these last two tests are merely testing the high pass part of the splitter, which is a set of capacitors with known values. However, these tests performed via the (known) 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 xDSL signals unnecessarily, i.e. does not attenuate, distort or add noise. Additionally, the test in this clause will also identify a defective high pass, i.e. one with too much IL from LINE port to xDSL port.

NOTE 1: In previous versions of the splitter documents (including TR 101 953-1-3 [i.5] and TR 101 953-2-3 [i.8]) it has never been clear how to measure correctly the effect on the xDSL signals caused by the presence of the low pass. The measurement could be done at the LINE port or the xDSL port of the splitter or at the Z_{RefDSL} (R_{DSL}) impedance inside the Z_{DSL-i}. In fact, the measurement of the IL of low pass section can be done at either position, with identical results. Furthermore, it was noted that in [i.5] and [i.8] it was required to measure using a reference situation without both high pass and low pass, and measure the IL between LINE and xDSL ports due to both high pass and low pass. This is not a relevant measurement, because the high pass of the splitter (i.e. the DC blocking capacitors) is conceived such that the capacitors of the splitter high pass (e.g. C_{DCB} = 27 nF) and the high pass filter at the entrance of Z_{DSL-i} (containing C_{DSL}) are always in series. Therefore, it is irrelevant to use a reference measurement in which the splitter high pass is absent.

The theoretical set-up of the IL from the LINE port to the xDSL port (with identical values for the inverse direction, due to the passive nature of the high pass circuit) is as shown in figure 15. (The reference case has the low pass and its load impedance at the TELE port removed. This is equivalent to opening switch S_1.)

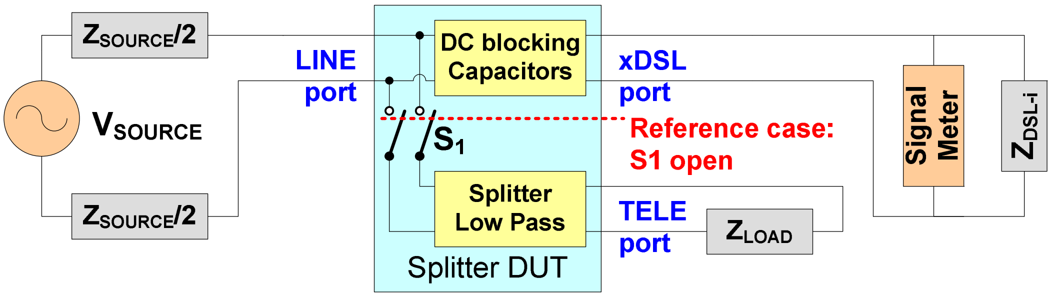


Figure 15: Theoretical test set-up for Insertion Loss from LINE port to xDSL port

The IL caused by only the low pass requires a switch inside the splitter, which is not available. Therefore, the following practical variant of the IL test can be used, in which the complete splitter is removed, but a reference high pass (see clause 5.3.1) identical to the DCB capacitors is inserted:

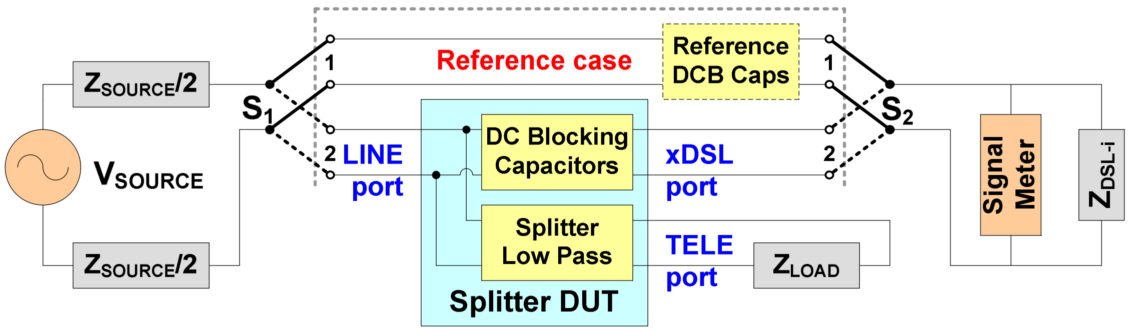


Figure 16: Practical test set-up for Insertion Loss from LINE port to xDSL port

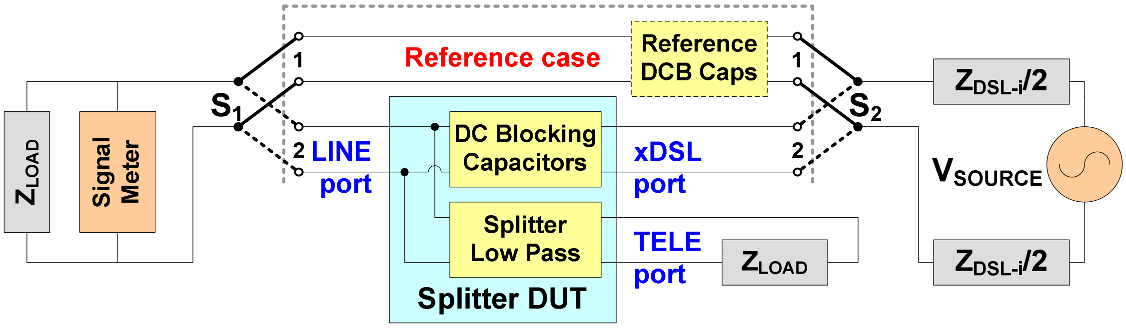


Figure 17: Practical test set-up for Insertion Loss from xDSL port to LINE port

The IL could be measured with the addition of the complete xDSL impedance model. E.g. the IL from LINE to xDSL port could be measured at the 100 Ω impedance in the $Z_{LOAD} = Z_{DSL-i}$, but this will result in more a complicated set-up, with identical results. The relevant diagrams are added in clause E.2.

If the splitter has no high pass part, because the DCB capacitors are merged with the Z_{DSL-i}, the tests set-up has to be adapted as show in clause L.3.

The POTS impedance at the TELE port will be modelled as a short circuit, an open circuit and relevant reference impedances. The ISDN impedance at the TELE port could be present of absent.

NOTE 2: Loading the TELE port of the low pass section of the splitter with different impedances covers a sufficiently wide range of impedances to cover all practical load situations at this port. The impedance changes at the TELE port can affect the xDSL, which could suffer CRC errors and might even loose synchronization. These transitional requirements are introduced in clause 6.12.

5.4.5 General definition of the Return Loss

The measurement of the Return Loss (RL) of a splitter at a given port indicates the way the impedance of the telephone line or equipment connected at another port is changed due to the insertion of the splitter as measured at the given port.

Normally POTS equipment (connected at the LE or at the TE side) is constructed to match the reference line impedance of Z_R or 600 Ω. When the POTS equipment at the LE and at the TE side are well matched, there will be little echoing of the POTS signals. A similar concept is used in ISDN equipment, which tries to match the line with a characteristic impedance of 135 Ω or 150 Ω.

However, for both POTS and ISDN equipment the insertion of the splitters could alter the generation of the echoes.

EXAMPLE: If the Z_R impedance is connected at the LINE port, and if this POTS impedance is seen at the TELE port with little change, the echoes stay low. However, when the impedance Z_R is connected to the LINE port and if then the impedance seen at the TELE port differs largely from Z_R, the telephone equipment at the TELE port will experience an undesirable enhancement of the echoes and/or sidetone. For ISDN the same principles apply, but the echoes affect the ISDN transceivers and not the perceived echoes on the voice channels carried on the ISDN transmission link.

The generalized definition of RL contains a reference impedance Z_{Ref}. The generic RL formula (below) compares the input impedance Z_{IN} with Z_{Ref}. The RL value will be higher, i.e. better, when Z_{IN} and Z_{Ref} are more similar.

$$RL = 20 \cdot \log\left(\frac{|Z_{Ref} + Z_{IN}|}{|Z_{Ref} - Z_{IN}|}\right)$$

NOTE: For splitters the RL is measured in the presence and absence of the xDSL service. This means that the RL is measured for either the splitter low pass section alone or for the combination of the low pass section, the optional high pass and Z_{DSL-i} termination. Therefore, the RL measurement with the switch S_{DSL} closed will include the effect of the Z_{DSL-i} impedance on the return loss. This means that a significant part of the RL measured with the switch S_{DSL} closed can be caused by the xDSL equipment. In Annex D the effect of the Z_{DSL-i} on the RL is shown, i.e. the intrinsic RL degradation as caused by the xDSL equipment.

5.4.6 Return Loss test set-up at LINE port and TELE port

The Return Loss (RL) measurements are limited to the POTS and ISDN bands and are also limited to the LINE port and the TELE port. For the xDSL signal stream there is no need for RL to be measured. For both POTS and ISDN services, the RL must be measured in the presence and absence of the xDSL service, i.e. with Z_{DSL-i} connected and removed by opening the switch $S_{DSL.}$

For the purpose of measuring RL of splitters, Z_{LOAD} is used as Z_{Ref} in the general formula, as shown in the formulae in figures 18 and 19. In this way the "transparency" of the splitter can be appreciated.

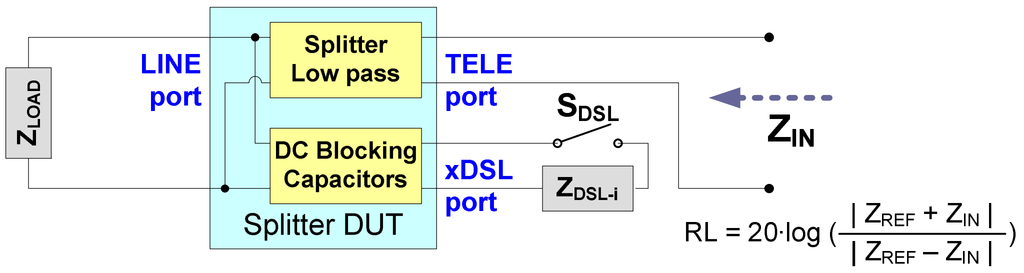


Figure 18: Definition for Return Loss at the TELE port

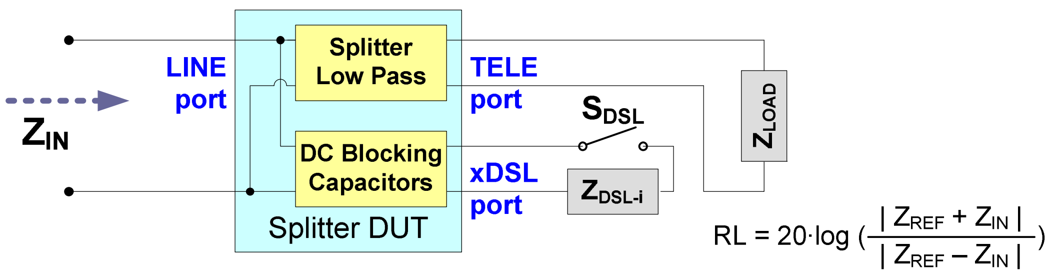


Figure 19: Definition of Return Loss at the LINE port

For the practical realisation of the RL measurements practical bridge-based circuit diagrams are included in Annex F.

If the DCB capacitors are absent in the splitter, because they are merged with the high pass of the xDSL transceiver, the Z_{DSL-i}, is replaced by the Z_{DSL-i2} impedance, as shown in clause L.4. Z_{DSL-i2} is defined in clause A.1.

5.5 Unbalance measurement

An additional property of a splitter at its ports is the unbalance, by which common mode signals are converted to differential signals, which can affect the POTS, the ISDN and the xDSL transmission.

In the POTS or ISDN band the balance has to be good at both the TELE port and the LINE port. In the xDSL band the balance has to be such that minimal amounts of disturbing differential signal are found at the LINE port or the xDSL port.

5.5.1 General definition of Longitudinal Conversion Loss

One of the balance properties is the Longitudinal Conversion Loss (LCL). For measuring LCL a common mode signal is injected at one port, while the other ports are connected to appropriate differential and common mode impedances.

The LCL is the ratio between the common mode voltage and the (undesirable resulting) differential voltage at the same port.

In the POTS or ISDN band the LCL has to be good at both the TELE port and the LINE port. In the xDSL band the LCL has to be good at the LINE port and at the xDSL port.

5.5.2 General definition of Longitudinal Conversion Transfer Loss

A second balance property is the Longitudinal Conversion Transfer Loss (LCTL). For measuring LCTL a common mode signal is injected at one port, while the other ports are connected to appropriate differential and common mode impedances.

The LCTL is the ratio between the common mode voltage injected at one port and transiting to another port to become an (undesirable resulting) differential signal at that other port.

In the xDSL band the LCTL is used to evaluate the extent that common mode noises entering via the TELE port are transiting through the splitter and converted into differential signals at the LINE port.

5.5.3 LCL and LCTL test set-up

The basic test set-up for measuring Unbalance about Earth (UaE) at the TELE port, with the termination at the LINE port is shown in figure 20. The xDSL port is terminated with a balanced Z_{RefDSL} impedance.

In the case of measuring at the LINE port with the termination at the TELE port, the test set-up of figure 21 is used, which is derived from figure 20 by reversing the TELE port and LINE port. For measuring at xDSL port, terminating at the LINE port, figure 22 is used. For measuring at LINE port, terminating at the xDSL port, figure 23 is used. The remaining third port is terminated with the appropriate balanced impedance as shown.

For LCL the source (U_0) and the measurement (U_{T1}) point are always located at the same port. For LCTL the source (U_0) is at one port and the measurement point (U_{T2}) is at the termination port.

This requirement shall be met for both the on-hook and off-hook case. The DC feeding is as specified in clause 5.1.2.

For measurements at frequencies above the voice band, for reasons of practical testing impedance of 150 Ω should be used in series with the longitudinal source (i.e. S_1 in figures 20 to 23 should be open).

The unbalance about earth is calculated by using the following equation (use U_{T1} or U_{T2} for LCL and LCTL respectively in figure 20; in figures 21 to 23 use U_T for LCL).

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

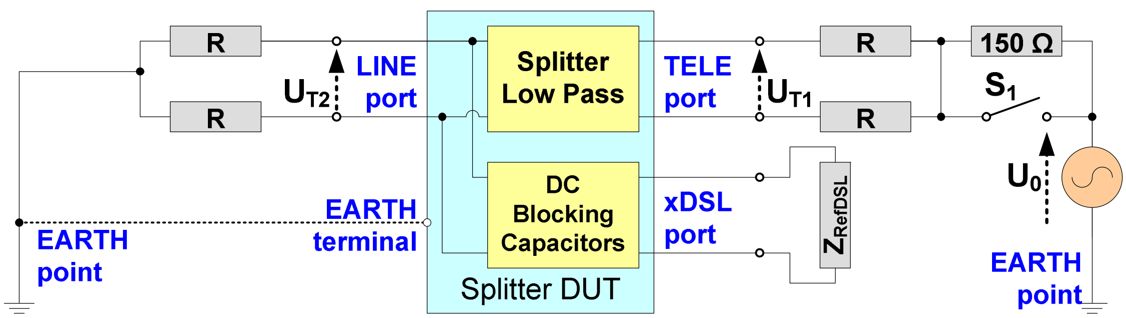


Figure 20: UaE; LCL or LCTL measurement test set-up TELE port to LINE port

All notes apply to figures 20 to 23.

NOTE 1: The 150 Ω models the longitudinal impedance of the line or of the POTS or ISDN circuits.

NOTE 2: The DC current feeding circuitry is not shown. Care should be taken that the feeding bridge is implemented in such a way not to have any significant influence on the accuracy of the measurement. Indeed, it is quite difficult to measure LCL and LCTL at high frequencies, in the presence of the feeding and loading bridges of clause 5.1.3. Indeed, practical implementation of such feeding and loading bridges is known to affect the balance measurement. If necessary the measurements have to be made with different bridges for different frequency ranges. Combining the DC feed with the LCL and LCTL test diagrams is one aspect of TR 101 953-1-3 [i.5] and TR 101 953-2-3 [i.8], which were already mentioned in the foreword in note 2. Similar examples of adding the DC feeding circuitry are also shown in Annex G.

NOTE 3: If the effect of DC current is balanced by design (e.g. by the use of transformers) a waiver of the measurement in the presence of DC current may be granted.

NOTE 4: The dotted connection is only used if the splitter has an earth terminal.

NOTE 5: For resistances R an equivalent circuit according to ITU-T Recommendation O.9 [2] can be used.

