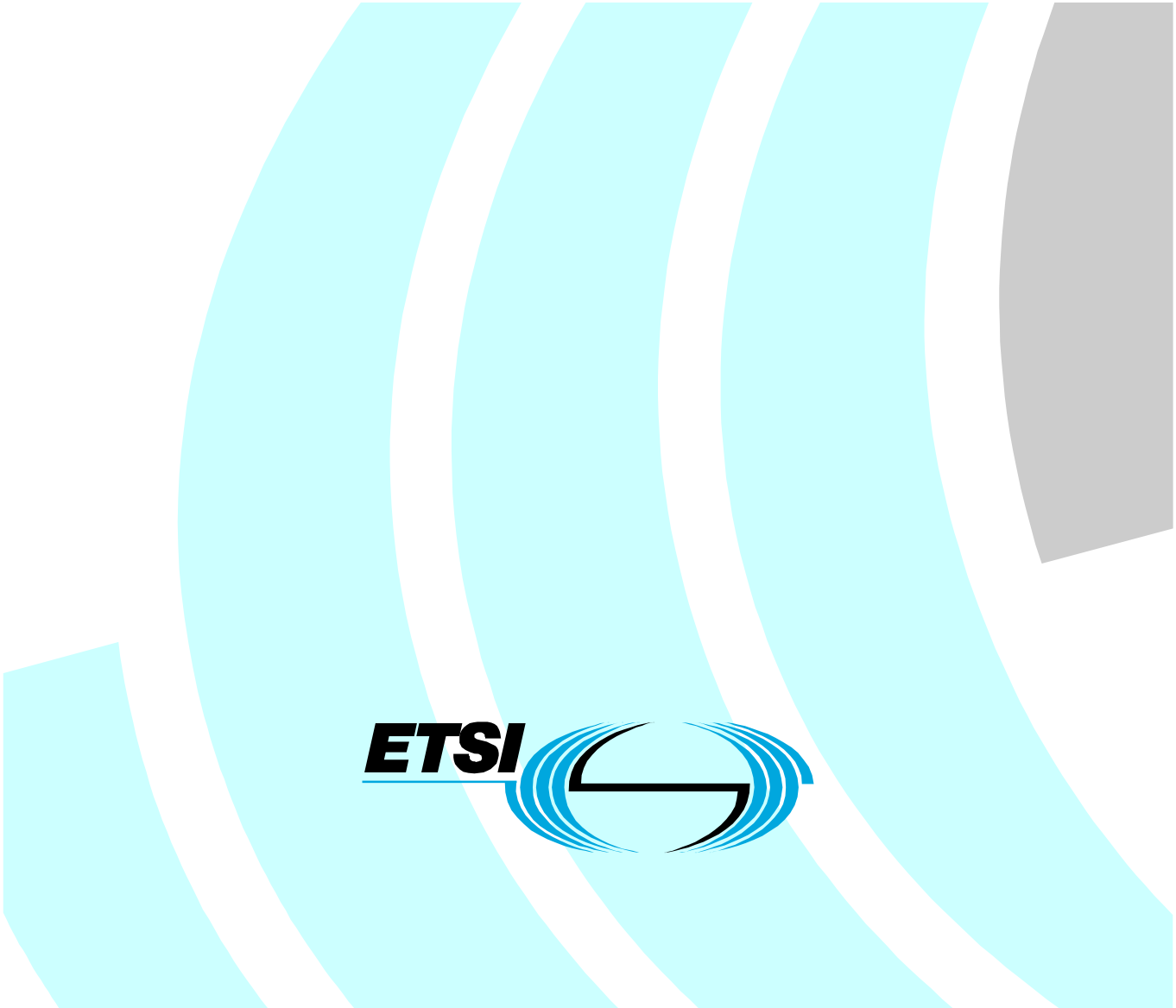
ETSI TR 101 953-2-3 V1.1.1 (2004-07)

Technical Report

Access network xDSL transmission filters;
Part 2: VDSL splitters for European deployment;
Sub-part 3: Specification of Testing methods
for VDSL/ISDN splitters



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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Transmission and Multiplexing (TM) as collaboration between:

- AT Analogue of Technical Committee Access and Terminals (AT); and
- TM6 of Technical Committee Transmission and Multiplexing (TM).

The present document is part 2, sub-part 3 of a multi-part deliverable supporting different aspects of European Specific DSL splitters, as identified below:

Part 1: "ADSL splitters for European deployment";

Part 2: "VDSL splitters for European deployment":

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

Sub-part 2: "Specification of Testing methods for high pass part of VDSL/POTS splitter";

Sub-part 3: "Specification of Testing methods for VDSL/ISDN splitters".

NOTE: The choice of a multi-part format for this deliverable is to facilitate maintenance and future enhancements.

1 Scope

The present document describes test methods for VDSL/ISDN splitters. These splitters are intended to be installed at the Local Exchange side of the local loop and at the user side near the NTP. In the case of splitters at the user side, the present document describes testing methods for the master splitter that is intended for use at the demarcation point of the customer premises.

NOTE 1: At some locations in the present document impedances values are listed. These values might differ from the values listed in the requirement specifications TS 101 952-2-3 [1]. If the values differ the values of TS 101 952-2-3 [1] have to be used.

NOTE 2: At some locations in the present document measurements are only shown for splitters at the user side. E.g. this is the case in figure 5. When measuring a splitter at the Local Exchange side the position of the Feeding bridge and the Holding Circuit have to be exchanged.

2 References

For the purposes of this Technical Report (TR) the following references apply:

[1] ETSI TS 101 952-2-3: "Access network xDSL transmission filters; Part 2: VDSL splitters for European deployment; Sub-part 3: Specification of VDSL/ISDN splitters for use at the Local Exchange (LE) and the user side near the Network Termination Point (NTP)".

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

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

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

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

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

3 Definitions and abbreviations

3.1 Definitions

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

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

3.2 Abbreviations

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

ADSL	Asymmetric Digital Subscriber LINE
CPE	Customer Premises Equipment
dBm	Absolute power level expressed in decibels relative to 1 mW
dBV	Absolute voltage level expressed in decibels relative to 1 Volt
DUT	Device Under Test

emf	electromotive force
I	Current
ISDN-BA	Integrated Services Digital Network-Basic Access
ITU	International Telecommunication Union
LCL	Longitudinal Conversion Loss
LCTL	Longitudinal Conversion Transfer Loss
LE	Local Exchange (Central Office)
NF	Narrow-band Frequency
NTP	Network Termination Point
POTS	Plain Old Telephone Service
R	Resistance
TE	Terminal Equipment (e.g. Telephone, Fax, voice band modem, etc.)
U	Voltage
VDSL	Very high speed Digital Subscriber Line
Z	Impedance

4 Introduction

The present document describes test methods for the low pass part and the high pass part of VDSL/ISDN-BA splitters.

The test methods of the present document are based on requirements of the following document:

- TS 101 952-2-3 [1]: "Specification of VDSL/ISDN Splitters".

For each test, the present document describes:

- title of the test;
- purpose of the test;
- reference to the specifications;
- test configuration;
- test setup;
- test parameters;
- test results matrix;
- measuring notes.

5 Test conditions and general notes

For each test, feeding bridge and holding circuit must comply with the requirements as specified in TBR 038 [4] with respect to the low frequency range. Similar performance is required for the high frequency range (up to 12 MHz). An equivalent accuracy may be obtained by calibrating the feeding bridge and holding circuit across the relevant frequency range.

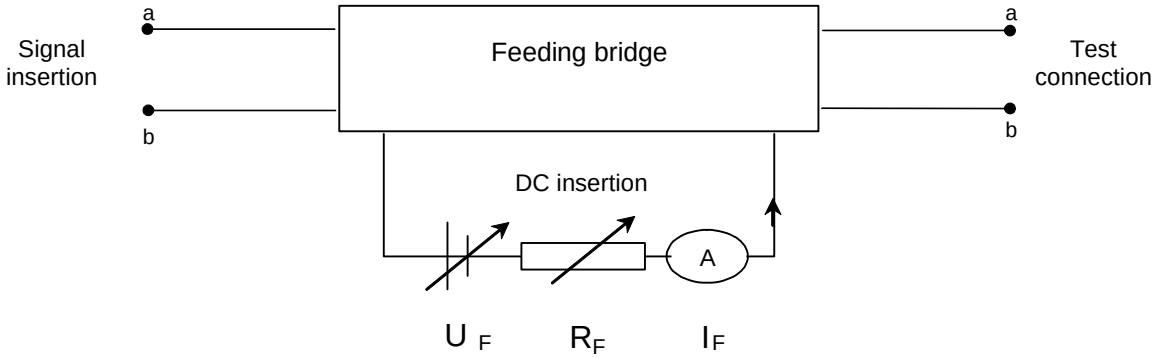


Figure 1: External circuitry for feeding bridge

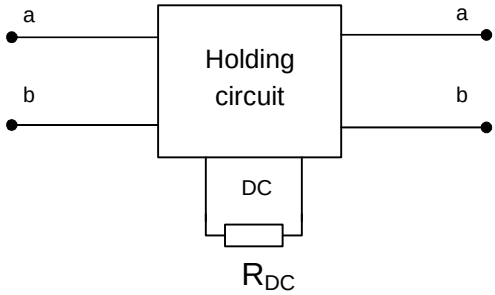


Figure 2: External circuitry for holding circuit

General notes:

Direction of the feeding current may impact the additional insertion loss caused by the feeding bridge and holding circuit. A calibration/normalization measurement needs to be taken before each single measurement step.