NOTE 6: If the splitter has no earth terminal, the test should be performed with the splitter placed on an earthed metal plate of a sufficiently large size.

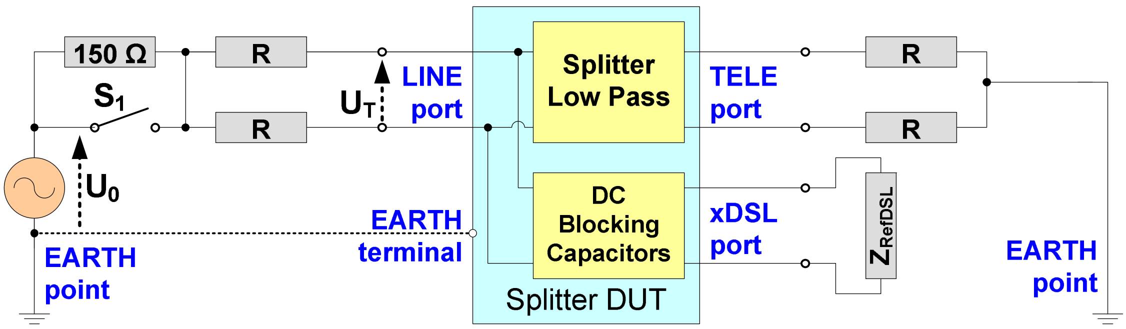


Figure 21: UaE; LCL measurement test set-up LINE port to TELE port

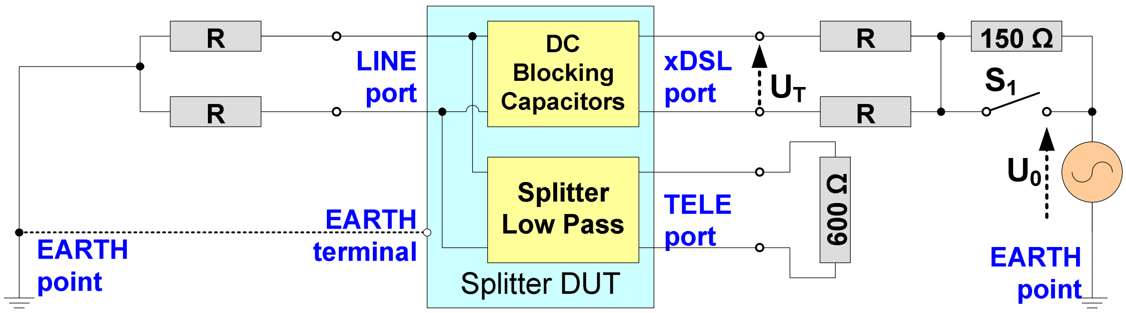


Figure 22: UaE; LCL measurement test set-up xDSL port to LINE port

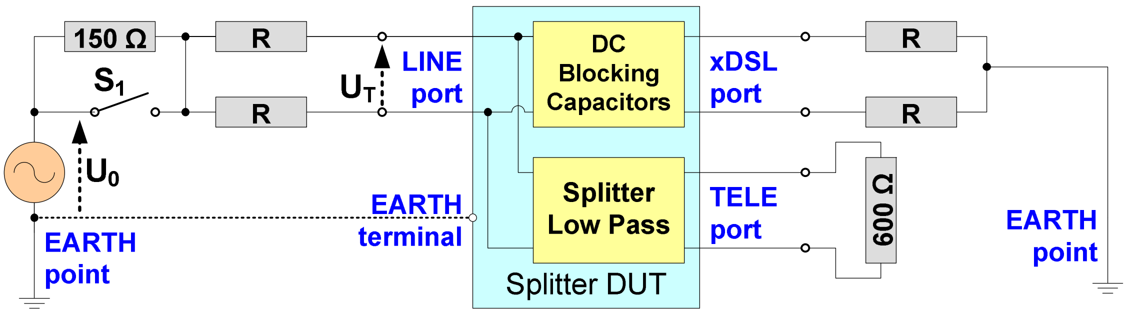


Figure 23: UaE; LCL measurement test set-up LINE port to xDSL port

5.6 Noise measurement

The measurement of noise in the POTS or ISDN band and the xDSL band is only required for active splitters.

NOTE: The use of active components in ISDN related splitters is not likely, because ISDN uses a power of more than 20 mW, which would challenge the dynamic range of the active circuits.

5.6.1 Psophometric noise in the POTS Band

The methodology for testing noise of active/dynamic splitters is F.F.S.

5.6.2 Noise in the ISDN Band

The methodology for testing noise of active/dynamic splitters is F.F.S.

5.6.3 Noise in the xDSL Band

The methodology for testing noise of active/dynamic splitters is F.F.S.

5.7 Common Mode Rejection Ratio measurement

Normally a splitter serves as a shield for the xDSL modem by suppressing the differential mode noises, which are present on the POTS or ISDN network in the user premises. However, also a common mode noise could be picked up on the POTS or ISDN network. This common mode noise might pass the splitter low pass section without any required attenuation. The common mode noise then reaches the xDSL modem and the telephone line where it will be partially converted into differential mode noise signals, which will enter the xDSL transceiver input stage and affect the xDSL transmission.

Therefore, splitters with the ability to suppress common mode signals will reduce the effects of these noises on the xDSL modem and will improve the xDSL signal transmission.

The test set-up for measuring the Common Mode Rejection Ratio (CMRR) of the splitter is in given figure 24.

The test can be carried out in different directions:

- from the TELE port to the LINE port, or from the LINE port to the TELE port, i.e. in the opposite direction;
- from the TELE port to the xDSL port, or from the xDSL port to the TELE port, i.e. in the opposite direction.

There is no CMRR measurement from the xDSL port to LINE port, neither is there one in the opposite direction. The port that is not used during the measurement is left open.

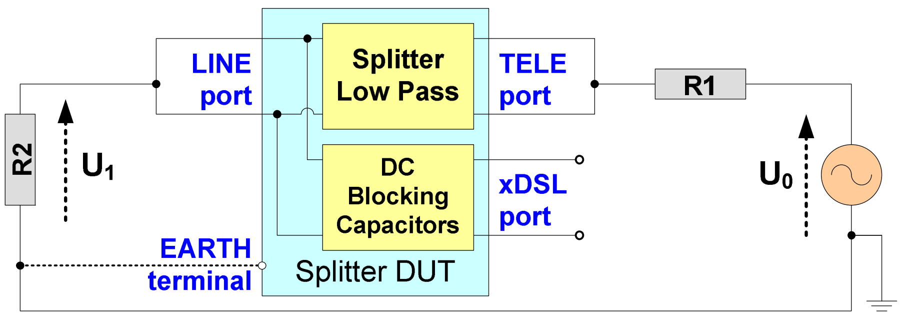


Figure 24: Test set-up for measuring the CMRR from TELE port to LINE port

The CMRR is calculated according to the following formula:

$$CMRR = 20 \times \log (U0 / U1) \quad \text{(dB)}$$

6 Splitter requirements

6.1 DC requirements

6.1.1 DC resistance to earth

The DC resistance $R_{to\ Earth}$ between each terminal (i.e. A-wire and B-wire) of the splitter and earth, when tested with 120 V DC, shall not be less than 20 MΩ.

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

6.1.2 DC isolation resistance between A-wire and B-wire

The DC resistance $R_{A\ to\ B\ wire}$ between the A-wire and the B-wire at both the LINE port and the TELE port of the splitter, when tested with 120 V DC, shall not be less than 5 MΩ.

NOTE 1: This requirement takes into account the minimum total DC Resistance between A and B wires that is acceptable for TE complying with ES 203 021-3 [6]. It is recognized that the majority of passive splitters will achieve DC Resistance between A and B wires of at least 20 MΩ. This reasoning is based on POTS systems, where it exists to allow testing of cables, but it is also applicable to ISDN splitters.

NOTE 2: 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 should be set accordingly.

6.1.3 DC series resistance

The DC resistance R_{DC} from the A-wire to the B-wire at the LINE port with the TELE port short circuited, or at the TELE port with the LINE port short circuited shall be less than or equal to 12,5 Ω.

This requirement shall be met for the feeding conditions described in clause 5.1.2.

6.1.4 DC signalling (for universal splitter only)

This clause is only applicable for universal xDSL splitters, i.e. over both ISDN and POTS.

In the past no requirements existed for the LPF of the universal splitter related to DC signalling. This situation is not altered: no DC signalling tests are required for universal splitters. The reasons are explained in the following note.

NOTE: The effect of a universal splitter on the DC signalling should be in line with clause 6.2.4 of TS 101 952-1 [7]. However, in [7] no practical test methodology is currently provided. Furthermore, no issues are expected as the LPF of the universal splitter is much wider than a regular POTS splitter. If the DC signalling affects the xDSL signals, this can be tested with the TR-127 [i.16] methodology. See also the remarks 4) and 5) in the introduction.

6.2 Ringing frequency requirements for the LPF (for universal splitter only)

This clause is only applicable for universal xDSL splitters, i.e. over both ISDN and POTS.

In principle the ringing requirements of TS 101 952-1 [7] apply. However, as explained in the note, only the test of the THD_{Ring} is considered necessary.

NOTE: In theory the loss and the input impedance of the universal splitter under ringing could be tested, in line with the tests in clauses 6.3.1 (V_{RD}) and 6.3.2 (Z_{InRing}) of [7]. In practice no issues are expected with V_{RD} and Z_{InRing}, as the LPF of the universal splitter has a lower series resistance and a wider bandwidth than a regular POTS splitter. Therefore, its attenuation of the ringing signal is lower and its input impedance at the ringing frequency will be much higher.

6.2.1 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 specified in table 1. The test shall be carried out at 25 Hz and at 50 Hz. With these voltages applied, the total harmonic distortion (THD_{Ring}) of the AC signal shall be less than 10 %. The test set-up is shown in figure 11 for the TE side splitter and in figure 12 for the LE side splitter. This requirement shall be met with the switch S_{DSL} in figures 11 and 12 closed.

Table 1: Test conditions for THD_{Ring} at 25 Hz and 50 Hz

	test 1	test 2
AC test signal source e.m.f.	100 V_{RMS}	50 V_{RMS}
DC feeding voltage	50 V DC	78 V DC
Signal source frequency	25 Hz and 50 Hz	
Signal source impedance	850 Ω (resistive)	
Load impedance, dependent of the ringing frequency	Z_{Ring} (as defined in clause 5.2.7)	

NOTE: The THD test of this clause is unable to verify that the distortion of the splitter under ringing does not affects the xDSL signals. The IMD_{DB} test in clause 6.9.3 is applicable for that purpose.

6.3 POTS and ISDN band IL requirements for the LPF

For passive splitters all requirements of IL in the POTS band and ISDN band need to be measured in one direction only. This IL is measured between LINE port and the TELE port or vice versa, according to clause 5.4.2.

The test set-ups are given in figures 11 and 12, i.e. with the switch S_{DSL} open and closed. The DC feeding conditions are specified in clause 5.1.2. Tests shall be done at the minimum and maximum current values.

6.3.1 POTS pass band loss requirements (for universal splitter only)

This clause is only applicable for universal xDSL splitters, i.e. over both ISDN and POTS. All requirements of IL for passive splitters need to be measured in one direction only.

6.3.1.1 On-hook POTS pass band insertion loss and distortion

In the past no requirements existed for the LPF of the universal splitter related to on-hook IL. This situation is not altered, for reasons explained in the following note. If IL_{PBOnH} is measured the Z_{OnHI} and Z_{OnLI} can be used.

NOTE: In theory the IL and the IL distortion should also be tested in on-hook, in line with the tests in clause 6.4 of TS 101 952-1 [7]. In practice only minor issues are expected as the LPF of the universal splitter is much wider than a regular POTS splitter. Furthermore, when a passive universal splitter is tested in off-hook, this will sufficiently indicate that also in on-hook it will pass POTS signals correctly (mainly CLIP).

6.3.1.2 Off-hook POTS pass band insertion loss

The test set-ups are given in clause 5.4.2. The off-hook pass band IL shall be measured according to figures 11 **and/or** 12 for both the LE side and the TE side splitter. The off-hook DC feeding conditions are specified in clause 5.1.2. The level of the POTS test signal shall be -4 dBV e.m.f.

The test shall be executed with two combinations of source and load impedances:

- Combination 1 shall apply Z_R as both Z_{SOURCE} and Z_{LOAD}.
- Combination 2 shall apply 600 Ω as both Z_{SOURCE} and Z_{LOAD}.

The IL of a universal splitter in off-hook (IL_{PBOffH}) shall be less than 1 dB at 1 kHz.

This requirement shall be met with the switch S_{DSL} in figures 11 and 12 both open and closed.

6.3.1.3 Off-hook POTS pass band insertion loss distortion

The IL distortion is the difference between the IL at any frequency in the range 200 Hz to 4 000 Hz and the IL at 1 kHz. It shall be less then ±1 dB.

6.3.2 ISDN pass band insertion loss

The pass band IL for ISDN (IL_{IB}) shall meet the requirements of tables 2 and 3.

The requirements of tables 2a and 2b are valid for the case where the switch S_{DSL} in figures 11 and 12 is closed.
The requirements of tables 3a and 3b are valid for the case where the switch S_{DSL} in figures 11 and 12 is open.

Source impedance: Z_T at the TELE port and Z_L at the LINE port
Load impedance: Z_T at the TELE port and Z_L at the LINE port

For an xDSL/ISDN 2B1Q splitter, the low pass filter of the splitter shall meet the requirements stated in tables 2a and 3a, for an xDSL/ISDN 4B3T splitter, the low pass filter of the splitter shall meet the requirements stated in tables 2b and 3b.

NOTE: Without xDSL load the IL requirements are slightly less stringent.

Table 2a: Insertion loss requirements in the case of ISDN 2B1Q with the xDSL load present

Frequency band	IL, S_{DSL} closed	$Z_T = Z_L$
1 kHz to 40 kHz	< 0,8 dB	135 Ω
40 kHz to 80 kHz	< 2 dB	135 Ω

Table 2b: Insertion loss requirements in the case of ISDN 4B3T with the xDSL load present

Frequency band	IL S_{DSL} closed	$Z_T = Z_L$
1 kHz to 60 kHz	< 1,2 dB	150 Ω
60 kHz to 80 kHz	< 2 dB	150 Ω

Table 3a: Insertion loss requirements in the case of ISDN 2B1Q without xDSL load

Frequency band	IL S_{DSL} open	$Z_T = Z_L$
1 kHz to 40 kHz	< 0,8 dB	135 Ω
40 kHz to 80 kHz	< 2,5 dB	135 Ω

Table 3b: Insertion loss requirements in the case of ISDN 4B3T without xDSL load

Frequency band	IL, S_{DSL} open	$Z_T = Z_L$
1 kHz to 60 kHz	< 1,5 dB	150 Ω
60 kHz to 80 kHz	< 2,5 dB	150 Ω

6.4 POTS and ISDN band return loss requirements for the LPF

The measurement of the return loss of a splitter is described in clause 5.4.6, figures 18 and 19, with the switch S_{DSL} open and closed. The DC feeding conditions are specified in clause 5.1.2. Tests shall be done at the minimum and maximum current values.

NOTE: Measuring at the LINE port was not required in previous versions of the splitter test document. It was considered unnecessary to measure the RL of the splitter at the LINE port, because this would assess the reflection of the splitter when terminated with the resistive ISDN impedance, while the actual impedance of the line attached to the LINE port is complex. Therefore, this approach is kept for the ISDN band in the present document. This note is in line with the information in Annex C.

The following test set-ups and requirements are equally applicable to the LE and TE splitters.

6.4.1 POTS band return loss

This clause is only applicable for universal xDSL splitters, i.e. over both ISDN and POTS. Return loss testing is to be carried out with the POTS off-hook DC feeding current conditions specified in clause 5.1.2.

The return loss for the POTS band RL_{PB} shall be above the template of figure 25. This requirement is applicable both in the case where the switch S_{DSL} of figures 18 and 19 is open and closed.

The load impedance and the reference impedance are identical: $Z_{LOAD} = Z_{REF} = Z_R$.

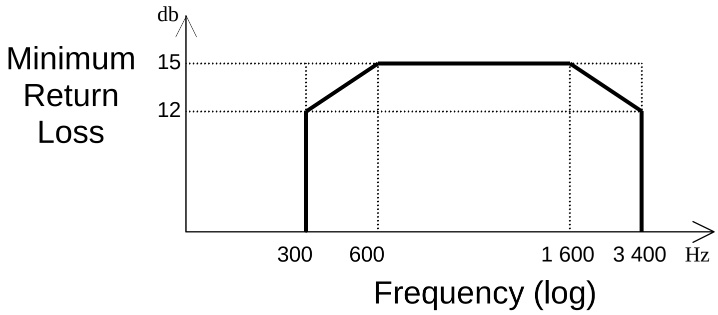


Figure 25: Minimum return loss for POTS band

NOTE: The return loss template of figure 25 corresponds to an echo return loss of 14 dB. In any case a minimum value of 8 dB is necessary.

6.4.2 Pass band return loss for ISDN

As explained in the note under clause 6.4, the return loss requirements in the ISDN band in the present document, are only applicable at the TELE port of the splitter, i.e. according to figure 18.

The pass band Return Loss in the ISDN band (RL_{IB}) shall meet the requirements of tables 4 and 5. Return loss testing is to be carried out with the ISDN DC feeding current at minimum and maximum values as specified in clause 5.1.2.

The requirements of tables 4a and 4b are valid for the case where the switch S_{DSL} in figure 18 is closed.
The requirements of tables 5a and 5b are valid for the case where the switch S_{DSL} in figure 18 is open.

The load impedance and the reference impedance are identical: $Z_{LOAD} = Z_{REF} = Z_T = Z_L$

For an xDSL/ISDN 2B1Q splitter, the low pass filter of the splitter shall meet the requirements stated in tables 4a and 5a. For an xDSL/ISDN 4B3T splitter, the low pass filter of the splitter shall meet the requirements stated in tables 4b and 5b.

NOTE: Without xDSL load the RL requirements are slightly less stringent.

Table 4a: Return loss requirements in the case of 2B1Q with the xDSL load present

Frequency band	Return Loss S_{DSL} closed	$Z_{LOAD} = Z_{REF} = Z_T = Z_L$
1 kHz to 40 kHz	> 16 dB	135 Ω
40 kHz to 80 kHz	> 14 dB	135 Ω

Table 4b: Return loss requirements in the case of 4B3T with the xDSL load present

Frequency band	Return Loss S_{DSL} closed	$Z_{LOAD} = Z_{REF} = Z_T = Z_L$
1 kHz to 60 kHz	> 16 dB	150 Ω
60 kHz to 80 kHz	> 14 dB	150 Ω

Table 5a: Return loss requirements in the case of 2B1Q without xDSL load

Frequency band	Return Loss S_{DSL} open	$Z_{LOAD} = Z_{REF} = Z_T = Z_L$
1 kHz to 40 kHz	> 12 dB	135 Ω
40 kHz to 80 kHz	> 10 dB	135 Ω

Table 5b: Return loss requirements in the case of 4B3T without xDSL load

Frequency band	Return Loss S_{DSL} open	$Z_{LOAD} = Z_{REF} = Z_T = Z_L$
1 kHz to 60 kHz	> 12 dB	150 Ω
60 kHz to 80 kHz	> 10 dB	150 Ω

6.5 Requirements relating to metering pulses at 12 kHz or 16 kHz (for universal splitter only) (optional)

This clause is only applicable for universal xDSL splitters, i.e. over both ISDN and POTS.

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

NOTE: There is no minimal IL required for metering.

The IL test set-up of figures 11 and 12 shall be used, using the condition of table 6. This requirement is applicable with the switch S_{DSL} both open and closed. The level of the test signal is 3,5 Vrms. This requirement is applicable with the POTS off-hook DC current as specified in clause 5.1.2.

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

Level of source voltage	Impedance Z_{SOURCE}	Impedance Z_{LOAD}	Impedance at the xDSL port
3,5 Vrms	200 Ω	200 Ω	Z_{xDSL-i}

6.6 Unbalance about earth

The tests for measuring unbalance of the splitter are described in clause 5.5, in figures 20, 21, 22 and 23.

6.6.1 Unbalance of the low pass part

The test set-up for measuring unbalance of the splitter low pass is in figures 20 and 21.

The following balance related characteristics of the low pass part are measured:

1) $LCL_{TELEport}$ LCL at the TELE port, with LINE port tied to ground.

2) $LCL_{LINEport}$ LCL at the LINE port, with TELE port tied to ground.

3) $LCTL_{TELEtoLINE}$ LCTL from TELE port to LINE port.

The test shall be carried out for the combinations described in table 7.

The DC feeding current is specified in clause 5.1.2.

In the case of performing measurements at frequencies above 30 kHz, for reasons of practical testing a 150 Ω impedance should be used in series with the longitudinal source (i.e. S1 in figures 20 and 21 shall be open).

Table 7: Low pass unbalance about earth, test set-ups

Test set-up #	Source port to termination port	Measurement port	Frequency range
1: LCL figure 20	TELE (to LINE)	TELE	50 Hz to 1,1 MHz
2: LCL figure 21	LINE (to TELE)	LINE	50 Hz to f_{Max} (see note)
3: LCTL figure 20	TELE (to LINE)	LINE	50 Hz to f_{Max} (see note)
NOTE: f_{Max} is still F.F.S. for some xDSL cases; in those cases the frequency range is 50 Hz to f_H.			

The xDSL port shall be terminated by a Z_{RefDSL} resistor for all unbalance tests described in the present document.

For each of the three 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 (note 1)	40 dB
600 Hz to 3 400 Hz	Closed	300 Ω (note 1)	40 dB
3 400 Hz to 4 000 Hz	Closed	300 Ω (note 1)	40 dB
300 Hz to f_L	Closed	$Z_L/2 = Z_T/2$	40 dB
f_L to f_{Max}	Open	$Z_{RefDSL}/2$	See Annex A (note 2)
NOTE 1: The UaE with 300 Ω is only measured in the POTS band, i.e. only for universal splitters; the other measurements apply for both ISDN and universal splitters. NOTE 2: Values of the frequencies and the applicable UaE in the xDSL band and above it are specified in tables A.7 to A.10 in clauses A.3 to A.6 for each xDSL variant.			

6.6.2 Unbalance of the high pass part

This clause is limited to splitters equipped with two DCB capacitors. When the high pass is absent, as described in clause 4.1 in the paragraph marked as case "2)", the balance at the LINE port is assessed with the balance measurement of the low pass in clause 6.6.1.

The following balance related characteristics of the high pass part are measured:

4. $LCL_{xDSLport}$ LCL at the xDSL port, with LINE port tied to ground.

5. $LCL_{LINEport}$ LCL at the LINE port, with xDSL port tied to ground.

NOTE: It should be clear that the common mode model of the source or the termination in the unbalance test set-up is not intended for modelling an xDSL transceiver in a realistic way. The common mode impedance is much too low at the lower edge of the xDSL pass band. As a result the measurement in this clause is mainly an assessment of the mismatch between the two blocking capacitors.

The basic test set-up for measuring unbalance at the xDSL port is shown in figure 22. In the case of measuring at the LINE port, the test set-up of figure 23 is used. The test shall be carried out for the combinations described in table 9. It should be noted that the source and measurement points are always at the same port.

Table 9: Unbalance about earth, test set-ups

Test set-up #	Source port to termination port	Measurement port	Frequency range
4: LCL figure 22	xDSL (to LINE)	xDSL	f_L to f_{Max} (see note)
5: LCL figure 23	LINE (to xDSL)	LINE	f_L to f_{Max} (see note)
NOTE: f_{Max} is still F.F.S for some xDSL cases; in those cases the frequency range is f_L to f_H.			

For both ISDN and Universal splitters the TELE port shall be terminated by a $Z_L = Z_T$ resistor for all unbalance tests described in the present clause.

For each of the test set-ups described above, the splitter shall meet the unbalance about earth requirements as specified in table 10.

In the case of performing measurements at frequencies above 4 kHz, for reasons of practical testing a 150 Ω impedance should be used in series with the longitudinal source (i.e. S1 in figures 22 and 23 should be open).

Table 10: Unbalance about earth, minimum values

Frequency range	State of S1	Value of R	Minimum Unbalance value
f_L to f_H	open	$Z_{RefDSL}/2$	See Annex A
f_H to f_{Max}	open	$Z_{RefDSL}/2$	See Annex A

6.7 xDSL band related requirements

In the xDSL band the POTS noises and transients and the ISDN signals must be attenuated sufficiently to protect xDSL. Also the POTS circuits and ISDN transceivers must be protected against the strong xDSL signals in the xDSL band and in the transition band, below the xDSL band. Finally the xDSL signals should not be affected by the splitter, when the xDSL signals transit from LINE port to xDSL port. The general issues of this protection and separation are described in Annex I.

For passive splitters all requirements of IL need to be measured in one direction only.

NOTE 1: Performance in the xDSL band always needs to be specified for ISDN signals. Furthermore, for the universal splitters it could also be specified for POTS signals in on-hook and off-hook state. This means that besides a test with stable impedance modelling ISDN band, there could also be a number of tests with different impedances, which should model the high-Ohmic and low-Ohmic states of the POTS equipment. Rather than performing a complex set of tests, the isolation is simply tested from TELE port to the xDSL port, and vice versa with a limited set of test impedances.

NOTE 2: In TS 101 952-1 [7] there is an optional clause with the isolation in the transition band between the POTS band and the xDSL band. This is not required for ISDN or Universal splitters.

6.7.1 xDSL band isolation: IL between TELE port and xDSL port

For the isolation of the splitter, that is the IL in the xDSL band (IL_{DB}) between TELE and xDSL port and vice versa at xDSL frequencies, the test set-up of clause 5.4.3 is used, as in figures 13, and 14. The DC feeding conditions are specified in clause 5.1.2.

The IL shall meet the requirements in table 11 for xDSL over ISDN splitters for 2B1Q and 4B3T. In the case where the source is connected to the TELE port, the TELE port impedance in table 11 is the source impedance (and vice versa for the xDSL port).

NOTE: For IL in the xDSL band stronger requirements are imposed for isolation of xDSL against ISDN. This is needed, because ISDN signals are substantially stronger in their out-of-band behaviour than POTS. Due to the PAM modulation, the ISDN spectra drop only gradually above their regular pass band (i.e. 120 kHz for 4B3T and 80 kHz for 2B1Q).

The isolation requirements are the same for 2B1Q and 4B3T. Only the value of impedance Z_T at the TELE port differs as already explained in clause 5.2.2. Z_T = 135 Ω for 2B1Q and 150 Ω for 4B3T.

Table 11: Minimum isolation requirements and test parameters for xDSL/ISDN splitters

Frequency range	Minimum Isolation	Impedance at TELE port	Impedance at LINE port	Impedance at xDSL port	xDSL
f_L to 2 208 kHz (note)	> 55 dB	Z_{RHF}	Z_{Line}	Z_{xDSL-i}	ADSL1, ADSL2+, VDSL1, VDSL2
f_L to 150 kHz 150 kHz to 1 104 kHz 1 104 kHz to 2 208 kHz	> 55 dB > 65 dB > 55 dB	Z_T = 2B1Q:135 Ω 4B3T: 150 Ω	Z_{Line}	Z_{xDSL-i}	ADSL1, ADSL2+, VDSL1, VDSL2
2 208 kHz to f_H	> 55 dB	Z_T	Z_{Line}	Z_{xDSL-i}	VDSL1, VDSL2
NOTE: The first line from f_L to 2 208 kHz applies to POTS signal isolation, i.e. only for a universal splitter on POTS impedances; the next 3 lines also covering f_L to 2 208 kHz are for ISDN.					

6.7.2 xDSL signal loss: IL between LINE port and xDSL port

The IL (i.e. the attenuation in the xDSL Band, abbreviated as Att_{DB}) due to the insertion of the low pass part of the splitter from the LINE port to the xDSL port and in the opposite direction shall be tested according to clause 5.4.4, figures 16 and 17. For passive splitters the test needs to be done in one direction only.

The correct ISDN and the POTS DC feeding conditions shall be applied as specified in clause 5.1.2.

For both ISDN and universal splitters the impedance at the LINE port shall be Z_{Line}, i.e. 135 Ω, and the impedance at the xDSL port shall be Z_{DSL-i}.

For splitters for xDSL over ISDN only, the requirements of table 12 shall be met with the TELE port both open circuited, terminated with 135 Ω for an xDSL/ISDN 2B1Q splitter and with 150 Ω for an xDSL/ISDN 4B3T splitter.

For universal xDSL splitters (i.e. over both ISDN and POTS) the requirements of table 12 shall be met with the TELE port terminated with the same impedances as the ISDN splitter (above), and additionally terminated with Z_{RHF}.

The different impedances at the TELE port represent the cases of a connection at the TELE port of ISDN equipment, or of POTS equipment both on-hook and off-hook, or the absence of any ISDN or POTS equipment, which should not influence the xDSL transmission.

NOTE 1: When the splitter does not contain DCB capacitors the test set-up is altered as explained in informative clause L.3.

NOTE 2: The Att_{DB} could change due to changing impedances at the TELE port, which may affect the xDSL transmission adversely. This can be tested according to clause 6.11, in which TR-127 of the Broadband Forum is recommended for this purpose. The TR-127 tests include rapid on-hook/off-hook transitions, which should have minimal effect on the ongoing xDSL transmission.
See also the remarks 4) and 5) in the Introduction. See also Annex H on TR-127 [i.16].

Table 12: Insertion loss between LINE and xDSL port for xDSL over ISDN and universal splitters

Frequency range	IL between LINE port and xDSL port	xDSL
f_L to 170 kHz (note)	-1 dB < Att_{DB} < 3 dB	ADSL1, ADSL2+, VDSL1, VDSL2
170 kHz to 1 104 kHz (note)	-1 dB < Att_{DB} < 1 dB	ADSL1, ADSL2+, VDSL1, VDSL2
1 104 kHz to 2 208 kHz	-1 dB < Att_{DB} < 1 dB	ADSL2+, VDSL1, VDSL2
2 208 kHz to f_H	-1 dB < Att_{DB} < 1 dB	VDSL1, VDSL2
NOTE: When f_L > 170 kHz the second row is applicable only above f_L and the first row is not applicable.		

6.8 Noise

Noise measurements need only to be specified for active/dynamic splitters. They are F.F.S. and they are introduced in Annex K.

6.8.1 POTS band audible noise level requirements

This clause is only applicable for universal xDSL splitters, i.e. over both ISDN and POTS.

The psophometric noise power N_{PB} is only measured for active/dynamic splitters, as discussed in Annex K.

6.8.2 ISDN band noise level requirements

Noise requirements for the ISDN band are F.F.S.

The noise power N_{IB} is only measured for active/dynamic splitters, as discussed in Annex K.

6.8.3 xDSL band noise level requirements

The noise power N_{DB} is only measured for active/dynamic splitters, as discussed in Annex K.

6.9 Intermodulation distortion

In earlier versions of the specification the **I**nter**M**odulation **D**istortion (IMD) was measured only in the POTS band. Furthermore, it was not clear if the IMD requirement in the POTS band was actually necessary or even sufficient to guarantee correct POTS operation.

6.9.1 POTS band intermodulation distortion requirements (mandatory)

This clause is only applicable for universal xDSL splitters, i.e. over both ISDN and POTS, and needed only in off-hook.

The test set-up for IMD_{PB} (IMD in the **P**OTS **B**and) to be used is given in figure 11, with the switches connecting the splitter under test to the set-up. This requirement is applicable with the switch S_{DSL} both open and closed. Both the source and load impedance used shall be equivalent to Z_R. 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 [4] injected at the LINE port.

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 TELE port.

NOTE 1: A methodology for performing this IMD test in the presence of an xDSL signal is available in [i.3] and [i.6]. It was thought that this represents a more realistic scenario for IMD evaluation. However, this is doubtful. The TR-127 [i.16] based methodology present in the clause 6.9.3 is considered a more recommendable approach to the test of splitter distortion in the presence of POTS and xDSL signals.

NOTE 2: This POTS band IMD test is relatively difficult to perform, particularly in the presence of DC feeding conditions. Although mandatory, there is no proof that this test is either necessary or sufficient. If a splitter passes the TR-127 tests this proves more about its intrinsic qualities than achieving the IMD_{PB}.

6.9.2 ISDN band intermodulation distortion requirements (F.F.S.)

This requirement is still F.F.S. However, to measure IMD in the **I**SDN **B**and (IMD_{IB}) it is expected that the TR-127 methodology of the Broadband Forum [i.16] will be adopted. For testing the ISDN distortion of a splitter, the methodology for ISDN is still under development by the Broadband Forum in a revision of TR-127. When it is published, reference will be made to the appropriate sections in the reworked Broadband Forum TR-127 document.