When a test is proposing "alternating polarity" the test should be performed in a way that the direction of the feeding current is changed from test to test (e.g. when a test is to be performed with 0 mA, 20 mA, 60 mA, 80 mA using alternating polarity the test should be performed with +0 mA, -20 mA, +60 mA, -80 mA).

The connection of the DC feeding is essential, i.e. for LE splitters the feeding bridge should be connected to the ISDN port and the holding circuit should be connected to the LINE port. For TE splitters the feeding bridge should be connected to the LINE port and the holding circuit should be connected to the ISDN port. The feeding arrangements shown in the test setups in the present document are generally for testing TE splitters.

The inaccuracy of the measurement resulting from tolerances in the test setup and its containing equipment should be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

Before splitters are tested the class of splitter should be categorized. A basis for this could be the schematic of the splitter or a statement of the manufacturer. The following classes have been identified so far in the course of this project:

- **passive:** splitters which do exclusively contain passive components;
- **passive with current/voltage detection:** splitters which perform NF filtering using passive components, which are enhanced by detection circuits based on the DC voltage and/or the DC current;
- **active:** splitters which contain active components (like OP amplifier) to perform the NF filtering.

At some test cases, a difference can be made between splitters which do not break the DC path and splitters which do break the DC path. The following drawings should give guidance for the separation of these two different types:

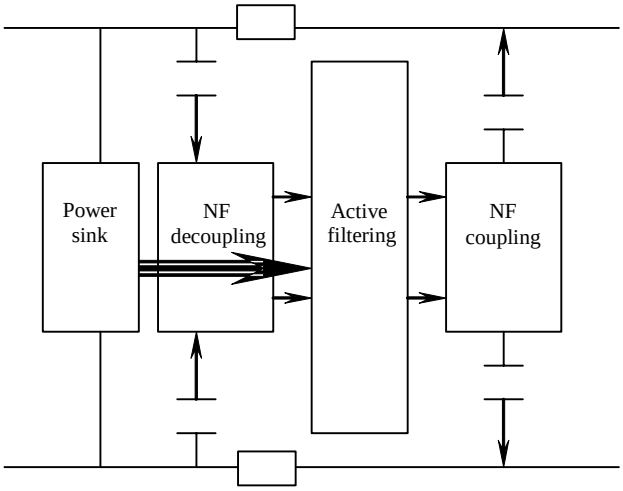


Figure 3: Example for a splitter not breaking the DC path

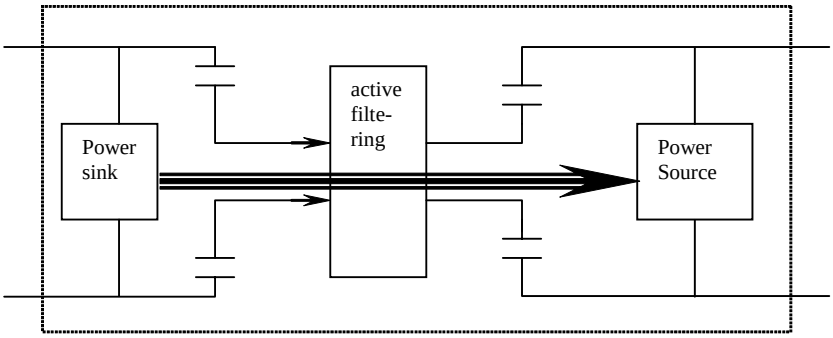


Figure 4: Example for a splitter breaking the DC path

Filters with current/voltage detection must be classified under the first type of splitter for their operating range (e.g. DC current above detection limit) and under the second type of splitter in the blocking range (e.g. DC current below detection limit).

6 Test cases for VDSL over ISDN-BA splitters

The test cases described include:

- insertion loss in the pass band (ISDN-BA);
- return loss in the pass band (ISDN-BA);
- delay distortion in the pass band (ISDN-BA);
- isolation (Insertion loss) at 150 kHz to 12 MHz;
- unbalance about earth;
- noise;
- DC resistance to earth;
- isolation resistance between A-wire and B-wire;

- DC series resistance;
- insertion loss requirements for the high pass part.

6.1 Insertion loss in the pass band (ISDN-BA)

Table 1: Description of the insertion loss in the pass band (ISDN-BA) test case

Test case name:	Insertion loss in the pass band (ISDN)
Reference:	TS 101 952-2-3 [1], clause 6.3
Test purpose:	To evaluate the insertion loss in the pass band (ISDN-BA) when tested with the test parameters as given in the related standards
Test configuration:	See test setup; DUT not configured

Test setup:

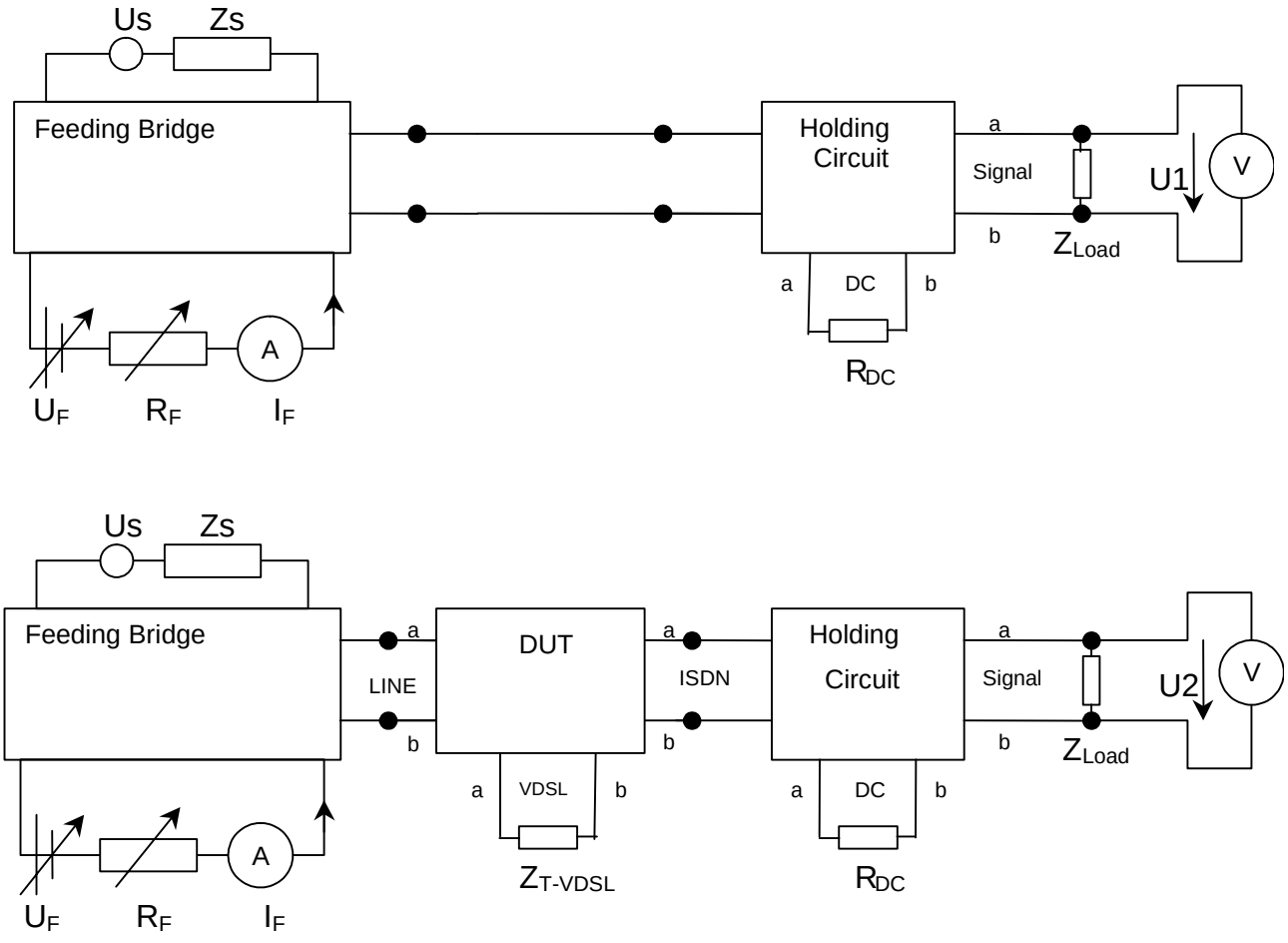


Figure 5: Test setup for insertion loss testing on a splitter

The Feeding Bridge and Holding Circuit must comply with the requirements as specified in TBR 038 [4]. As the TBR 038 [4] defines the feeding bridge and the holding circuit only for the voice frequency band, special care need to be taken on the electrical characteristics of the feeding bridge and the holding circuit in the ISDN-BA specific frequency band.