It is necessary to test the effect of non-linear behaviour of the splitter components, under variable DC voltages and currents, under ISDN AC and DC signals, and also under the strongest possible wideband xDSL signals.

This can be done in dynamic tests, in which a splitter as Device Under Tests (DUT) is operating together with 2 baseline xDSL modems, ISDN transceivers and a baseline splitter. This kind of test for ISDN signals is under construction at the Broadband Forum. This test is described in informative Annex H. The transient aspect for ISDN signals is handled in clause 6.11.

6.9.3 xDSL band intermodulation distortion requirements (optional)

For testing the xDSL distortion of a splitter, the methodology developed by the Broadband Forum (TR-127) is adopted. The TR-127 document is published by the Broadband Forum [i.16]. The test is described in Annex H.

NOTE: As long as the methodology in the Broadband Forum was not finalized and it was not replicated with sufficient consistency in different certified labs, the content of this clause was for information only. As the Broadband Forum methodology is finalized and replicated with sufficient consistency, ETSI recommends TR-127 to test IMD_{DB} in the xDSL band.

These optional tests (if required by the operator) will be based on stationary tests within TR-127. This requires 5 tests in sections 8.2 to 8.6 plus the section 8.10 of the TR-127 to be executed. The following ETSI proprietary adaptations of the testing requirements: the line lengths specified in section 8.1.2 of TR-127 for ADSL will be augmented with one extra maximum length of 4,2 km.

The requirements for the tests 8.4 and 8.6 with splitters as DUT will be identical as in the TR-127. (The tests 8.2, 8.3, 8.5 are calibrations and baseline tests, with no DUT present.)

For the test in clause 8.10, the drop in capacity allowed for the maximal length is maximally 30 %.

6.10 Delay distortion

6.10.1 POTS band delay distortion

This clause is only applicable for universal xDSL splitters, i.e. over both ISDN and POTS.

The increase of the group delay distortion by inserting one splitter shall be less than the figures in table 13, relative to the lowest measured delay in the frequency range 200 Hz to 4 000 Hz. The test set-up is given in figure 11. This requirement is applicable with the switch S_{DSL} both open and closed. The off-hook DC feeding current is specified in clause 5.1.2.

Table 13: 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

Source impedance: Z_R

Load impedance: Z_R

Level of the test signal: -10 dBV.

6.10.2 ISDN band delay distortion

The signal delay distortion of the low pass filter of the splitter shall be < 20 μs up to 80 kHz. The signal delay distortion is defined as the absolute difference between the minimum signal delay (as measured at a discrete frequency in the range up to 80 kHz) and the maximum signal delay as measured at a discrete frequency over the same frequency range.

The set-up for measuring group delay distortion is given in figure 11. This requirement is applicable with the switch S_{DSL} both open and closed. The ISDN DC feeding current is specified in clause 5.1.2.

Source impedance: 135 Ω for an xDSL/ISDN 2B1Q splitter, 150 Ω for an xDSL/ISDN 4B3T splitter.
Load impedance: 135 Ω for an xDSL/ISDN 2B1Q splitter, 150 Ω for an xDSL/ISDN 4B3T splitter.

6.11 POTS/ISDN transient effects (optional)

A POTS transient test existed in previous versions of the present document, published under TS 101 952-1-4 to test how the transient signals caused by POTS affect the xDSL system. Such a test would be extremely useful. However, the validity of the associated test method was unsatisfactory and therefore the old test method was removed completely.

6.11.1 POTS transient effects (optional)

Recently a new approach to transient testing was published by in the Broadband Forum. The Broadband Forum document Technical Requirement 127 (TR-127) [i.16] describes this methodology, which consists in testing the splitters on a real line, with two baseline xDSL modems and with the injection of POTS LE signals (POTS AC, POTS DC, ringing, …) including POTS TE transients, such as off-hook and ring-trip.

Therefore, for all transitional tests of Universal splitter under POTS transients, it is recommended that the TR-127 methodology be used.

These optional tests (if required by the operator) will be based on transitional tests within TR-127. This requires calibration and baseline tests 8.2, 8.3 and 8.5, and DUT checks according to sections 8.7 to 8.9 of the TR-127 to be executed.

NOTE: The following ETSI proprietary adaptations of the testing requirements is still F.F.S.: in line with the clause 6.9.3 the line lengths specified in section 8.1.2 of TR-127 [i.16] for ADSL might be augmented with one extra maximum length of 4,2 km.

6.11.2 ISDN transient effects (optional)

The ISDN version of TR-127 will allow checking how ISDN state transitions might affect xDSL and vice versa. However, this newer version of TR-127 is still under construction. Therefore, the use of the TR-127 methodology to test how splitters prevent the interaction between ISDN and xDSL is still F.F.S. in the present document. See also the remarks 4) and 5) in the Introduction. A tutorial text on TR-127 is given in informative Annex H.

6.12 Requirements for Common Mode rejection (optional)

In the present document the requirements for CMRR are not defined. The CMRR requirement in TS 101 952-1 [7] is specified from 25 kHz to 1,1 MHz, which is appropriate for ADSL over POTS splitters, but not for VDSL splitters or for ADSL splitters over ISDN or universal splitters. Extrapolating from part 1, the CMRR should be defined on the xDSL band only, i.e. above the f_L (e.g. 138 kHz for ADSL over ISDN).

6.13 Requirements for Crosstalk at the LE (optional)

For a board with multiple splitters at the LE side of the line (at LE or cabinet) the splitter can be a source of additional crosstalk between lines, which is added to the crosstalk of the cables, the backplanes, other boards and other elements in the DSLAM. This clause is F.F.S.

One general way of defining the requirement would be to ask that the crosstalk should be better than the crosstalk in the cable for some typical or minimal length of cable. The type of cable to make this comparison has to be defined.

Annex A (normative): xDSL specific information

A.1 Z_{DSL-i} and Z_{RefDSL} for specific xDSL variants

In many of the tests, the xDSL port of the splitter is terminated with impedances called Z_{DSL-i} and Z_{RefDSL}. Their purpose is explained in clause 5.2.1.

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

Z_{DSL-i} is an impedance, connected as a termination at the xDSL port of the splitter. This impedance is a high pass filter (HPF). For xDSL over ISDN, the different variants of Z_{DSL-i}, as defined in clause 5.2.1, are composed of Z_{RefDSL}, C_{DSL}, and L_{DSL}, which results in the equivalent circuit of figures A.1.

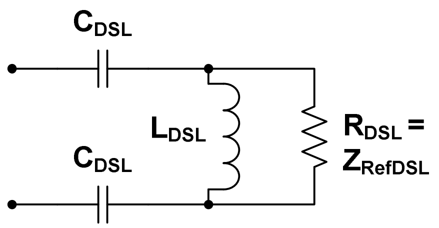


Figure A.1: Equivalent schematic of the Z_{DSL-i} HPF impedance model

There are two different Z_{DSL-i} variants, depending on the presence or absence of the high pass function inside the splitter (see figure 2). They differ only in the value of the DC blocking capacitor C_{DSL} in the model of figure A.1.

- The first variant of Z_{DSL-i} is the most common one. It is intended for use with a splitter containing two DC blocking capacitors, as described in clause 5.3.
- However, in some cases the DC blocking capacitors are merged with the input impedance of the xDSL transceiver. To test a splitter without DC blocking caps, either the reference DCB capacitors are put in series with the Z_{DSL-i} of the previous bullet, or a different impedance (called Z_{DSL-i2}) can be used. How to use this impedance Z_{DSL-i2} is explained in Annex L.

Z_{RefDSL} is the design impedance of the xDSL transceivers of a specific xDSL variant, and is a resistor independent of the used frequency range. In practice the Z_{RefDSL} is purely resistive, and the symbol R_{DSL} is used as its equivalent.

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

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

The impedance of the second variant (Z_{DSL-i2}) is identical to the value of the series connection of the first variant of Z_{DSL-i} and the DC blocking capacitors. In this way the total impedance of the xDSL transceiver model and the DCB high pass as seen from the LINE port has always the same value.

NOTE: Some contributions studied the order of the Z_{DSL-i} HPF impedance model. As alternative to the second order variant (above) it was proposed to allow a third order filter. However, no consensus could be reached on this. Therefore, only the second order Z_{DSL-i} is defined and in use.

To simplify the measurements above 1 MHz, the source or load termination with Z_{DSL-i} can be replaced by $Z_{RefDSL} \equiv R_{DSL}$, i.e. the coil L_{DSL} and the capacitors C_{DSL} are removed. If needed DC blocking capacitors (with an appropriate value) should still be included, to prevent DC current to flow in R_{DSL} ($\equiv Z_{RefDSL}$). This is applicable when the R_{DSL} would not sustain any DC current, or when the DC current should follow another desirable path in the test set-up.

Table A.1: Values of elements of Z_{DSL-i} for different xDSL system variants

Impedance name	ADSL1 or ADSL2 over ISDN / Universal (mandatory)	ADSL2plus over ISDN / Universal (mandatory)	European VDSL1 over ISDN / Universal starting at 138 kHz	European VDSL1 over ISDN / Universal starting at other frequencies (note 1)	VDSL2 over ISDN / Universal including the US0 band from 138 kHz	VDSL2 Over ISDN / Universal not including the US0 band (note 1)
$Z_{RefDSL} \equiv R_{DSL}$	100 Ω	100 Ω	135 Ω	135 Ω	100 Ω	100 Ω
L_{DSL}	82 µH	82 µH	111 µH	not specified	82 µH	F.F.S.
C_{DCB}	27 nF	27 nF	27 nF	Note 2	27 nF	Note 2
C_{DSL} if C_{DCB} is present	42 nF	42 nF	22 nF	not specified	42 nF	F.F.S.
C_{DSL} if C_{DCB} is absent	16,4 nF	16,4 nF	12,2 nF	not specified	16,4 nF	F.F.S.
xDSL capacitance seen at LINE port	8,2 nF	8,2 nF	6,1 nF	not specified	8,2 nF	F.F.S.
NOTE 1: There are VDSL1 and VDSL2 variants over ISDN, with a lower frequency edge of the used frequency band higher than 138 kHz. These VDSL transceivers might have a high pass with a higher cut-off frequency.						
NOTE 2: The DCB capacitors for the cases described in note 1 could be kept at 27 nF, to unify these capacitors for all cases of ADSL(2(plus)) and VDSL(1 or 2), irrespective of the lowest used frequency.						

A.1.2 Z_{DSL-i} for ADSL over ISDN/Universal

For ADSL over ISDN the splitter normally must contain DC blocking capacitors. The impedance model of figure A.2 shall be used to terminate the xDSL port of the splitter.

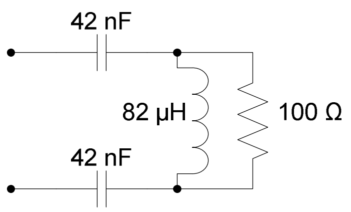


Figure A.2: Schematic diagram of the impedance Z_{DSL-i} for ADSL over ISDN/Universal, if blocking capacitors are *present* in the splitter filter

In the case where DC blocking capacitors are not present inside the splitter, but merged with the ADSL transceiver, the impedance network of figure A.3 (Z_{DSL-i2}) shall be used to terminate the xDSL port of the splitter.

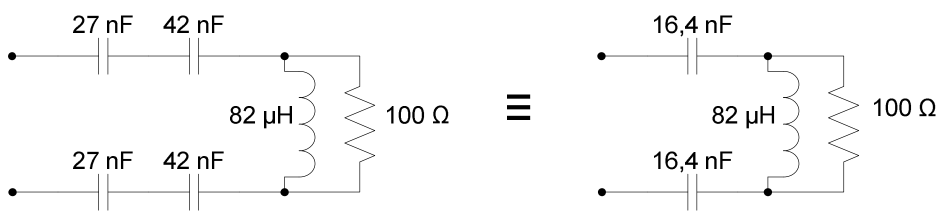


Figure A.3: Schematic diagram of the impedance Z_{DSL-i2} for ADSL over ISDN/Universal, if blocking capacitors are *merged* with the input impedance of the ADSL transceiver

A.1.3 Z_{DSL-i} for European VDSL1 over ISDN/Universal, with US0

The design impedance of the European VDSL1 Z_{RefDSL} (≡ R_{DSL}) is 135 Ω. The Z_{DSL} impedance model is scaled with the appropriate scaling factor of 1,35.

For European VDSL1 over ISDN/Universal starting at 138 kHz the splitter normally must contain DC blocking capacitors. The impedance model of figure A.4 shall be used to terminate the xDSL port of the splitter.

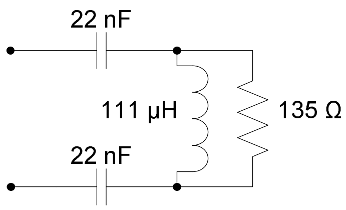


Figure A.4: Schematic diagram of the impedance Z_{DSL-i} for European VDSL1 over ISDN/Universal, starting at 138 kHz if blocking capacitors are present in the splitter filter

In the case where either DC blocking capacitors are absent inside the splitter, but merged with the ADSL transceiver, the impedance network of figure A.5 (Z_{DSL-i2}) shall be used to terminate the xDSL port of the splitter.

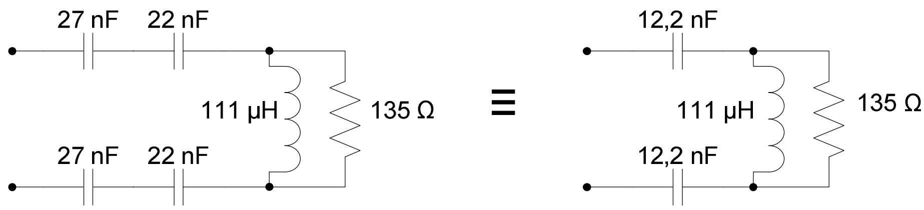


Figure A.5: Schematic diagram of the impedance Z_{DSL-i2} for European VDSL1 over ISDN/Universal, starting at 138 kHz if blocking capacitors are *merged* with the input impedance of the VDSL transceiver

A.1.4 Z_{DSL-i} and Z_{DSL-i2} for VDSL2 over ISDN with US0

For this VDSL2 variant, the impedance models are **identical** to the ADSL over ISDN/Universal impedance model in clause A.1.2.

NOTE: The harmonization of the Z_{DSL-i} for VDSL2 with ADSL and its variants was established in the ITU-T.

A.2 General requirements for ISDN and universal splitters

A complete overview of all requirements for xDSL over ISDN splitters is listed in table A.2. They apply to both LE and TE side splitters. Symbols are explained in clause 3.2. The specific frequency ranges for the individual xDSL types are compiled in additional tables A.4 to A.6.