Test parameters:

Table 2: Test parameters for the insertion loss in the pass band (ISDN-BA) test case

Parameter	Value
Level of the test signal Us	-10 dBm
Frequency of the test signal Us	1 kHz to 80 kHz
Combination of source and load Impedances	combination 1: Z_{source} = 135 Ω; Z_{load} = 135 Ω; R_{DC} = 470 Ω (2B1Q) combination 2: Z_{source} = 150 Ω; Z_{load} = 150 Ω; R_{DC} = 470 Ω (4B3T)
Termination at VDSL: $Z_{T\text{-}VDSL}$	$Z_{T\text{-}VDSL} = Z_{VDSL\text{-}I}$ $Z_{T\text{-}VDSL}$ = open circuit
Level of feeding voltage	U_F = 50 V_{DC}, U_F may be increased to reach the specified feeding current values
Value of feeding current I_F	0 mA to 60 mA
Polarity of feeding voltage	normal and reversed, alternating between the single measurements
Measured transmission	passive splitters: LINE - ISDN active splitters: LINE - ISDN and ISDN - LINE
Optional tests	none

Test matrix:

Table 3: Test matrix for the insertion loss in the pass band (ISDN-BA) test case

	TS 101 952-2-3 [1]	Essential tests
Level of the test signal - 10 dBm	X	X
Frequency of the test signal 1 kHz to 80 kHz	X	X
Source/load combination 1 Source/load combination 2	X (see note) X (see note)	X (see note) X (see note)
DC feeding voltage/current +50 V_{DC}/0 mA -50 V_{DC}/60 mA	 X X	 X X
$Z_{T\text{-}VDSL} = Z_{VDSL\text{-}I}$ $Z_{T\text{-}VDSL}$ = open circuit	X X	X X
Transmission Direction ISDN - LINE Transmission Direction LINE - ISDN	active and passive active only	active and passive active only
Number of tests	passive: 8 tests, active: 16 tests	passive: 8 tests, active: 16 tests
NOTE: If a splitter is specially designed to work only for one of the options (with ISDN 4B3T or ISDN 2B1Q) it is sufficient to test it with one of the source/load combinations.		

Test procedure notes:

NOTE 1: Direction of the feeding current is not expected to impact the insertion loss of splitters.

NOTE 2: Direction of the feeding current may impact the additional insertion loss caused by feeding bridge and holding circuit - a calibration/normalization measurement need to be taken before each single measurement step.

NOTE 3: For passive splitters and for passive splitters with current/voltage detection it is sufficient to measure insertion loss in one direction (LINE to ISDN). For active splitters it is necessary to measure both directions. However, it seems unlikely that active splitters will be used for VDSL-over-ISDN.

NOTE 4: A verification measurement should not just be taken with 0 Ω, but also with a resistor which leads to an insertion loss of about 3 dB. For instance inserting 2 × 60 Ω resistors instead of the DUT would mean an insertion loss of 3 dB for a 150 Ω source/load impedance and an insertion loss of about 3,2 dB for a 135 Ω source/load impedance.

NOTE 5: If necessary, the feeding voltage can be increased to achieve the specified feeding current.

NOTE 6: The feeding conditions for active splitters and for passive splitters with current/voltage detection need to be determined. However, it seems unlikely that active splitters will be used for VDSL-over-ISDN.

NOTE 7: For active and for passive splitters it is sufficient to measure at the lowest and the highest specified current.

Test results:

Test result should be recorded in dB, where: IL = -20 log10 (U2/U1), where U2 is the voltage observed when the splitter is connected as in test setup and where U_1 is the voltage observed when the splitter is replaced by a direct wire connection of less than 0,01 Ω.

Measuring notes:

The inaccuracy of the measurement which results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

6.2 Return loss in the pass band (ISDN-BA)

Table 4: Description of the return loss in the pass band (ISDN-BA) test case

Test case name:	Return loss in the pass band (ISDN-BA)
Reference:	TS 101 952-2-3 [1], clause 6.4
Test purpose:	To evaluate the return loss in the pass band (ISDN-BA) when tested with the test parameters as given in the related standards
Test configuration:	See test setup; DUT not configured

Test setup:

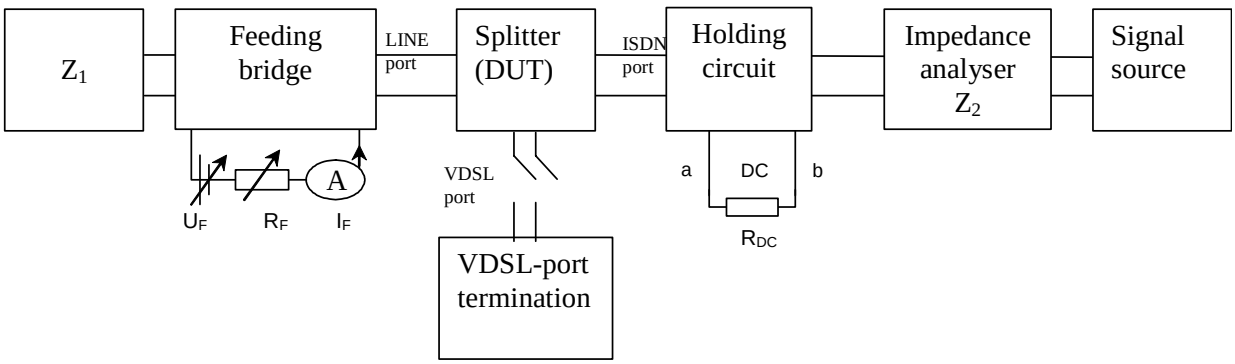


Figure 6: Test setup for return loss testing on a splitter (at the ISDN-BA port)

Test parameters:

Table 5: Test parameters for the return loss in the pass band (ISDN-BA) test case

Parameter	Value
Level of test signal	-10 dBV
Frequency range	1 kHz to 80 kHz
Load impedances	combination 1: Z_1 = 135 Ω for VDSL/ISDN Splitter 2B1Q combination 2: Z_1 = 150 Ω for VDSL/ISDN Splitter 4B3T
Termination at VDSL	VDSL load = Z_{VDSL-I} VDSL load = open circuit
Load resistance R_{DC}	470 Ω
Level of feeding voltage U_F	50 V_{DC}
DC feeding current I_F	0 mA to 60 mA
Polarity of feeding voltage	normal and reversed, alternating between the single measurements
Optional tests	none

Test matrix:

Table 6: Test matrix for the return loss in the pass band (ISDN-BA) test case

	TS 101 952-2-3	Essential tests
Level of test signal -10 dBV	X	X
Frequency range 1 kHz to 80 kHz	X	X
Impedance of a splitter Combination 1: Z_1 = 135 Ω/ISDN 2B1Q Combination 2: Z_1 = 150 Ω/ISDN 4B3T	 X (see note) X (see note)	 X (see note) X (see note)
DC feeding voltage/current +50 V_{DC}/0 mA -50 V_{DC}/60 mA	 X X	 X X
VDSL load = Z_{VDSL-I} VDSL load = open circuit	X X	X X
Number of tests	8 tests	8 tests
NOTE: If a splitter is specially designed to work only for one of the options (with ISDN 4B3T or ISDN 2B1Q) it is sufficient to test it with one of the source/load combinations.		

Test procedure notes:

NOTE 1: Direction of the feeding current is not expected to impact the return loss of splitters.

NOTE 2: Reduction of line currents to just 0 mA and 60 mA as no significant differences were evident during the tests.

Test results:

Test result shall be recorded in dB, where: $R_L = 20 \log_{10} |Z_1 + Z_2|/|Z_1 - Z_2|$, where Z_1 is the impedance connected to the line port and where Z_2 is the impedance observed at the ISDN port.

Measuring notes:

The inaccuracy of the measurement which results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

6.3 Delay distortion in the pass band (ISDN-BA)

Table 7: Description of the delay distortion in the pass band (ISDN-BA) test case

Test case name:	Delay distortion in the pass band (ISDN-BA)
Reference:	TS 101 952-2-3 [1], clause 6.8
Test purpose:	To evaluate the delay distortion in the pass band (ISDN-BA) when tested with the test parameters as given in the related standards
Test configuration:	See test setup; DUT not configured

Test setup:

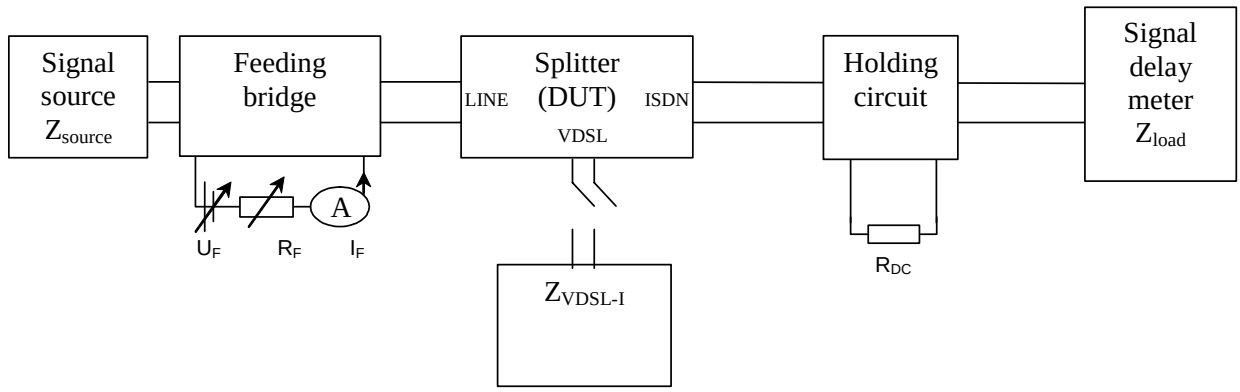


Figure 7: Test setup for delay distortion testing on a splitter

Test parameters:

Table 8: Test parameters for the delay distortion in the pass band (ISDN-BA) test case

Parameter	Value
Level of the test signal	-10 dBV
Frequency range	1 kHz to 80 kHz
Level of feeding voltage	$50V_{DC}$
Feeding current	0 mA to 60 mA
Polarity of feeding voltage	normal and reversed, alternating between the single measurements
Load resistance R_{DC}	470 Ω
Source impedance	135 Ω resistive (2B1Q) 150 Ω resistive (4B3T)
Load impedance	135 Ω resistive (2B1Q) 150 Ω resistive (4B3T)
VDSL termination	Z_{VDSL-I} Open circuit

Test matrix:

Table 9: Test matrix for the delay distortion in the pass band (ISDN-BA) test case

	TS 101 952-2-3 [1]	Essential tests
Source and Load 135 Ω Source and Load 150 Ω	X (see note) X (see note)	X (see note) X (see note)
DC feeding voltage/current +50V_{DC}/0 mA -50V_{DC}/60 mA	 X X	 X X
VDSL: Z_{VDSL-I} VDSL: Open circuit	X X	X X
Number of tests	8 tests	8 tests
NOTE: If a splitter is specially designed to work only for one of the options (with ISDN 4B3T or ISDN 2B1Q) it is sufficient to test it with one of the source/load combinations.		

Test procedure notes:

NOTE 1: Direction of the feeding current is not expected to impact the delay distortion of splitters.

NOTE 2: Reduction of line currents to just 0 mA and 60 mA did not provide significant differences.

Test results:

For each test case, the normalized signal is obtained by subtracting the signal delay values without the splitter from the signal values with the splitter at each measured frequency point:

$$SD_{nf} = SD_{sf} - SD_{0f}$$

where:

SD_{nf} is Normalised Signal Delay at frequency f

SD_{sf} is measured Signal Delay at frequency f with splitter in circuit

SD_{0f} is measured Signal Delay at frequency f without splitter in circuit

$$SDD_f = SD_{nf} - SD_{\min}$$

where:

SDDf is the Signal Delay Distortion at frequency f

SDnf is the normalized Signal Delay at frequency f

SDmin is the minimum normalized Signal Delay for all frequencies for that load

Measuring notes:

The inaccuracy of the measurement that results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

6.4 Isolation (insertion loss) at 150 kHz to 12 MHz

Table 10: Description of the isolation (insertion loss) at 150 kHz to 12 MHz test case

Test case name:	Isolation (insertion loss) at 150 kHz to 12 MHz
Reference:	TS 101 952-2-3 [1], clause 6.6
Test purpose:	To measure the isolation of the ISDN port from the VDSL signals and vice versa in the frequency range from 150 kHz to 12 MHz which may impact the ISDN or VDSL transmission
Test configuration:	See test setup; DUT not configured

Test setup:

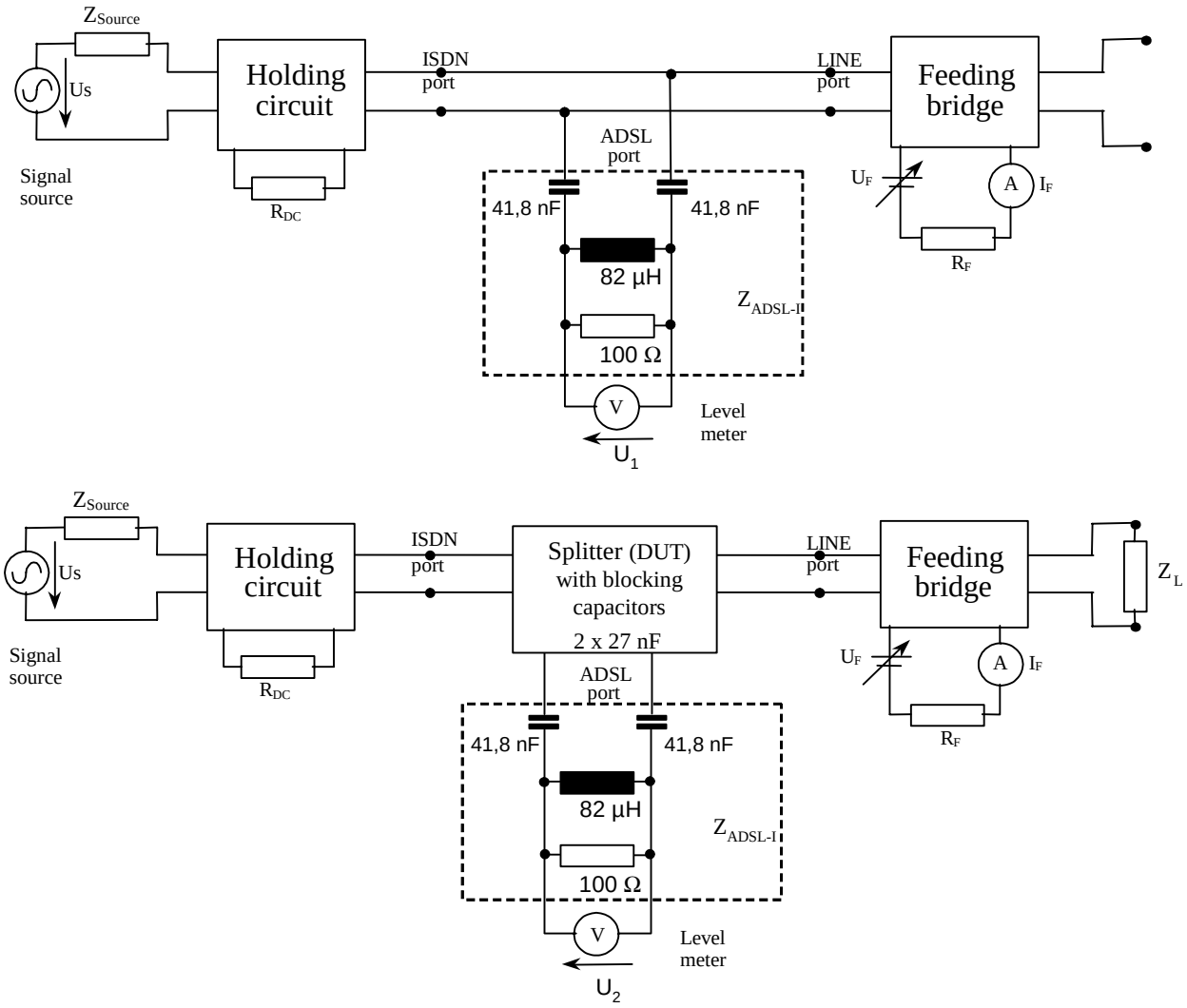


Figure 8: Test setup for isolation testing on a splitter from ISDN to VDSL port

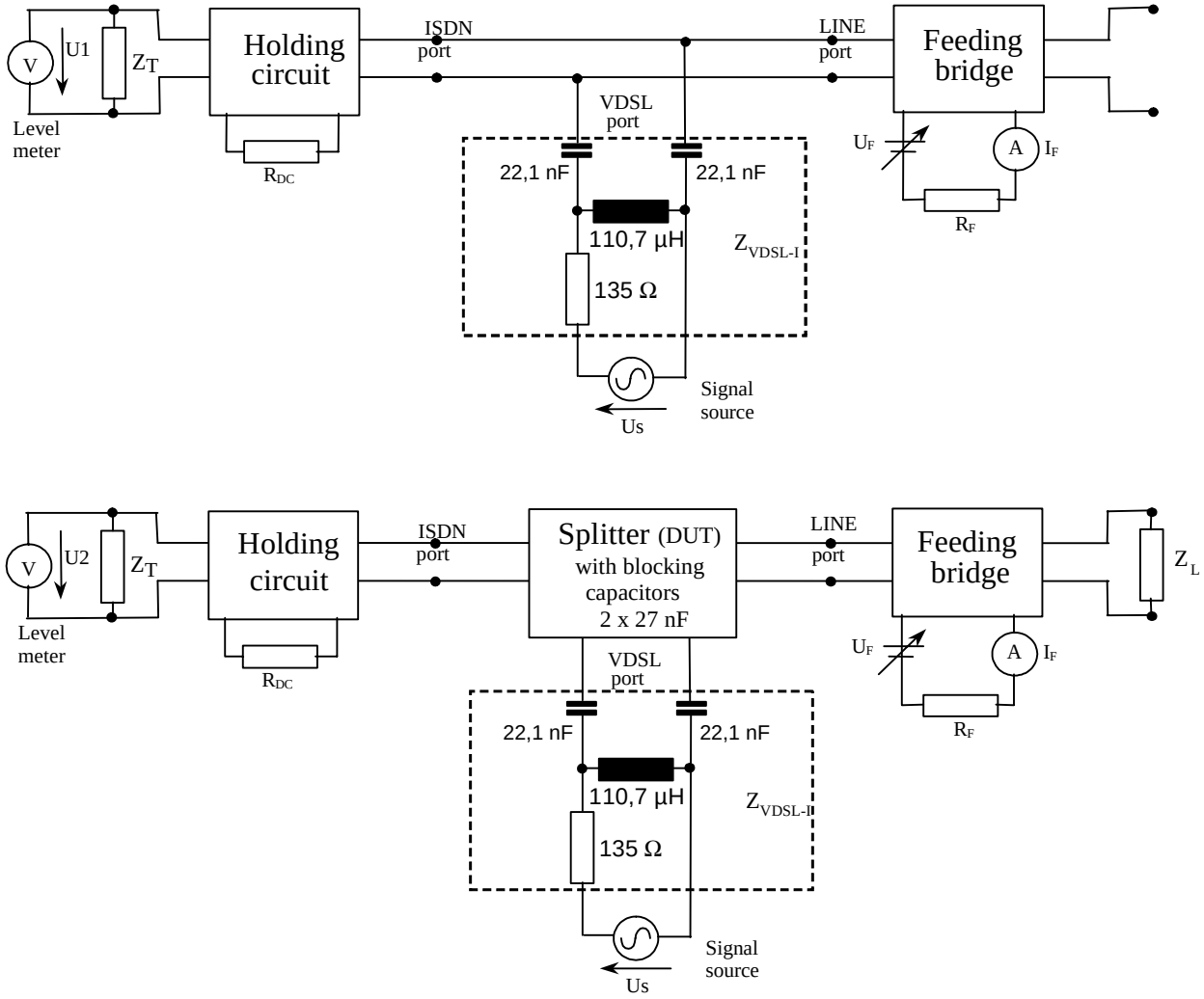


Figure 9: Test setup for isolation testing on a splitter from VDSL port to ISDN port

The Feeding Bridge and Holding Circuit must comply with the requirements as specified in TBR 038 [4]. As the TBR 038 [4] defines the feeding bridge and the holding circuit only for the voice frequency band, special care need to be taken on the electrical characteristics of the feeding bridge and the holding circuit in the ISDN-BA and VDSL specific frequency band.

Test parameters:

Table 11: Test parameters for the isolation (insertion loss) at 150 kHz to 12 MHz test case

Parameter	Value
Level of the test signal Us	-6 dBV emf
Frequency range of Us	150 kHz to 12 MHz
Combinations of directions	combination 1: ISDN to VDSL combination 2: VDSL to ISDN
Source impedance Z_{Source}	combination 1: Z_T = 135 Ω for VDSL/ISDN Splitter 2B1Q Z_T = 150 Ω for VDSL/ISDN Splitter 4B3T combination 2: 135 Ω as a part of Z_{VDSL-I}
Load impedance Z_{Load}	combination 1: Z_{VDSL-I} combination 2: Z_T = 135 Ω for VDSL/ISDN Splitter 2B1Q Z_T = 150 Ω for VDSL/ISDN Splitter 4B3T
LINE termination Z_{T-LINE}	Z_L = 135 Ω
Level of feeding voltage	50 V_{DC}
Load resistance R_{DC}	470 Ω
DC feeding current I_F	0 mA to 60 mA
Polarity of feeding voltage	normal and reversed, alternating between the single measurements
Optional tests	none

Test matrix:

Table 12: Test matrix for the isolation (insertion loss) at 150 kHz to 12 MHz test case

	TS 101 952-2-3	Essential tests
Level of test signal -6 dBV	X	X
Frequency range 150 KHz to 12 MHz	X	X
Combination 1: ISDN to VDSL Combination 2: VDSL to ISDN	X (see note) X (see note)	X (see note) X (see note)
Source and load 135 Ω Source and load 150 Ω	X X	X X
DC feeding voltage/current +50 V_{DC}/0 mA -50 V_{DC}/60 mA	 X X	 X X
Number of tests	8 tests	8 tests
NOTE If a splitter is specially designed to work only for one of the options (with ISDN 4B3T or ISDN 2B1Q) it is sufficient to test it with one of the source/load combinations.		

Test procedure notes:

NOTE 1: The source impedance Z_{SOURCE} shall be realized in a symmetrical way.

NOTE 2: Normally the splitter consists of two parts: low pass filter and high pass filter realized with two blocking capacitors 27 nF each. If the splitter does not contain the blocking capacitors, the two capacitors 27 nF each have to be connected externally.

NOTE 3: During the calibration of the test setup the line impedance Z_L at the LINE port shall be removed (open end).

Test results:

Test result shall be recorded in dB, where $I_L = -20 \log_{10} (U_2/U_1)$, where U_2 is the voltage observed when the splitter is connected as in test setup and where U_1 is the voltage observed when the splitter is replaced by a direct wire connection of less than 0,01 Ω.

Measuring notes:

NOTE 1: The inaccuracy of the measurement that results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

NOTE 2: The difference in the measurement result dependent on the measurement direction.

(ISDN ⇒ VDSL or VDSL ⇒ ISDN) is theoretically 0,9 dB for ISDN (4B3T, 150 Ω) and 0 dB for ISDN (2B1Q, 135 Ω) due to the different impedances of the signal source (135 Ω, 135 Ω or 150 Ω).

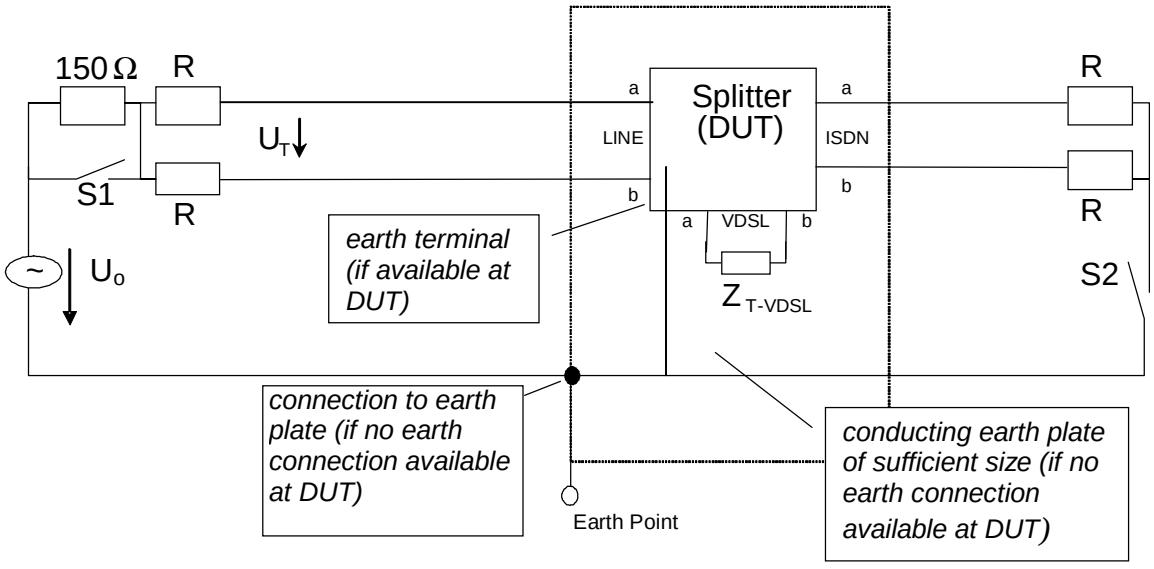
6.5 Unbalance about earth

TS 101 952-2-3 [1] requires the unbalance about earth to be measured up to 12 MHz under the application of DC feeding. Applying a feeding bridge and a holding circuit to an unbalance test set-up means a significant impact to the set-up´s balance about earth, especially at higher frequencies. However, the evaluation of the unbalance of splitters should be done with a DC feeding applied, as the impedance of splitter components might vary upon the feeding current. To achieve both a valid LCL/LCTL test result as well as a prove of the splitters behaviour under the influence of the DC current it is recommended to test this characteristic in two steps (see clauses 6.51.1 and 6.5.2).

6.6 Unbalance about earth without DC feeding

Table 13: Description of the unbalance about earth test case

Test case name:	Unbalance about earth
Reference:	TS 101 952-2-3 [1], clause 6.5
Test purpose:	To evaluate the symmetry (unbalance) of the splitter about earth when tested with the test parameters as given in the related standards
Test configuration:	See test setup; DUT not configured



NOTE: When testing at the ISDN port the test setup of figure 10 is to be used, however, terminations at LINE and ISDN need to be reversed.