Table A.2: Dedicated requirements for ISDN and universal splitters for xDSL system variants

Clause number	Symbol	Frequency Range	REQUIREMENTS	Splitter Type (note)
6.1.1	$R_{to\ Earth}$	DC	> 20 MΩ	Both
6.1.2	$R_{A\ to\ B\ wire}$	DC	> 5 MΩ	Both
6.1.3	R_{DC}	DC	< 12,5 Ω	Both
6.2.1	THD_{Ring}	25 Hz and/or 50 Hz	10 %	Universal
6.3.1.1	IL_{PBOnH}	(200 Hz to 2,8 kHz)	Recommended, but not required; Refer to Part 1 [7] (±4 dB)	Universal
6.3.1.2	IL_{PBOffH}	1 kHz	< 1 dB	Universal
6.3.1.3	IL distortion	0,2 kHz to 4 kHz	± 1 dB relative to IL @ 1 kHz	Universal
6.3.2 2B1Q	IL_{IB}	ISDN band 1 kHz to 40 kHz 40 kHz to 80 kHz	With Z_{DSL-i} Without Z_{DSL-i} < 0,8 dB < 0,8 dB < 2 dB < 2,5 dB	Both
6.3.2 4B3T	IL_{IB}	ISDN band 1 kHz to 60 kHz 60 kHz to 80 kHz	With Z_{DSL-i} Without Z_{DSL-i} < 1,2 dB < 1,5 dB < 2 dB < 2,5 dB	Both
6.4.1	RL_{PBOffH}	POTS band	Template 12-15-15-12 dB in figure 25	Universal
6.4.2 2B1Q	RL_{IB}	ISDN band 1 kHz to 40 kHz 40 kHz to 80 kHz	With Z_{DSL-i} Without Z_{DSL-i} > 16 dB > 12 dB > 14 dB > 10 dB	Both
6.4.2 4B3T	RL_{IB}	ISDN band 1 kHz to 60 kHz 60 kHz to 80 kHz	With Z_{DSL-i} Without Z_{DSL-i} > 16 dB > 12 dB > 14 dB > 10 dB	Both
6.5	IL_{Meter}	12 kHz and/or 16 kHz	Optional (5 dB suggested)	Universal
6.6.1 low pass	UaE_{PB}	POTS band	40 dB	Universal
	UaE_{IB}	ISDN band	40 dB	Both
6.6.1 low pass	$LCL_{TELEport}$ $LCL_{LINEport}$ $LCTL_{TELEtoLINE}$	DSL band	Differs depending on the xDSL variant and differs between LE and TE side. See Specific clauses A.3 to A.6	Both
6.6.2 high pass	$LCL_{xDSLport}$ $LCL_{LINEport}$	DSL band		Both
6.7.1	IL_{DB}	DSL band	Requirement for ISDN and POTS: see clause. Optional differentiation between LE and TE side, see table A.3	Both
6.7.2	Att_{DB}	f_L to 170 kHz 170 kHz to f_H	-1 dB < Att_{DB} < 3 dB -1 dB < Att_{DB} < 1 dB	Both
6.8.1	N_{PB}	POTS band	N.A. for passive splitters	Universal
6.8.2	N_{IB}	ISDN band	N.A. for passive splitters	Both
6.8.3	N_{DB}	xDSL band	N.A. for passive splitters	Both
6.9.1	IMD_{PB}	POTS band	See requirement in the clause	Universal
6.9.2	IMD_{IB}	ISDN band	F.F.S. using TR-127 of Broadband Forum	Both
6.9.3	IMD_{DB}	xDSL band	TR-127 based (optional)	Both
6.10.1	Group Delay	POTS band	See details in clause 6.10.1	Universal
6.10.2	Group Delay	ISDN band	< 20 µs	Both
6.11.1	Transients	POTS band	TR-127 of Broadband Forum (optional)	Universal
6.11.2	Transients	ISDN band	F.F.S. using TR-127 of Broadband Forum	Both
6.12	CMRR	DSL band	Optional, see template in clause	Both
6.13	Crosstalk	DSL band	See specific clauses A.3 to A.6 (optional)	Both
NOTE: The column marked "splitter type" indicates either Universal, or both (i.e. Universal and ISDN).				

Table A.3: Differentiation of IL in the DSL band between LE and TE side

Clause number	Symbol	Frequency Range	Splitters over xDSL over POTS at the LE/CO side	Splitters over xDSL over POTS at the TE/CPE side
6.7.1	IL_{DB} POTS	f_L to f_H	> 55 dB	> 55 dB (note 1)
6.7.1	IL_{DB} ISDN	f_L to 150 kHz	> 55 dB	> 55 dB (note 1)
		150 kHz to 1 104 kHz	> 65 dB (NOTE 2)	> 65 dB (note 1)
		1 104 kHz to f_H	> 55 dB	> 55 dB

NOTE 1: ADSL1, ADSL2 and ADSL2plus are usually deployed without overlap of US and DS, i.e. with FDD (Frequency Division Duplexing). (Similarly VDSL usually only uses FDD). For FDD systems the upstream (US0 or US) at the TE side (transmitted) needs less protection. At the TE side the US transmitter does not need the same protection as the US receiver at the LE side. Therefore, it is possible to relax the splitter isolation from TELE port to the xDSL port, in the US (or US0) band. Furthermore, by reducing the IL in the range f_L to f_{M1}, the IL above f_{M1} could be increased. This would protect the downstream of a triple play data stream better, which can be proven with the TR-127 methodology. For example: at TE side (e.g.) 45 dB up to f_{M1} and (e.g.) > 65 dB above f_{M1} up to e.g. 1,1 MHz could improve DS data receiver protection for triple play.

NOTE 2: At the LE side the US receiver needs more protection than the DS transmitter at the LE side. Therefore, it is possible to keep the splitter isolation from TELE port to the xDSL port, in the US (or US0) band. However, while keeping the IL in the range f_L to f_{M1}, the IL above f_{M1} could be decreased (e.g. to only 55 dB), because the downstream transmitter is not requiring the same protection as the upstream receiver.

The differentiation in note 1 and note 2 at the LE or TE side is optional. The values are proposals. Exact values are F.F.S.

Table A.4: Dedicated frequency ranges for splitters for ADSL system variants

Frequency Symbol	ADSL1 or ADSL2 over ISDN: ITU-T G.992.1 [i.9], Annex B or ITU-T G.992.3 [i.10] Annex B	ADSL2plus over ISDN: ITU-T G.992.5 [i.11], Annex B
f_L	120 kHz	120 kHz
f_{M1}	276 kHz	276 kHz
f_H	1 104 kHz	2 208 Hz
f_{Max}	5 MHz	5 MHz

Table A.5: Dedicated frequency ranges for splitters for VDSL1 system variants

Frequency Symbol	Splitters for VDSL1 over ISDN ITU-T G.993.1 [i.12], starting at 138 kHz)	Splitters for VDSL 1 over ISDN for ITU-T G.993.1 [i.12], starting above 138 kHz
f_L	138 kHz	Lowest used VDSL1 frequency
f_{M1}	Not applicable	Not applicable
f_H	12 MHz	12 MHz
f_{Max}	F.F.S.	F.F.S.

Table A.6: Dedicated frequency ranges for splitters for VDSL2 system variants

Frequency Symbol	Splitters for VDSL2 over ISDN ITU-T G.993.2 [i.13], with US0 band type B	Splitters VDSL2 over ISDN ITU-T G.993.2 [i.13], starting above 120 kHz
f_L	120 kHz	Lowest used VDSL2 frequency
f_{M1}	276 kHz	276 kHz or not applicable when f_L > 276 kHz
f_H	30 MHz	30 MHz
f_{Max}	F.F.S.	F.F.S.

A.3 Specific requirements for passive splitters for ADSL over ISDN variants

Specific requirements limited to passive splitters for ADSL over ISDN or Universal ADSL splitters are listed in table A.7. They apply to both LE and TE side splitters. Symbols are explained in clause 3.2. Frequency values dedicated to ADSL are in table A.4.

Table A.7: Dedicated requirements for passive splitters for ADSL over ISDN/Universal variants at both the LE and the TE side

Clause number	Symbol	Frequency Range	Splitters over ISDN for ADSL1, ADSL2 or ADSL2plus
6.6.1 low pass	$LCL_{TELEport}$	4 kHz to f_L f_L to 1,1 MHz	> 40 dB > 50 dB
6.6.1 low pass	$LCTL_{TELEtoLINE}$ or $LCL_{LINEport}$	4 kHz to f_L f_L to f_H f_H to f_{Max}	> 40 dB > 50 dB > 30 dB
6.6.2 high pass	$LCL_{xDSLport}$ or $LCL_{LINEport}$	f_L to f_H f_H to f_{Max}	> 45 dB > 30 dB
6.13	Crosstalk	DSL band f_L to f_H	F.F.S. Only applicable at the LE side

A.4 Specific requirements for passive splitters for VDSL1 over ISDN variants

Specific requirements limited to passive splitters for VDSL1 over ISDN are listed in table A.8. They apply to both LE and TE side splitters. Symbols are explained in clause 3.2. Frequency values dedicated to VDSL1 are in table A.5. Examples of VDSL1 over ISDN starting well above 120 kHz could be a VDSL at the cabinet, possibly in parallel with ADSL from the LE.

Table A.8: Dedicated requirements for passive splitters for VDSL1 over ISDN variants at both the LE side and TE side

Clause number	Symbol	Frequency Range	Splitters for VDSL1 over ISDN/Universal for any f_L
6.6.1 low pass	$LCL_{TELEport}$	4 kHz to f_L f_L to 1,1 MHz	> 40 dB > 50 dB
6.6.1 low pass	$LCTL_{TELEtoLINE}$ or $LCL_{LINEport}$	4 kHz to f_L f_L to f_H f_H to f_{Max}	> 40 dB > 45 dB > 30 dB
6.6.2 high pass	$LCL_{xDSLport}$ or $LCL_{LINEport}$	f_L to f_H f_H to f_{Max}	> 45 dB > 30 dB
6.13	Crosstalk	DSL band f_L to f_H	F.F.S. Only applicable at the LE side

A.5 Specific requirements for passive splitters for VDSL2 over ISDN variants at the TE side

Specific requirements limited to passive splitters for VDSL2 over ISDN at the TE side are listed in table A.9. Symbols are explained in clause 3.2. Frequency values dedicated to VDSL2 are in table A.6.

Table A.9: Dedicated requirements for passive splitters for VDSL2 over ISDN variants at the TE side

Clause number	Symbol	Frequency Range	Splitters for VDSL2 over ISDN/Universal for any f_L
6.6.1 low pass	$LCL_{TELEport}$	4 kHz to f_L f_L to 1,1 MHz	> 40 dB > 50 dB
6.6.1 low pass	$LCTL_{TELEtoLINE}$ or $LCL_{LINEport}$	4 kHz to f_L f_L to 2,2 MHz 2,2 MHz to 12 MHz 12 MHz to f_H f_H to f_{Max}	> 40 dB > 50 dB > 45 dB Drop 20 dB/decade from 45 dB at 12 MHz Note that f_{Max} is still F.F.S.
6.6.2 high pass	$LCL_{xDSLport}$ or $LCL_{LINEport}$	f_L to 12 MHz 12 MHz to f_H f_H to f_{Max}	> 45 dB Drop 20 dB/decade from 45 dB at 12 MHz Note that f_{Max} is still F.F.S.

A.6 Specific requirements for passive splitters for VDSL2 over ISDN variants at the LE side

Specific requirements limited to passive splitters for VDSL2 over ISDN at the LE side are listed in table A.10. Symbols are explained in clause 3.2. Frequency values dedicated to VDSL2 are in table A.6.

Table A.10: Dedicated requirements for passive splitters for VDSL2 over ISDN variants at the LE side

Clause number	Symbol	Frequency Range	Splitters for VDSL2 over ISDN/Universal for any f_L
6.6.1 low pass	$LCL_{TELEport}$	4 kHz to f_L f_L to 1,1 MHz	> 40 dB > 50 dB
6.6.1 low pass	$LCTL_{TELEtoLINE}$ or $LCL_{LINEport}$	4 kHz to f_L f_L to 2,2 MHz 2,2 MHz to 12 MHz 12 MHz to f_H f_H to f_{Max}	> 40 dB > 50 dB > 30 dB (see note) > 30 dB Note that f_{Max} is still F.F.S.
6.6.2 high pass	$LCL_{xDSLport}$ or $LCL_{LINEport}$	f_L to 12 MHz 12 MHz to f_H f_H to f_{Max}	> 45 dB Drop 20 dB/decade from 45 dB at 12 MHz Note that f_{Max} is still F.F.S.
6.13	Crosstalk	DSL band f_L to f_H	F.F.S.
NOTE: The LCL requirements are based on what is presently required by operators in ISDN deployment at the CO. Clearly the balance at the LE side can be relaxed compared to what is useful at the TE side.			

Annex B (informative): Evolution of the documents

This annex should explain the old organization of the splitter documents. However, it appears only in part 1 of the new documents. All other parts point to Annex B in part 1. Thus refer to the document TS 101 952-1 [7], which contains an Annex B with the same title and the necessary content.

Related to the present document the following additional information is useful:

The present document is derived by merging and complementing 3 existing specifications, which were numbered according to the older structure of the splitter documents:

Splitters for ADSL over ISDN, TS 101 952-1-3 (old numbering),

Splitters for ADSL over ISDN or POTS, the so-called "universal" splitter, TS 101 952-1-4 (old numbering),

Splitter for VDSL over ISDN, TS 101 952-2-3 (old numbering).

Annex C (informative): Use of the present document for splitters at the cabinet

To test **splitters at the remote cabinet** the use of present document in its previous versions was kept F.F.S.

C.1 Splitters on POTS lines at the cabinet

For POTS application, the use at the cabinet was restricted, due to the fact that the splitters at the cabinet are connected to the LE with lines, which represent an extra length, between the splitter and the characteristic impedance (Z_R or 600 Ω) present at the LE. This extra length "X" is marked in functional diagram of figure 1 in clause 4.1.

However, the European Z_R is chosen in such a way that it represents both the Z_R of the telephone equipment, the impedance of a line terminated by Z_R, and the impedance of a long line terminated by 600 Ω. As the splitters are tested with the European Z_R, this test covers the impedance of line connected at the cabinet. Similarly for 600 Ω equipment, the Z_{SL} impedance models a short loop terminated by 600 Ω.

When splitters are tested to achieve a RL according to option A, they might be connected to both 600 Ω and Z_R equipment at the CO, and they are tested with both Z_R and Z_{SL}, which sufficiently represent various impedances seen at the cabinet, at the TELE port of the splitter. If the splitter achieves a good RL on these two test impedances, it can be used safely at the cabinet position also.

When splitters are tested to achieve a RL according to option B, the Z_R impedance is the only reference impedance used in the deployment, and Z_R represents the impedance seen at the TELE port of the splitter at the LE side of the cabinet for any line length between the cabinet and the LE.

C.2 Splitters for ISDN lines at the cabinet

For ISDN lines similar restrictions were stated in earlier documents, merged to compile the present document as explained in Annex B. Indeed, when a splitter is installed at the cabinet, it is terminated by the impedance at the LE, in series with the cable connecting the LE to the cabinet. This might cause the terminating impedance to differ substantially from the resistive impedance models used in the present document. Therefore, **in principle** it cannot be assumed that a splitter passing the requirements in the present document for normal use at the LE will also work correctly when used at the cabinet, because the standard Ohmic termination impedances used for the static tests of ISDN splitters do not look like an ISDN transceiver in series with a line of various length.

However, there is some evidence that splitters complying with the present document are performing satisfactorily in installations at the remote cabinet, with the extra line length to the LE. This is due to the adaptive echo cancelling and equalization inside an ISDN transceiver, which allow it to perform well on complex line impedances.

NOTE: It makes little sense to test ISDN splitters with Ohmic termination impedances, which deviate from actual transceivers or lines, when ISDN transceivers adapt to complex impedances anyway.

Annex D (informative): IL and RL caused by the Z_{DSL-i} in the POTS or ISDN band

The IL in the POTS band is measured according to a diagram (see figures 11 and 12) in which Z_{DSL-i} is not present in the reference case. The fact that Z_{DSL-i} is only present when the IL of the splitter is measured causes additional signal losses introduced by the Z_{DSL-i}. This extra loss due to the Z_{DSL-i} limits the IL loss caused by the low pass, because the combined IL of both low pass and Z_{DSL-i} should be within the allowed boundaries.

A similar reasoning is done for the RL. The RL is measured for the combination of the splitter low pass in the presence and absence of the splitter. However, it is clear that the Z_{DSL-i} on its own causes a degradation of the RL, which limits the amount of additional RL the splitter can cause.

Examples of the intrinsic IL and RL degradation caused by Z_{DSL-i} are given in the Annex D of TS 101 952-1 [7], but for the case of xDSL over POTS splitters. For universal splitters these intrinsic degradations in the POTS band are less important, because the Z_{DSL-i} impedance is more high-Ohmic at 4 kHz.

There is a similar intrinsic IL and RL degradation caused by Z_{DSL-i} in the ISDN band, i.e. up to 80 kHz. The next figures show this intrinsic effect for a case of 4B3T (150 Ω). The case for 2B1Q (135 Ω) is very similar.