Figure 10: Test setup for unbalance about earth measurements at the LINE port

Test parameters:

Table 14: Test parameters for the unbalance about earth test case (without feeding)

Parameter	Value
Level of the test signal Uo	-10 dBm
Frequency of the test signal Uo	frequency range 1: 300 Hz to 30 kHz frequency range 2: 30 kHz to 1 104 kHz frequency range 3: 1 104 kHz to 12 MHz
Combination of source and load Impedances	combination 1: R = $Z_L/2$ = 135 Ω/2 = 67,5 Ω combination 2: R = $Z_L/2$ = 150 Ω/2 = 75 Ω
Status of S1	open closed
Status of S2	open closed
Termination at VDSL: $Z_{T\text{-}VDSL}$	$Z_{T\text{-}VDSL}$ = 135 Ω
Feeding voltage/current	no feeding applied
Optional tests	none

Test matrix:

Table 15: Test matrix for the unbalance about earth test case (without feeding)

	TS 101 952-2-3	Essential tests
Level of the test signal -10 dBm	X	X
Frequency Range 1 (300 Hz to 30 kHz) Frequency Range 2 (30 kHz to 1 104 kHz) Frequency Range 3 (1 104 kHz to 12 MHz)	X X X	X X X
Impedance combination 1 (see note) Impedance combination 2 (see note)	X X	X X
Status of S1 = open Status of S1 = closed	X X	X X
Measured at ISDN port; S2 = open Measured at ISDN port; S2 = closed Measured at LINE port; S2 = open Measured at LINE port; S2 = closed	X X X	X X X
$Z_{T\text{-}VDSL}$ = 135 Ω	X	X
Number of tests	9 tests	9 tests
NOTE: If a splitter is specially designed to work only for one of the options (with ISDN 4B3T or ISDN 2B1Q) it is sufficient to test it with one of the source/load combinations).		

Test procedure notes:

NOTE: If the splitter has no earth terminal, the test should be performed while the splitter is placed on an earthed metal plate with an area at least 50 % larger than the foot-print of the splitter.

Test results:

Test result should be recorded in dB, where: unbalance = 20 $\log_{10}$ (U_0/U_T), where U_0 is the longitudinal voltage fed in by the generator and where U_T is the differential voltage observed at the input of the DUT.

Measuring notes:

Special care need to be taken to achieve a test setup of sufficient balance about earth. It is highly recommended to perform a calibration/normalization measurement before the test where the balance of the test setup without DUT is investigated. The unbalance achieved at this measurement shall be at least 15 dB greater than the tested requirement.

The inaccuracy of the measurement that results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

6.7 Unbalance about earth with DC feeding

This testing method is for further study.

6.8 Noise

Table 16: Description of the noise test case

Test case name:	Noise
Reference:	TS 101 952-2-3 [1], clause 6.7
Test purpose:	To evaluate the noise generated by the splitter at the VDSL and LINE ports when tested with the test parameters as given in the related standard
Test configuration:	See test setup; DUT not configured

Test setup:

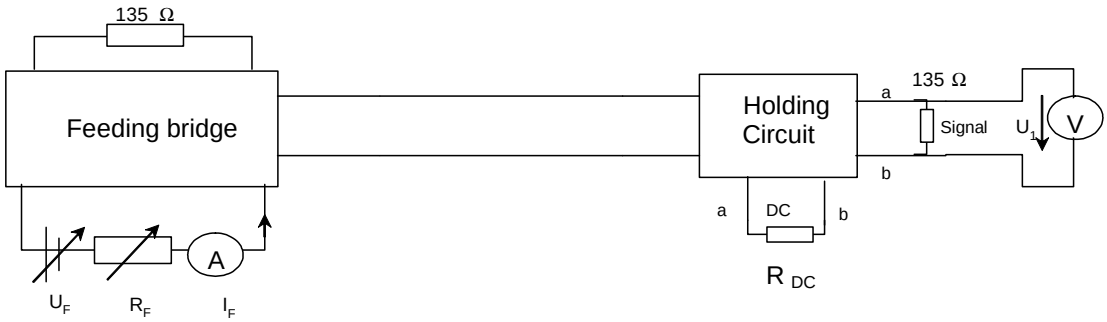


Figure 11: Verification of the test setup

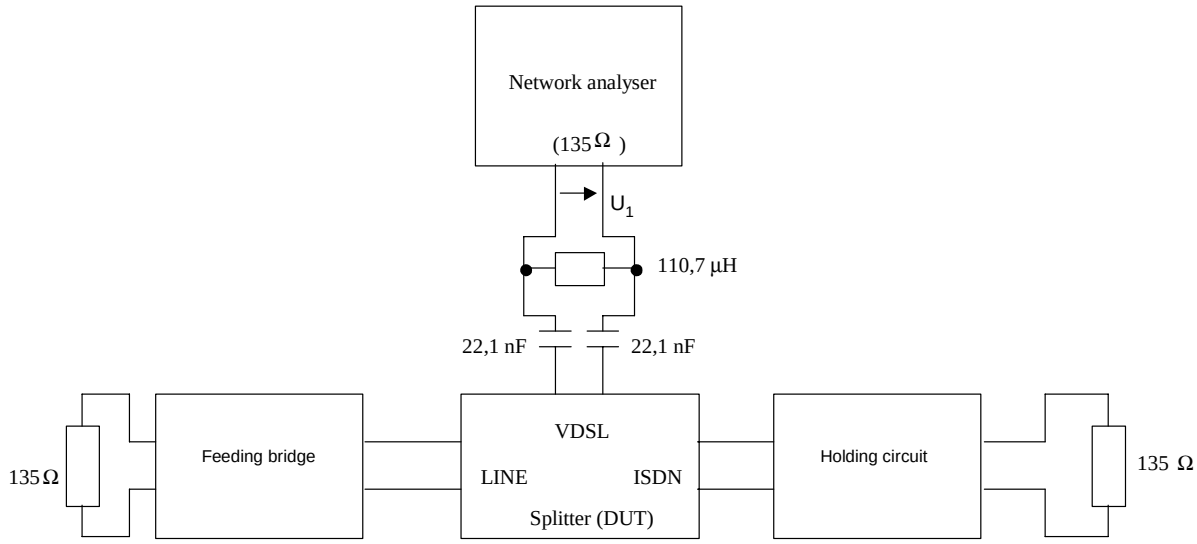


Figure 12: Test setup for noise testing at the VDSL port

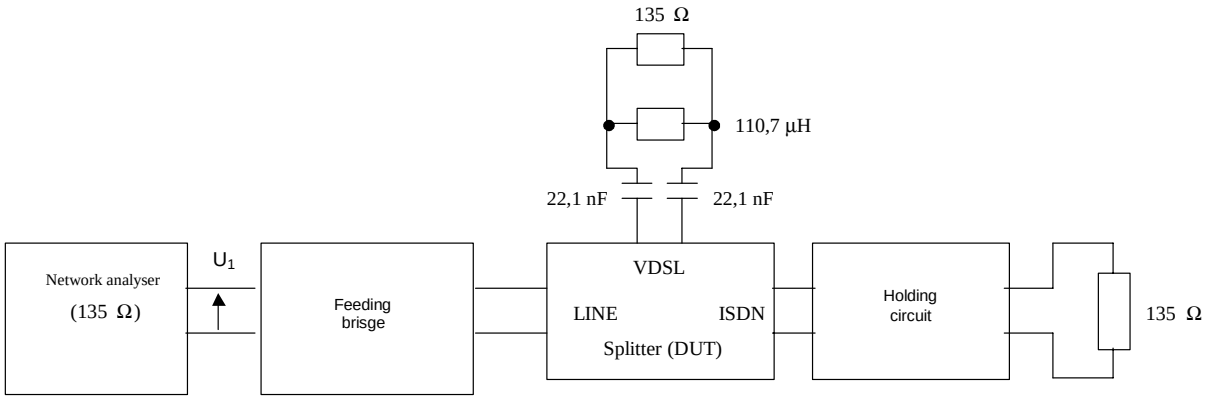


Figure 13: Test setup for noise testing at the LINE port

The Feeding Bridge and Holding Circuit must comply with the requirements as specified in TBR 038 [4]. Furthermore the insertion loss of Feeding and Holding Circuit in the "signal" path shall be less than 1 dB in the frequency range from 138 kHz to 12 MHz.

Test Parameters:

Table 17: Test parameters for the noise test case

Parameter	Value
Frequency range	138 kHz to 12 MHz
Termination at VDSL: $Z_{T\text{-}VDSL}$	$Z_{T\text{-}VDSL} = Z_{VDSL\text{-}I}$
Level of feeding voltage	50 V_{DC}
Load resistance R_{DC}	470 Ω
DC feeding current I_F	0 mA 20 mA 40 mA 60 mA
Polarity of feeding voltage	normal and reversed, alternating between the single measurements
Ports to be tested	LINE VDSL
Optional tests	none

Test matrix:

Table 18: Test matrix for the noise test case

	TS 101 952-2-3 [1]	Essential tests
Frequency range 138 kHz to 12 MHz	X	X
DC feeding voltage/current		
+50 V_{DC}/0 mA	X	X
-50 V_{DC}/20 mA	X	X
+50 V_{DC}/40 mA	X	X
-50 V_{DC}/60 mA	X	X
$Z_{T\text{-}VDSL} = Z_{VDSL\text{-}I}$	X	X
Measured at port LINE	X	X
Measured at port ISDN	X	X
Number of tests	8 tests	8 tests

Test procedure notes:

Before starting the measurements the test setup shall be verified with respect to the noise present when having the DC source as well as the holding circuit present in the setup but not having connected the splitter under test. Measuring U1 as shown in the test setup is an appropriate way to do so. The observed value for U1 (dBm/Hz) measured with a bandwidth of 10 kHz should be at least 10 dB lower than the value that is to be proven.

Values of DC feeding current I_F are set by adjusting the values of the external circuitry (namely U_F, R_F and R_{DC}).

Test results:

Test result shall be recorded as follows:

- U_1 in dBm/Hz, where U_1 is the voltage observed, when the splitter is connected as in test setup.

Measuring notes:

The inaccuracy of the measurement which results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

It is considered that this test is primarily concerned with noise generated by an active splitter. Passive splitters are not considered likely to be a source of spectral noise.

6.9 DC requirements

6.9.1 DC resistance to earth

Table 19: Description of the DC resistance to earth test case

Test case name:	DC resistance to earth
Reference:	TS 101 952-2-3 [1], clause 6.1.1
Test purpose:	To measure the DC resistance between each terminal (i.e. A-wire and B-wire) of the splitter and earth. This test only applies to splitters which provide a terminal which is connected to ground. (See note.)
Test configuration:	See test setup; DUT not configured
NOTE: A splitter is considered to provide an earth connection, as soon as there is a specific terminal which might lead to the reasonable assumption that is could be connected to ground. Furthermore, this test is to be performed, when there are non-insulated conducting parts at the enclosure.	

Test setup:

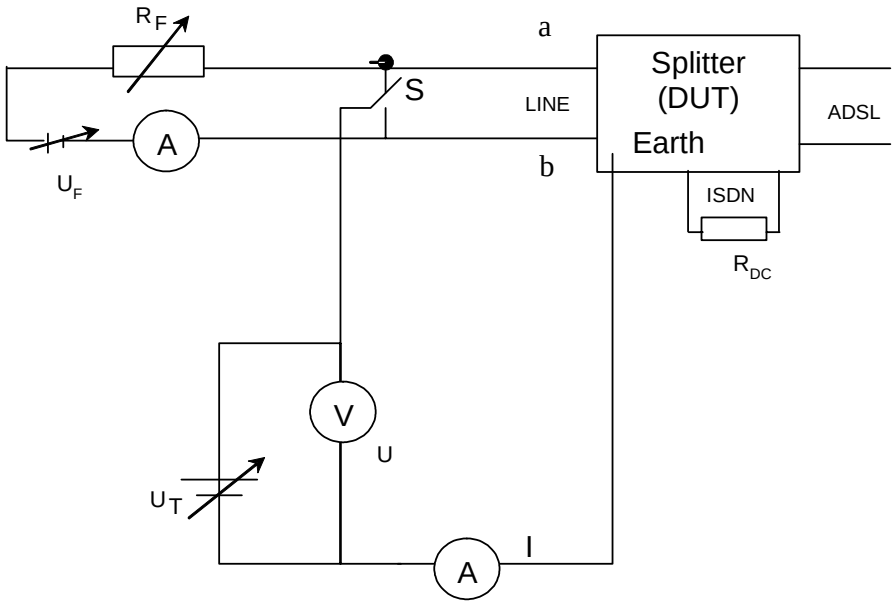


Figure 14: Test setup for DC resistance to earth (LINE port)

Test parameters:

Table 20: Test parameters for the DC Resistance to earth test case

Parameter	Value
Level of the DC test voltage U_T	+120 V_{DC} -120 V_{DC}
Level of feeding voltage	50 VDC
Level of feeding current	0 mA to 60 mA
Polarity of feeding voltage	normal and reversed, alternating between the single measurements
Position of Switch S	a-wire b-wire
Termination at ISDN port	RDC = 470 Ω
Termination at VDSL port	open circuit
Ports to be tested	LINE ISDN VDSL

Test Matrix:

Table 21: Test matrix for the DC resistance to earth test case

	TS 101 952-2-3 [1]	Essential tests
DC source voltage +120 V_{DC}	X	X
DC source voltage -120 V_{DC}	X	X
U_T applied to LINE	X	X
U_T applied to ISDN (only with DC path break)	X	X
U_T applied to VDSL	X	X
Switch in position a	X	X
Switch in position b	X	X
DC feeding voltage/current		
+50 V_{DC}/0 mA	X	X
-50 V_{DC}/60mA	X	X
Termination at ISDN R_{DC} = 470 Ω	X	X
Termination at ISDN open circuit		
Number of tests	16 tests (24 for splitters breaking the DC path)	16 tests (24 for splitters breaking the DC path)

Test procedure notes:

NOTE 1: When a DC current is flowing, the difference in the test results between the measurements from a-wire to earth and b-wire to earth is expected to be negligible (only the R_{DC} and the series resistance of the holding circuit is added to the result). With this, at the LINE port and the ISDN port testing only one wire against earth is sufficient when there is no break in the DC path.

NOTE 2: Splitters breaking the DC path should be tested completely (all three ports), splitters not breaking the DC path can use a reduced test which only requires testing at the VDSL port and the LINE port.

NOTE 3: At the VDSL port a- and b- wire should be tested separately, however, a DC current need not be applied.

NOTE 4: Verification of the test result: To verify the test result, a well-known resistor of about 5 MΩ (measured independently at an uncertainty of less than 0,1 %) should be connected to the test setup and the resulting current should be compared with the theoretically expected result.

Test results:

Test result shall be recorded as follows:

- I in µA, where: I is the value of the observed current, which is flowing into the branch under test.
- $R_{DC\text{-}wire\text{-}earth}$, where $R_{DC\text{-}wire\text{-}earth} = U_T/I$.

Measuring notes:

The inaccuracy of the measurement that results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

6.9.2 Isolation resistance between A-wire and B-wire

Table 22: Description of the isolation resistance between A-wire and B-wire test case

Test case name:	Isolation resistance between A-wire and B-wire
Reference:	TS 101 952-2-3 [1], clause 6.1.2
Test purpose:	To measure the isolation resistance between the A-wire and B-wire
Test configuration:	See test setup; DUT not configured

Test setup:

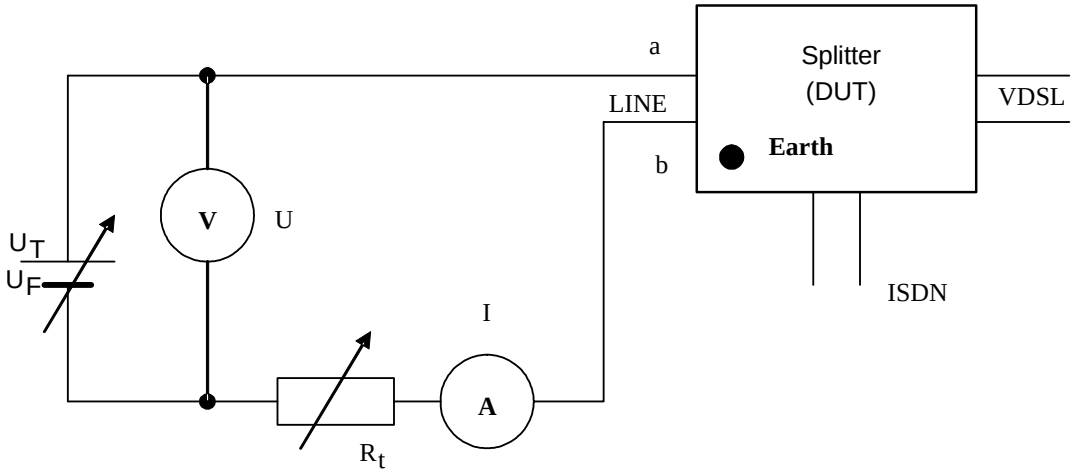


Figure 15: Test setup for isolation resistance between A-wire and B-wire (LINE port)

Test parameters:

Table 23: Test parameters for the isolation resistance between A-wire and B-wire test case

Parameter	Value
Level of the test voltage U_T	+120 V_{DC} -120 V_{DC}
Termination at ports under test	open circuit
Termination at ports not under test	open circuit
Ports to be tested	LINE ISDN VDSL

Test matrix:

Table 24: Test matrix for the isolation resistance between A-wire and B-wire test case

	TS 101 952-2-3	Essential tests
DC source voltage +120 V_{DC}	X	X
DC source voltage -120 V_{DC}	X	X
V_{DC} applied to LINE	X	X
V_{DC} applied to ISDN	X	X
V_{DC} applied to VDSL	X	X
Number of tests	6 tests	6 tests

Test procedure notes:

NOTE 1: If the splitter is not breaking the DC path, it is sufficient to measure at one port (the LINE port). If the splitter is breaking the DC path, both ports (LINE and ISDN) should be measured.

NOTE 2: Verification of the test result: To verify the test result, a well-known resistor of about 5 MΩ (measured independently at an uncertainty of less than 0,1 %) should be connected to the test setup and the resulting current should be compared with the theoretically expected result.

NOTE 3: It is not expected that a DC level occurs in normal operation at the VDSL port and therefore it may be appropriate to delete the requirement for DC resistance between open wires at the VDSL port.

Test results:

Test result should be recorded as follows:

- I in µA, where: I is the value of the observed current, which is flowing into the branch under test.
- $R_{DC\text{-}A\text{-}wire\text{-}B\text{-}wire}$, where $R_{DC\text{-}A\text{-}wire\text{-}B\text{-}wire} = U_T/I$.