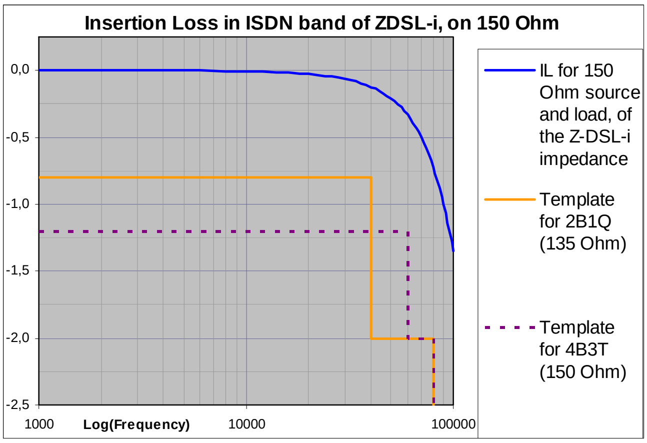


Figure D.1: IL effect of the Z_{DSL-i} in the ISDN band (case: 4B3T ISDN impedance of 150 Ω)

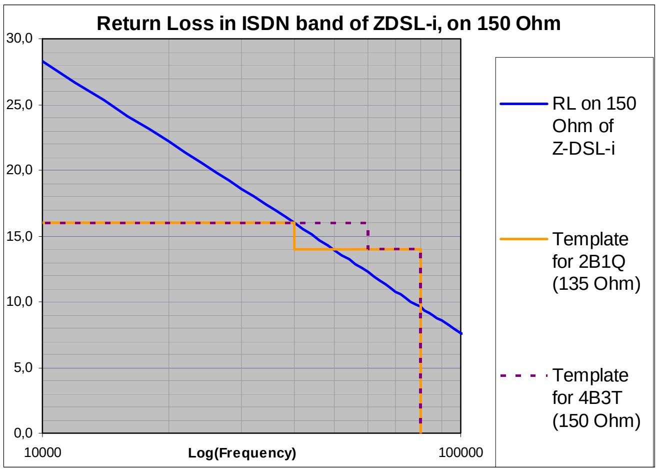


Figure D.2: effect of Z_{DSL-i} on RL in the ISDN band at TELE or LINE port (case: 4B3T ISDN impedance)

Note that Z_{DSL-i} degrades the RL on 150 Ω intrinsically below both the 4B3T and the 2B1Q RL templates. This means that the splitters has to **compensate** (i.e. to correct) the deteriorating effect of Z_{DSL-i} on the RL.

Annex E (informative): IL Measurement inside Z_{DSL-i}

The IL can be measured from TELE port to xDSL port and from LINE port to xDSL port, but not as described in clauses 5.4.3 and 5.4.4, but by measuring inside Z_{DSL-i} or generating signal from inside Z_{DSL-i}. However, this does not change the measurement result. The related alternative test set-ups are documented in this informative annex. This way of measuring was introduced in TR 101 953-1-3 [i.5] and TR 101 953-2-3 [i.8].

E.1 IL TELE port to xDSL port (clause 5.4.3) inside Z_{DSL-i}

Measuring the IL inside the Z_{DSL-i} impedance as shown in figure E.1, or generating the source signal inside the Z_{DSL-i} as shown in figure E.2, does not differ from measuring the IL at the xDSL port (as in figure 13) or generating a signal in series with the total Z_{DSL-i} (as in figure 14). In [i.5] and [i.8] the generation of source signal and the measurement of the resulting signal inside the Z_{DSL-i} was done, because it was expected that the extra high pass function of Z_{DSL-i} would increase the IL and would make it easier to achieve a higher IL value. However, the high pass function of Z_{DSL-i} is present in the reference measurement also, and therefore the effect of this high pass is effectively cancelled.

For the IL from TELE to xDSL port in theory the signal could be measured or generated inside the Z_{DSL-i} on the R_{DSL} termination impedance. However, this does not change the measurement result.

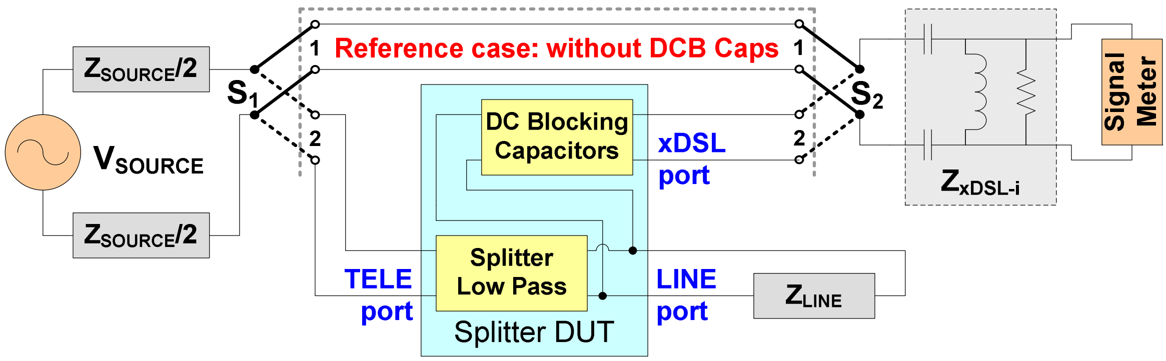


Figure E.1: Test set-up for IL from TELE port to xDSL port as in [i.5] and [i.8]

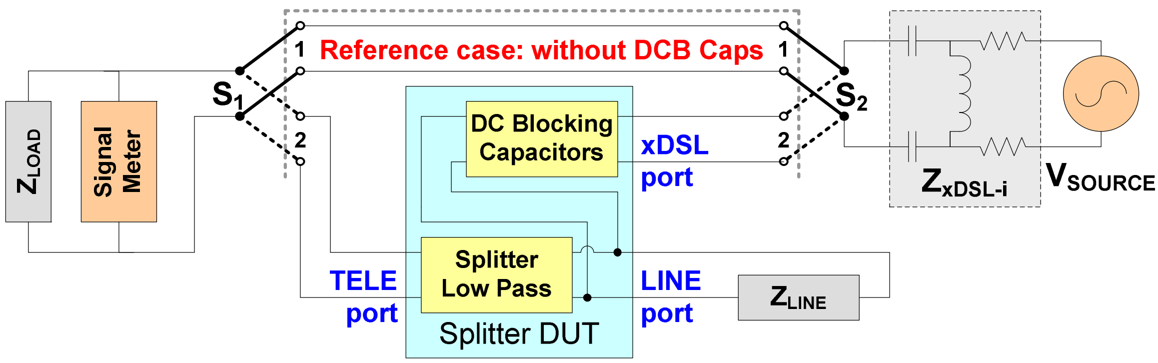


Figure E.2: Test set-up for IL from xDSL port to TELE port as in [i.5] and [i.8]

As shown in [i.5] and [i.8], the injection of signal from within the Z_{DSL-i} or the measurement of the signal on the Z_{RefDSL} (= R_{DSL}) can be done with circuits using a balun transformer inside Z_{DSL-i}. Consider figures E.3, E.4, E.5 and E.6.

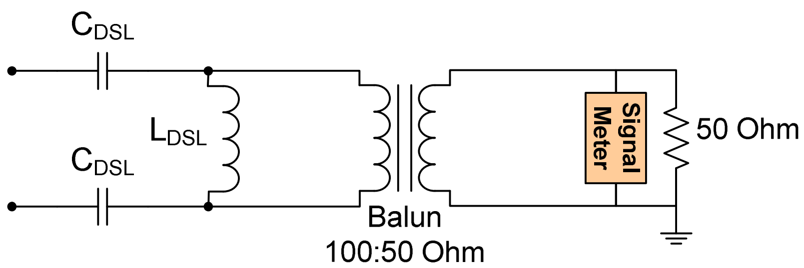


Figure E.3: Sensing signal inside the Z_{DSL-i} impedance with a 100:50 Ω BALUN

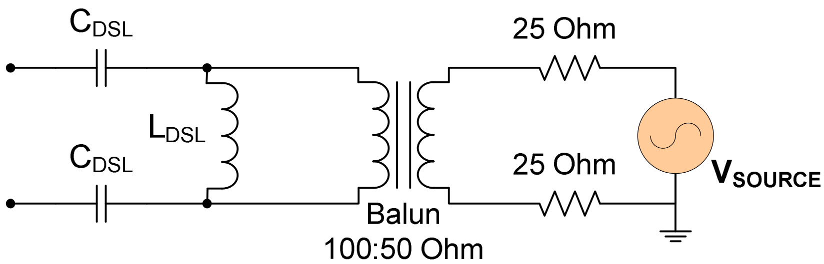


Figure E.4: Sourcing signal inside the Z_{DSL-i} impedance with a 100:50 Ω BALUN

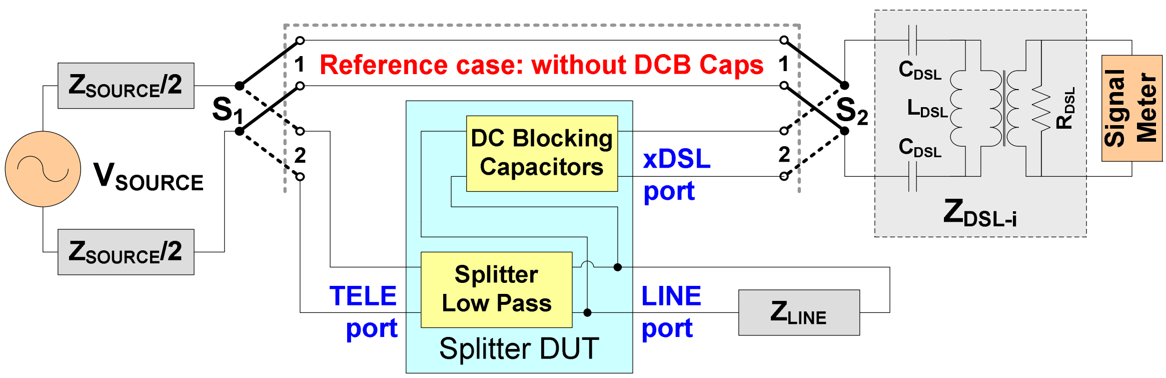


Figure E.5: Test set-up for IL from TELE port to xDSL port with BALUN (1:1)

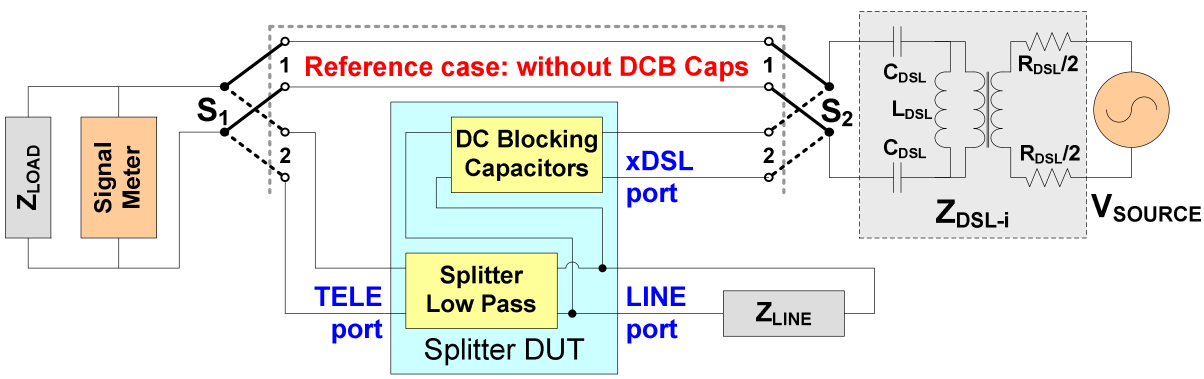


Figure E.6: Test set-up for IL from xDSL port to TELE port with BALUN (1:1)

E.2 IL LINE port to xDSL port (clause 5.4.4) inside Z_{DSL-i}

With a similar explanation as in clause E.1, the IL from LINE to xDSL port in theory could be measured or generated inside the Z_{DSL-i} on the R_{DSL} termination impedance. However, this does not change the measurement result. Consider the tutorial figures E.7, E.8, E.9 and E.10.

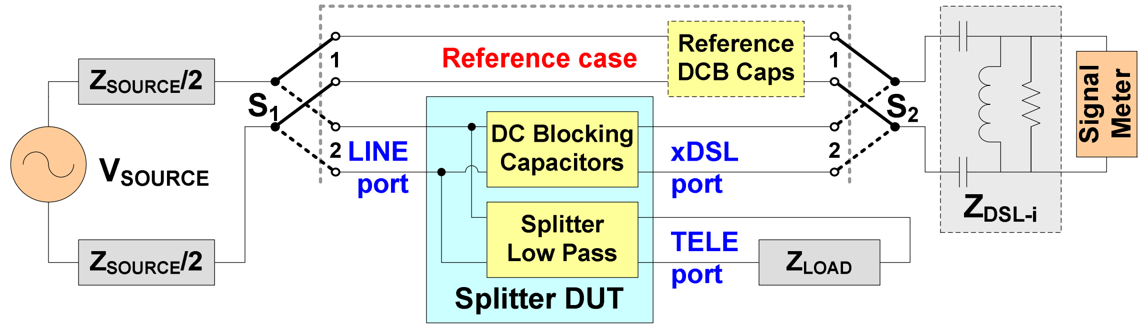


Figure E.7: Test set-up for Insertion Loss from LINE port to xDSL port, measured at R_{DSL}

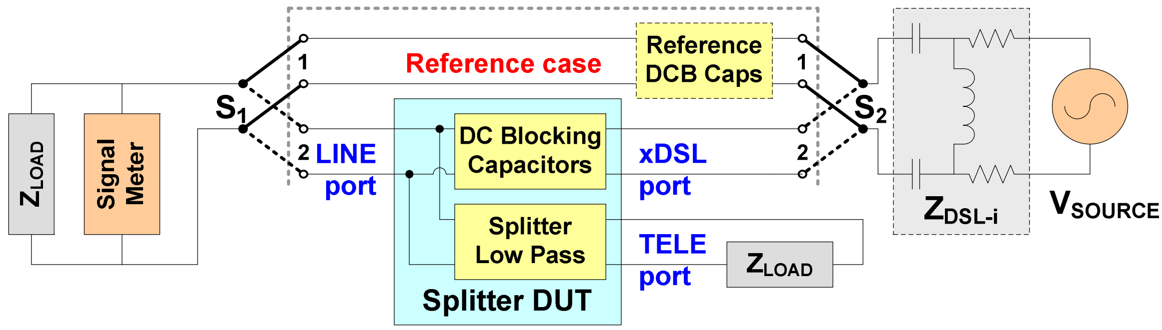


Figure E.8: Test set-up for Insertion Loss from xDSL port to LINE port, injected at R_{DSL}

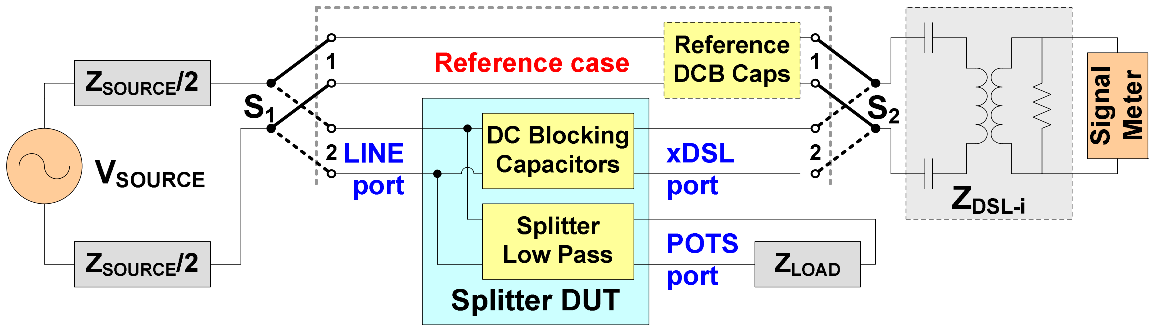


Figure E.9: Sensing signal inside the Z_{DSL-i} impedance with a BALUN transformer

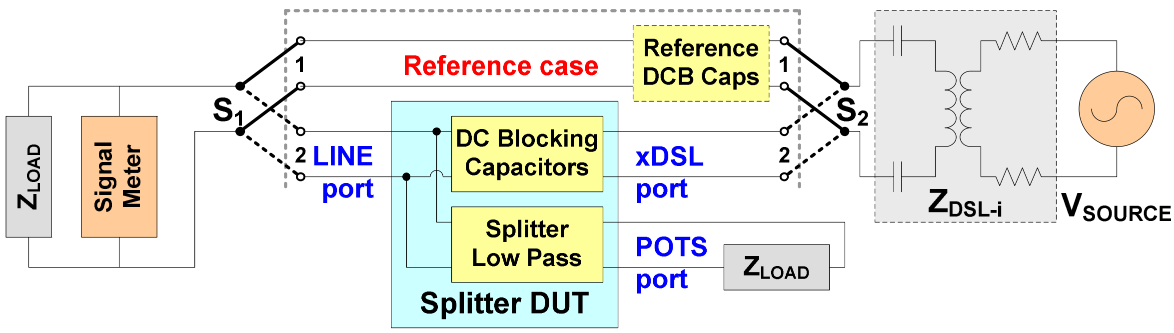


Figure E.10: Sourcing signal inside the Z_{DSL-i} impedance with a BALUN transformer

Annex F (informative): Return Loss measurements: practical diagrams

To measure the input impedance of a splitter terminated with a load impedance and to calculate the RL according to the formula of clause 5.4.6, the following practical diagrams show a bridge scheme with which the RL can be calculated by measuring voltages instead. It is possible to balance this scheme, but it is not absolutely necessary. The applicable formulae are shown inside the figures. Z_{SOURCE} is Z_{Ref} in the formula of clause 5.4.5. Z_{Aux} is an auxiliary impedance.

For determining the RL of a splitter according to the formula defined in clause 5.4.6, Z_{LOAD} is used as Z_{SOURCE}.

A practical test set-up for Return Loss at the TELE port is shown in figure F.1.

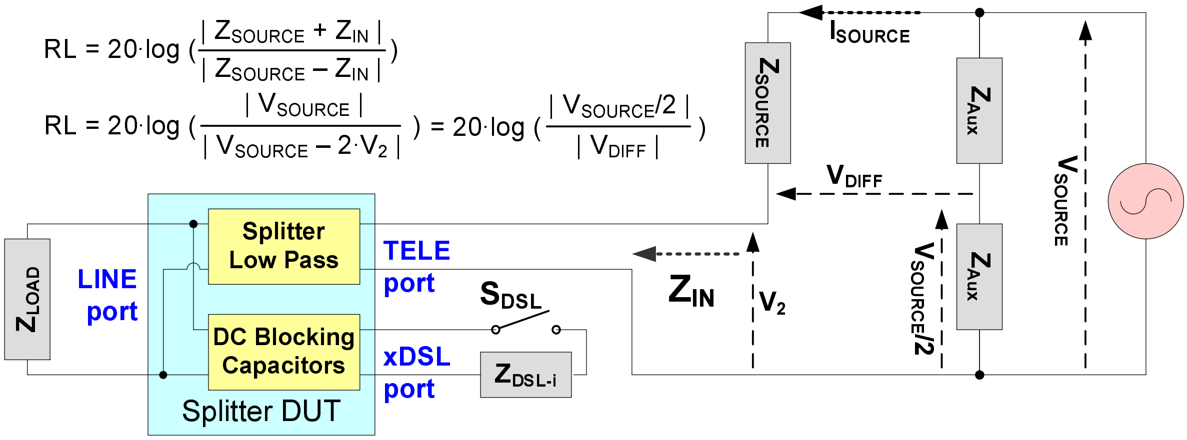


Figure F.1: Practical test set-up for Return Loss at the TELE port

A similar practical test set-up for Return Loss at the LINE port can be derived as shown in figure F.2.

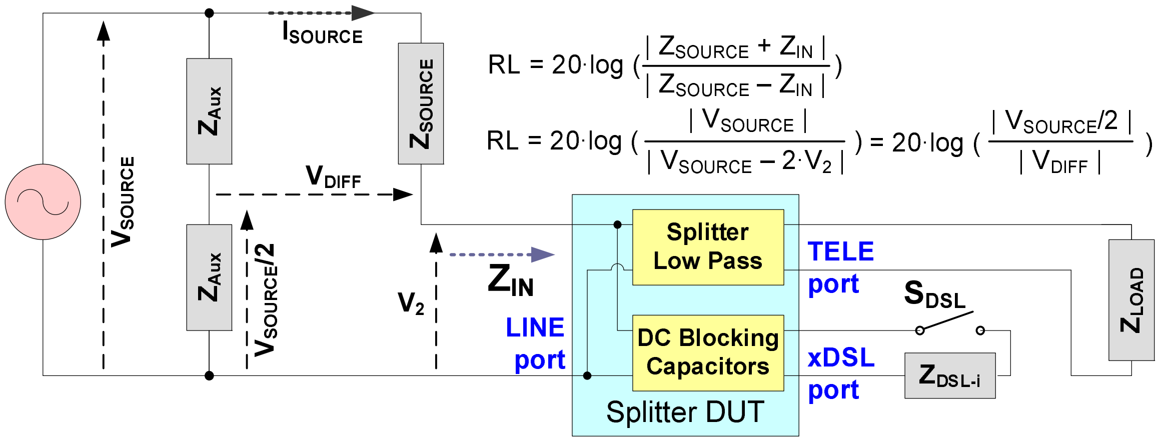


Figure F.2: Practical test set-up for Return Loss at the LINE port

The formulae inside the figures can be derived as follows:

$$RL = 20\times\log\left(\frac{|Z_{SOURCE}+Z_{IN}|}{|Z_{SOURCE}-Z_{IN}|}\right) = 20\times\log\left(\frac{|Z_{SOURCE}+Z_{IN}|}{|Z_{SOURCE}+Z_{IN}-2\times Z_{IN}|}\right) =$$

$$20\times\log\left(\frac{|V_{SOURCE}/I_{SOURCE}|}{|V_{SOURCE}/I_{SOURCE}-2\times Z_{IN}|}\right) = 20\times\log\left(\frac{|V_{SOURCE}|}{|V_{SOURCE}-2\times V_2|}\right) = 20\times\log\left(\frac{|V_{SOURCE}/2|}{|V_{DIFF}|}\right)$$

Annex G (informative): Insertion Loss measured with feeding and loading bridges

It is necessary to combine the IL, RL and other measurements described e.g. in clauses 5.4 to 5.7 with the DC conditions of clause 5.1.2. This requires the combination of the circuits of the figures 11 to 24 with the feeding and loading bridges of clause 5.1.3.

Please refer to Annex G of TS 101 952-1 [7], where two diagrams are shown, as examples on how the figures 11 and 12 of the present document can be adapted to this combination. Similarly the other figures of the clauses 5.4 to 5.7 can be adapted to the DC feeding conditions. The diagrams are for information. Note that similar diagrams are available in TR 101 953-1-2 [i.4], TR 101 953-1-3 [i.5], TR 101 953-2-2 [i.7] and TR 101 953-2-3 [i.8].

Annex H (informative): Dynamic tests of splitters in the presence of xDSL transceivers

H.1 General description of TR-127 of the Broadband Forum

For the general description of TR-127 [i.16] (published as Technical Report by the broadband forum) please refer to part 1 of the present multipart document, TS 101 952-1 [7]. In Annex H of part 1 [7] the case of POTS related dynamic tests are explained.

H.2 Dynamic ISDN tests needed (in a revision of TR-127)

The TR-127 [i.16] presently only deals with the POTS tests. For ISDN related dynamic tests a newer version of the TR-127 will be compiled.

The additional tests for ISDN are now under development at the Broadband Forum. For ISDN TR-127 [i.16]will likely contain the following additional tests:

4) The ISDN loss test
   - This test checks how many dB in IL of the access loop line at 40 kHz is lost, when splitters are inserted in the ISDN transceiver.
5) xDSL start-up test
   - Checking how the start of xDSL affects the ISDN transmission.
6) ISDN start-up test
   - Checking how ISDN start-up procedure affects the xDSL transmission.
7) Test of the cabinet deployment (under study)
   - Check if the ISDN stays functional for various combinations of the lengths X and "Line" in figure 1.
8) Power feeding of the ISDN TE from the LE
   - Sudden demand for CO power feeding causes transients in the DC current flowing through the splitters. It should be checked how these transients affect the xDSL transmission.

Annex I (informative): Optimal transmission of POTS or ISDN signals and xDSL signals and their separation

Please refer to TS 101 952-1 [7]. Annex I of part 1 contains a general tutorial describing how POTS and xDSL should be affected minimally by the splitters and how the POTS and xDSL should be separated (or prevented from interworking) by the splitters.

Similar issues between ISDN and xDSL also exist, but are not described in the present document.

Annex J (informative): More on feeding and loading bridges

Please refer to TS 101 952-1 [7]. In Annex J of part 1 some issues of feeding and loading bridges are explained.

Annex K (informative): Additional requirements for Active Splitter (F.F.S.)

It is unlikely that a dynamic or active splitter will be used with ISDN. The power used by ISDN (about 22,5 mW) and the associated voltage and current levels are probably too large to use active components inside the splitters.

However, in case an active splitter for ISDN or an active Universal splitter is proposed, please refer to TS 101 952-1 [7]. In Annex K of part 1 the issues of active splitters are introduced. E.g. the noise measurement techniques are based on ITU-T Recommendation O.41 [3].

Annex L (informative): Measuring when C_{DCB} capacitors are merged with Z_{DSL-i}

As stated under clause 4.1 and 4.2, and explained also under clause A.1, the C_{DCB} capacitors are sometimes merged with the DSL transceiver. This means that the load at the xDSL port of the splitter should be altered. This means that it is necessary to adapt different subclauses of clause 5.4, as shown in this annex.

L.1 Adapting clause 5.4.2

For the clause 5.4.2 the circuit to measure IL between LINE port and TELE port should be corrected, when the C_{DCB} capacitors are merged with the xDSL load Z_{DSL-i}. The original figure 11 in clause 5.4.2 is as follows:

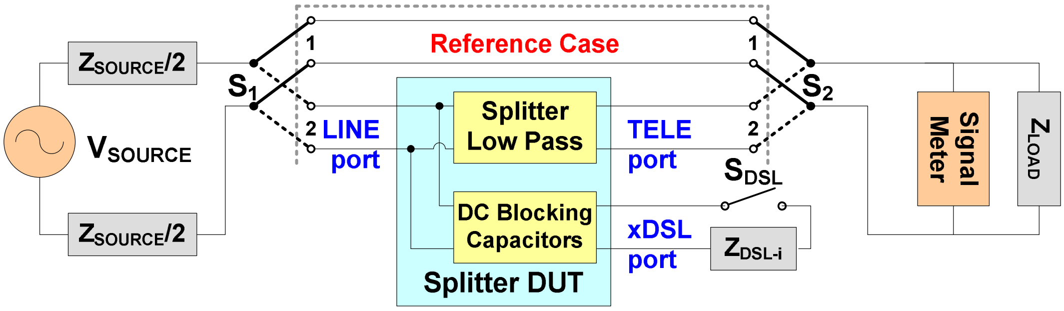


Figure L.1: Standard measurement of the IL from LINE port to TELE port (≡ Figure 11)

If the splitter does not contain the C_{DCB}, because they will be merged with the Z_{DSL-i}, the following circuit applies:

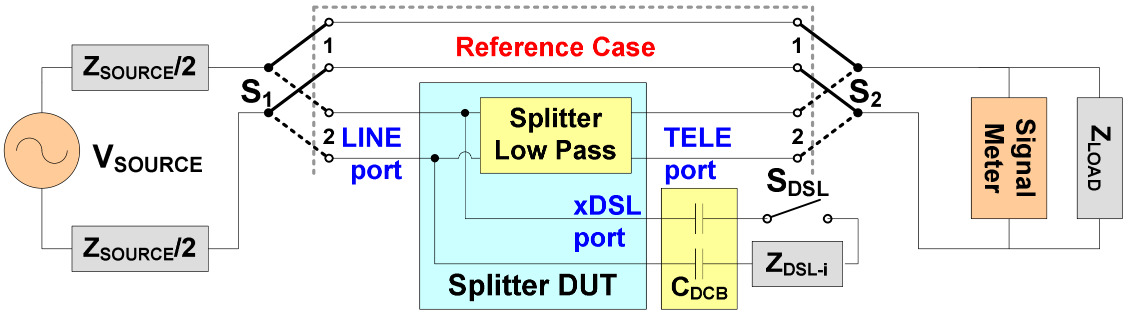


Figure L.2: Adapted measurement of IL from LINE port to TELE port for splitters without C_{DCB}

In figure L.2 the termination of the xDSL port can be simplified to the merge C_{DCB} with Z_{DSL-i} as Z_{DSL-i2}.

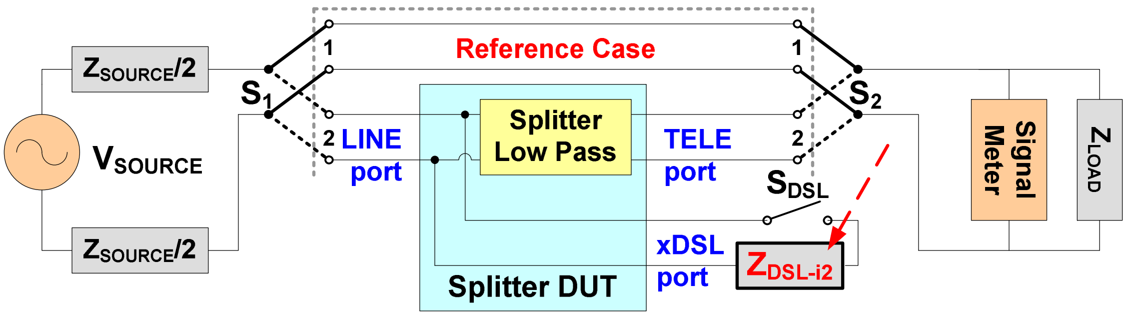


Figure L.3: Alternative measurement of IL from LINE port to TELE port for splitters without C_{DCB}

It is also possible to measure IL in the opposite direction, i.e. from TELE port to LINE port, as in figure 12 in clause 5.4.2. If the splitter does not contain the DCB capacitors, the xDSL port will be terminated in the same way as shown in figures L.2 and L.3.

L.2 Adapting clause 5.4.3

For the clause 5.4.3 the circuit to measure IL between TELE port and xDSL port should be corrected, when the C_{DCB} capacitors are merged with the xDSL load Z_{DSL-i}. The original figure 13 in clause 5.4.3 is as follows:

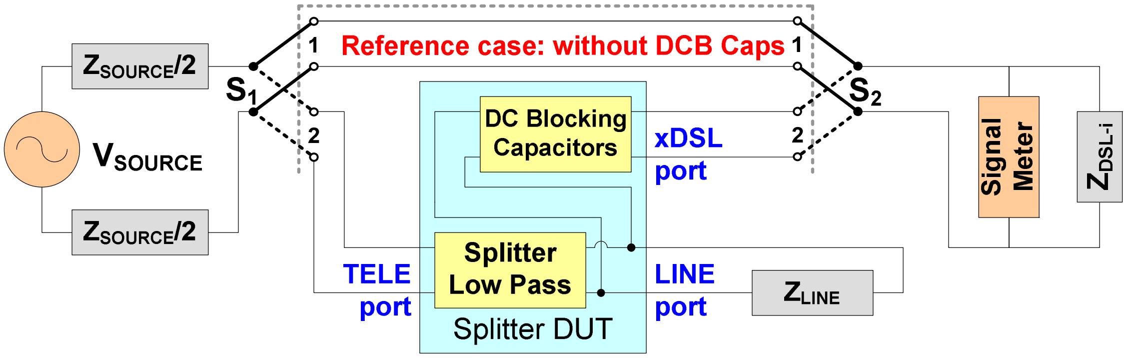


Figure L.4: Standard measurement of the IL from TELE port to xDSL port (≡ Figure 13)

If the splitter does not contain the C_{DCB}, because they are merged with the Z_{DSL-i}, the following circuit applies, in which the DCB capacitors are added in series with the xDSL port and the signal meter:

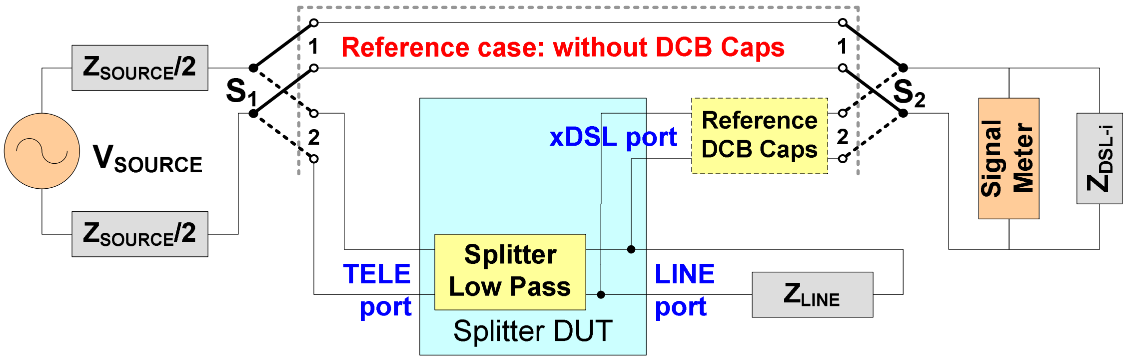


Figure L.5: Adapted measurement of IL from TELE port to xDSL port for splitters without C_{DCB}

It is also possible to measure IL in the opposite direction, i.e. from xDSL port to TELE port, as in figure 14 in clause 5.4.3. If the splitter does not contain the DCB capacitors, the extra CDCB will be inserted in series with the xDSL port in the same way as shown in figures L.5.

L.3 Adapting clause 5.4.4

For the clause 5.4.4 the circuit to measure IL between LINE port and xDSL port should be corrected, when the C_{DCB} capacitors are merged with the xDSL load Z_{DSL-i}. The original figure 16 is as follows:

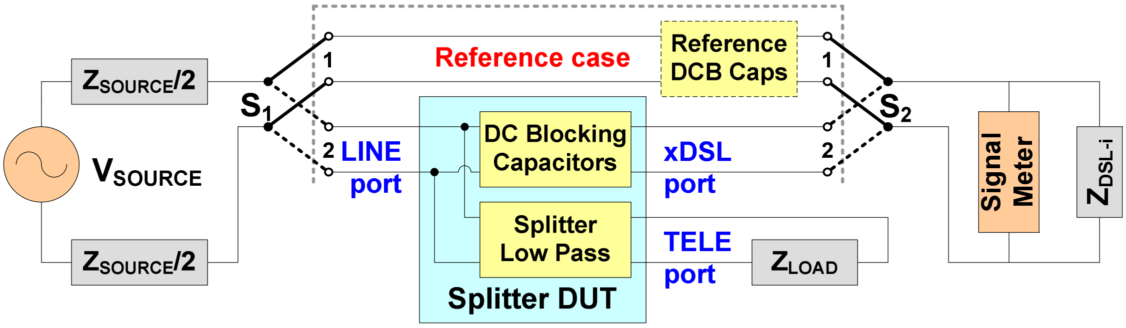


Figure L.6: Standard measurement of the IL from LINE port to xDSL port (≡ Figure 16)

If the splitter does not contain the C_{DCB}, because they are merged with the Z_{DSL-i}, the following circuit applies, in which the DCB capacitors are added in series with the xDSL port and the signal meter:

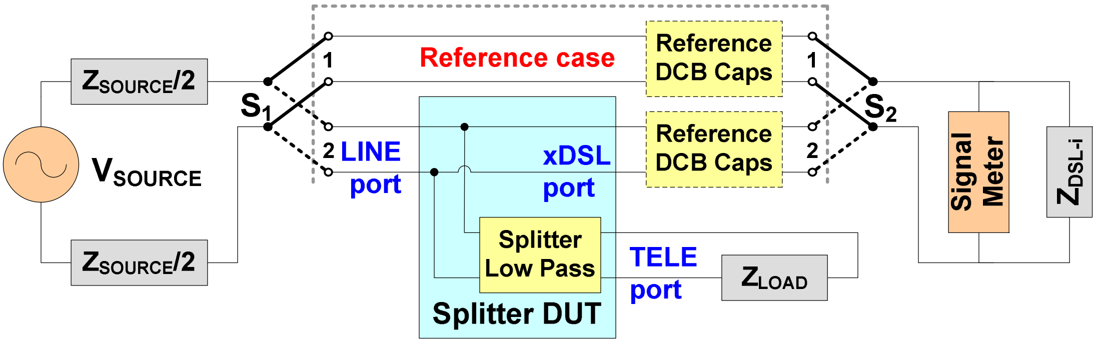


Figure L.7: Adapted measurement of IL from LINE port to xDSL port for splitter without C_{DCB}

The situation of figure L.7 can be altered by moving the Reference DCB Capacitors to the other side of the Switch S2 as shown in figure L.8. Finally the position of the signal meter can be moved to the left of the Reference DCB Capacitors, and the Reference DCB Capacitors can be merged with the Z_{DSL-i} to form Z_{DSL-i2}, as shown in figure L.9.

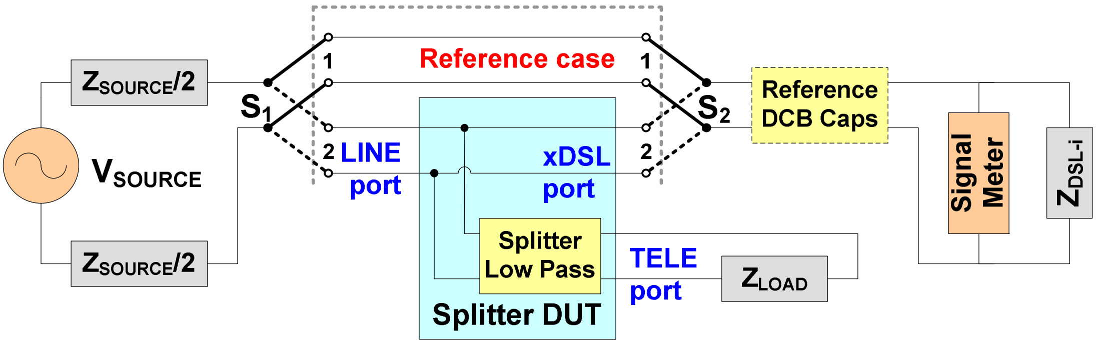


Figure L.8: Alternative measurement of IL from LINE port to xDSL port for splitter without C_{DCB}

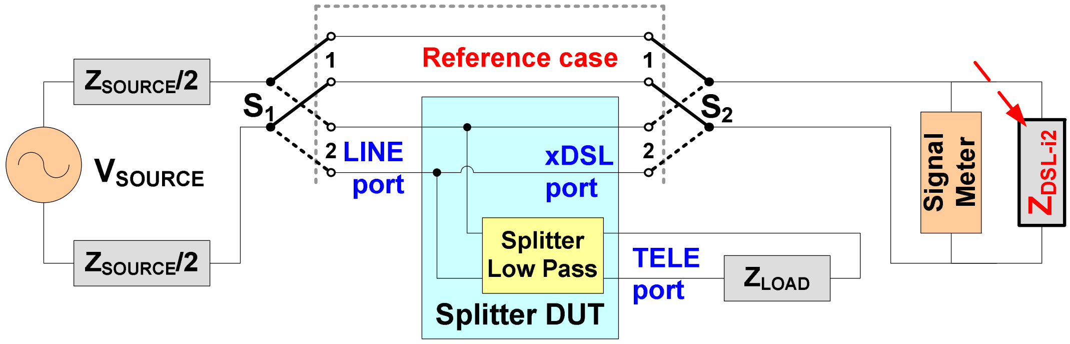


Figure L.9: Alternative measuring of IL with Z_{DSL-i2} from LINE port to xDSL port splitter without C_{DCB}

It is also possible to measure IL in the opposite direction, i.e. from xDSL port to LINE port, as in figure 17. If the splitter does not contain the DCB capacitors, the extra C_{DCB} will be inserted in series with the xDSL port in the same way as shown in figure L.7.

L.4 Adapting clause 5.4.6

For the clause 5.4.6 the circuit to measure RL between LINE port and xDSL port should be corrected, when the C_{DCB} capacitors are merged with the xDSL load Z_{DSL-i}. The original figure 18 is as follows:

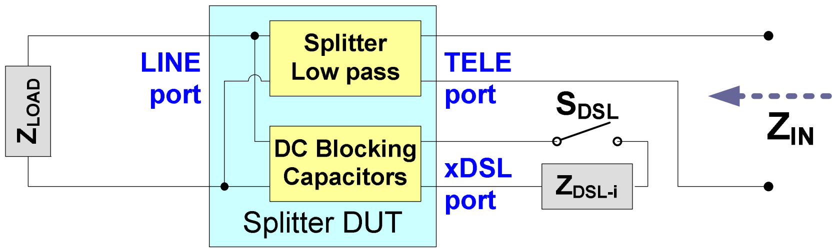


Figure L.10: Standard Definition for Return Loss at the TELE port (≡ Figure 18)

If the splitter does not contain the C_{DCB}, because they are merged with the Z_{DSL-i}, the following measurement circuit applies, in which the DCB capacitors are added in series with the xDSL impedance Z_{DSL-i} at the xDSL port:

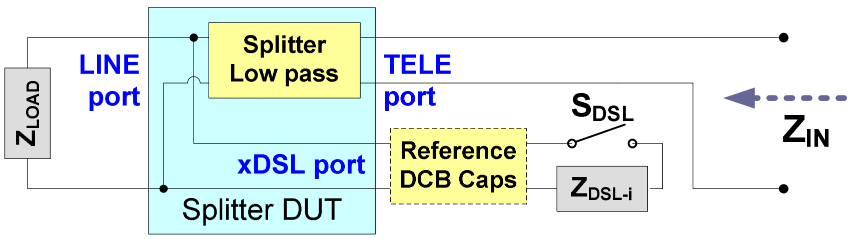


Figure L.11: Adapted measurement of RL at the TELE port for splitter without C_{DCB}

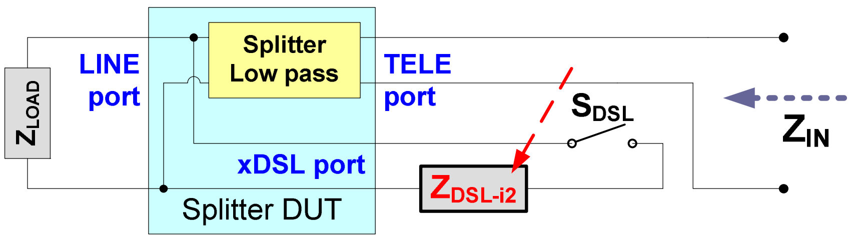


Figure L.12: Alternative measurement with Z_{DSL-i2} of RL at the TELE port for splitter without C_{DCB}

It is also needed to measure RL at the LINE port, as in figure 19 in clause 5.4.6. If the splitter does not contain the DCB capacitors, the figure 19 should be adapted. The xDSL port will be terminated in the same way as shown in figures L.9 and L.10. This produces the diagram of figure L.13.

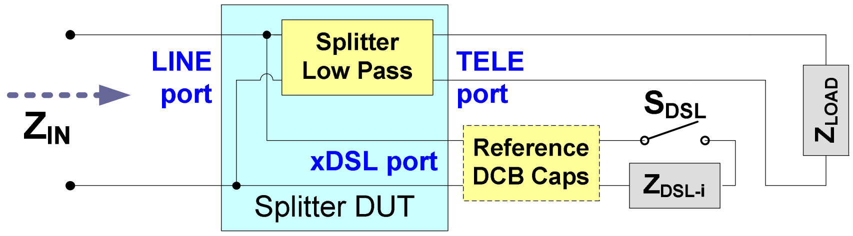


Figure L.13: Adapted measurement of RL at the LINE port for splitter without C_{DCB}

Of course in figure L.13 the reference DCB capacitors can be merged with Z_{DSL-i} to form Z_{DSL-i2} shown in figure L.14 in the same ways as was done in figure L.12.

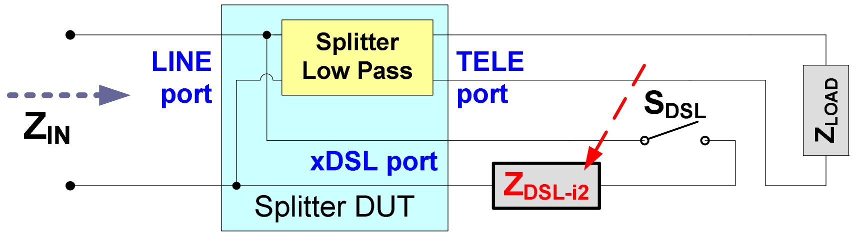


Figure L.14: Alternative measurement with Z_{DSL-i2} of RL at the LINE port for splitter without C_{DCB}

Annex M (informative): Measuring IL of the splitter low pass in the xDSL band

To measure the isolation caused by the splitter low pass section in the xDSL band, the loss effect resulting from the splitter insertion should be measured. The isolation could be measured between the TELE port and the LINE port and between the TELE port and the xDSL port and vice versa, i.e. in the opposite directions. For passive filters measuring in the opposite direction will give the same results, due to the reciprocity theorem (see note 1 under clause 5.4.1).

The xDSL over POTS splitters are measured from the TELE port to LINE port, and no additional measurement is required between TELE port and xDSL port. However, this is not the case for xDSL over ISDN or Universal splitters.

For historic reasons the isolation of the ISDN splitter and the universal splitters have always been measured between the TELE port and the xDSL port (or in the opposite direction). In theory one could also measure the isolation between TELE port and LINE port as an IL according to the set-up of the clause on IL in the POTS band (clause 5.4.2), with the switch S_{DSL} closed. However, in the past this was never specified. For the isolation of ISDN or universal splitters measuring the IL in the xDSL band between TELE port and LINE port was never required.

Moreover, the IL (measured only between TELE port and xDSL port, or vice versa) is measured for the series connection of the low pass and the high pass (i.e. the DC blocking capacitors). This means that the reference case is measured without the blocking capacitors. This might not look normal, but historically it has always been done this way, and we keep it this way. It is explained below:

If one would measure the Insertion Loss (IL) of the splitter low pass (which is enhanced because it is loaded with Z_{LINE}) between TELE port and xDSL port the theory states that the IL should be measured at the actual xDSL port of the splitter as shown in figure M.1. In this figure, to measure the IL of only the low pass, the highpass has to be present in the reference case.

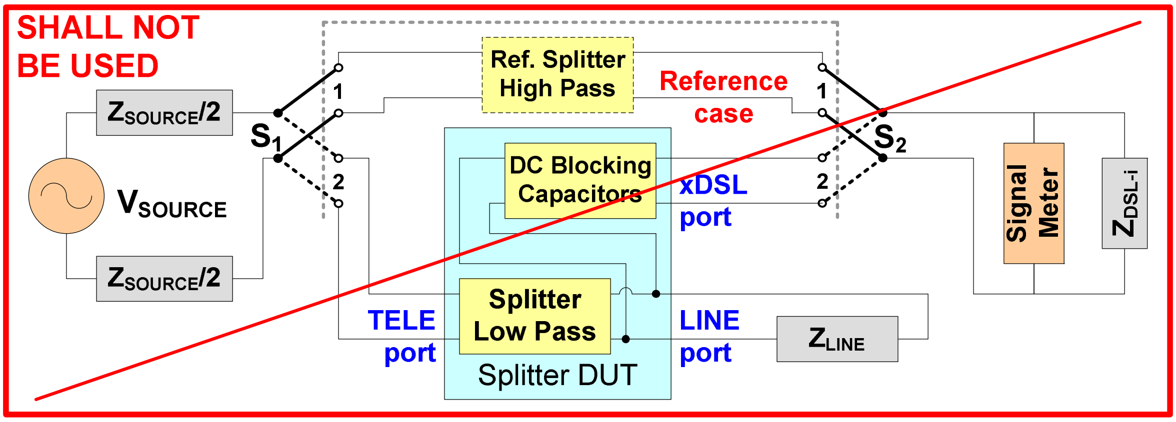


Figure M.1: Normal, but unused test set-up for Insertion Loss from TELE port to xDSL port

However, as shown in figures 13 and 14 in clause 5.4.3 the DCB blocking capacitors are **not** included in the reference case, and as such the IL of series connection of the low pass and the high pass (i.e. two DCB capacitors) is effectively measured. This is kept for historic reasons. If we keep the same technique, we are able to compare older and newer designs with the same methodology.

Annex N (informative): Bibliography

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

Find ITU-T documents via: http://www.itu.int/ITU-T/publications/recs.html.

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

ITU-T Recommendation G.994.1: "Handshake procedures for digital subscriber line (DSL) transceivers".

ITU-T Recommendation G.995.1: "Overview of digital subscriber line (DSL) Recommendations".

ITU-T Recommendation G.996.1: "Test procedures for digital subscriber line (DSL) transceivers".

ITU-T Recommendation G.997.1: "Physical layer management for digital subscriber line (DSL) transceivers".

ITU-T Recommendation G.122: "Influence of national systems on stability and talker echo in international connections".

History

Document history		
V1.1.1	November 2010	Publication

NOTE: The present document is derived by merging and complementing 3 older, existing specifications. Details can be found in the foreword and in Annex B.