Measuring notes:

The inaccuracy of the measurement that results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

6.9.3 DC series resistance

Table 25: Description of the DC series resistance test case

Test case name:	DC series resistance
Reference:	TS 101 952-2-3 [1], clause 6.1.3
Test purpose:	To measure the DC series resistance of the splitter
Test configuration:	See test setup; DUT not configured

Test setup:

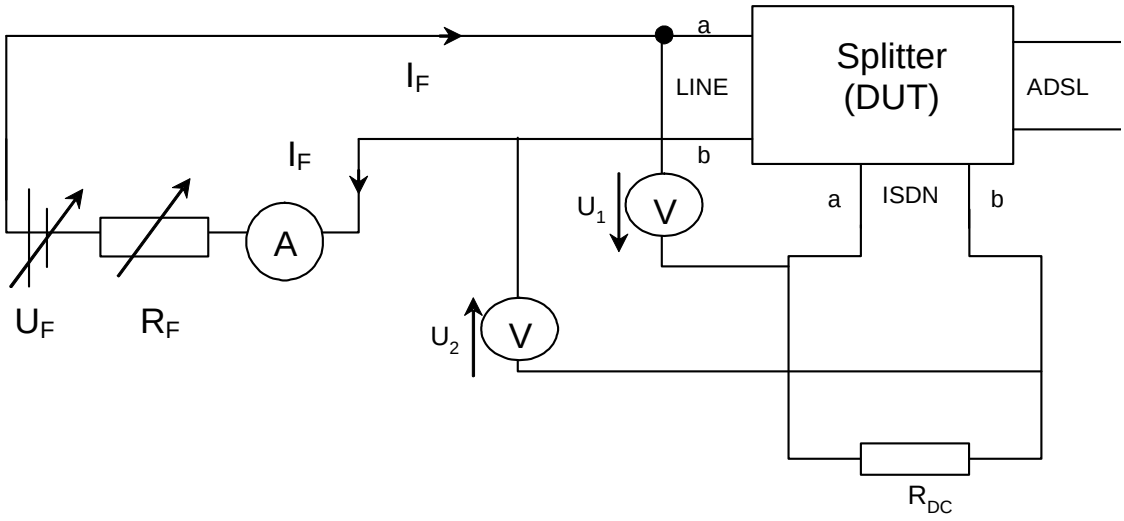


Figure 16: Test setup for series resistance between A-wire and B-wire (LINE to ISDN)

Test parameters:

Table 26: Test parameters for the DC series resistance test case

Parameter	Value
Level of feeding voltage U_F	50 V_{DC}
Value of feeding current I_F	0 mA to 60 mA
Polarity of feeding voltage	normal and reversed, alternating between the single measurements
Termination at VDSL port	Open circuit
Termination at port not under test (R_{DC} = 0 Ω)	Short circuit
Ports to be tested	LINE ISDN

Test matrix:

Table 27: Test matrix for the DC series resistance test case

	TS 101 952-2-3 [1]	Essential tests
DC feeding voltage/current +50 V_{DC}/0 mA -50 V_{DC}/60 mA	 X X	 X X
Termination at VDSL open circuit	X	X
LINE to ISDN (ISDN port short circuit) ISDN to LINE (LINE port short circuit)	X X	X X
Number of tests	4 tests	4 tests

Test procedure notes:

NOTE 1: The DC series resistance of passive splitters without current/voltage detection does not change significantly with the value or direction of the current.

NOTE 2: Splitters that break the DC path cannot be assessed using this type of test.

The assessment of active splitters and splitters that break the DC path in any way is for further study.

NOTE 3: Verification of the test result:

To verify the test result, two calibrated 25 Ω resistors (measured independently at an uncertainty of not more than 0,1 %) should +be connected to the test setup, simulating two DC branches of the splitter. The resulting current should be compared with the theoretically expected result.

Test results:

Test result should be recorded as follows:

- U_1 and U_2 in V, where: U_1 is the voltage drop between a-wire of the LINE port and the a-wire of the ISDN port and U_2 is the voltage drop between b-wire of the LINE port and the b-wire of the ISDN port.
- I_F in mA, where I_F is the resulting feeding current.
- $R_{DC\text{-}series}$, where $R_{DC\text{-}series} = (U_1 + U_2)/I_F$.

Measuring notes:

The inaccuracy of the measurement that results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

6.10 Insertion loss requirements for the high pass part

Table 28: Description of the insertion loss requirements for the high pass part test case

Test case name:	Insertion loss requirements
Reference:	TS 101 952-2-3 [1], clause 6.9.1
Test purpose:	To measure the insertion loss between the LINE port and the VDSL port of the high pass part of the VDSL over ISDN-BA splitters in the frequency range from 120 kHz to 12 MHz
Test configuration:	See test setup; DUT not configured

Test setup:

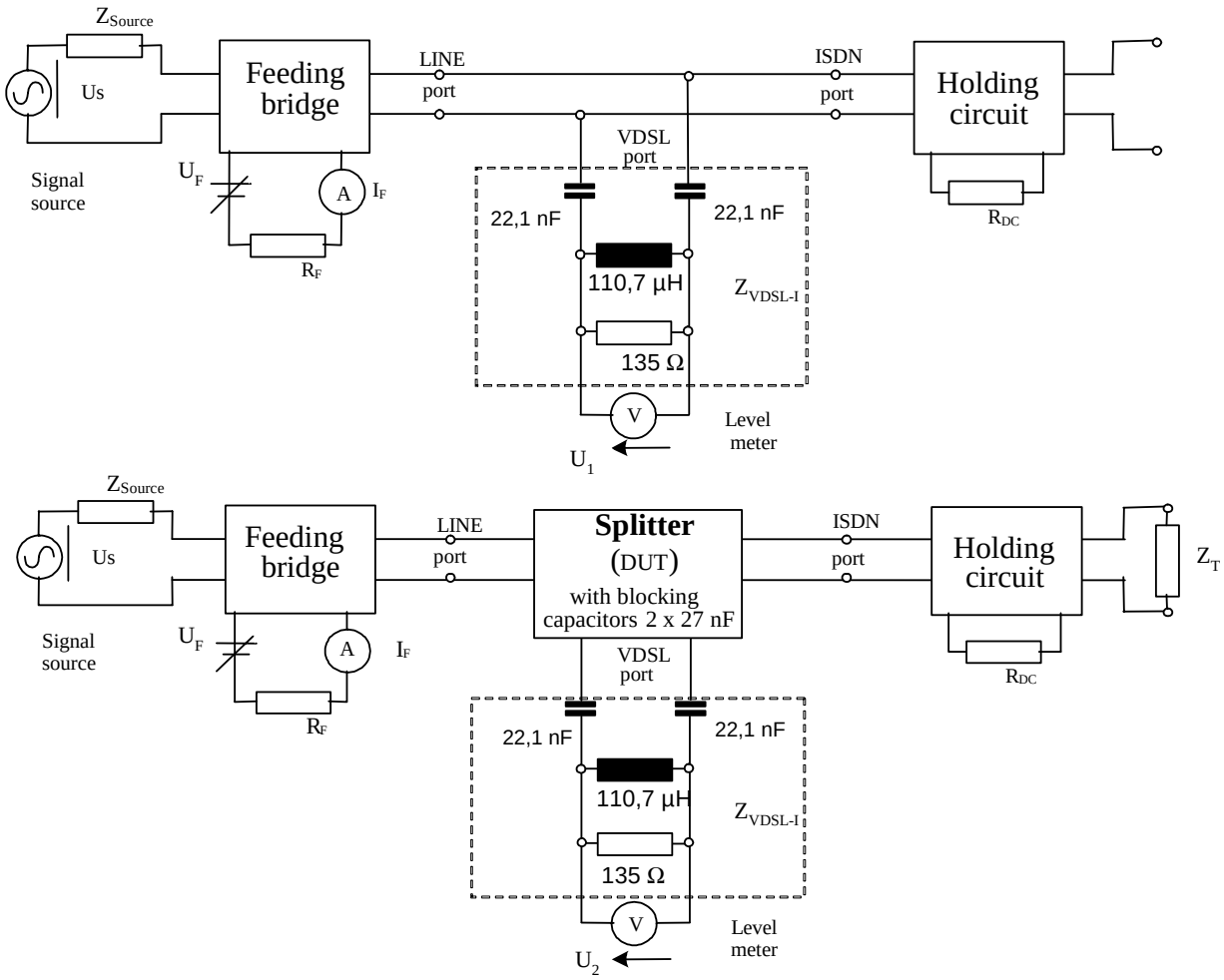


Figure 17: Test setup for insertion loss testing on a splitter from LINE to VDSL port

Feeding Bridge and Holding Circuit must comply with the requirements as specified in TBR 038 [4]. As the TBR 038 [4] defines the feeding bridge and the holding circuit only for the voice frequency band, special care need to be taken on the electrical characteristics of the feeding bridge and the holding circuit in the ISDN-BA and VDSL specific frequency band.

Test parameters:

Table 29: Test parameters for the insertion loss requirements for the high pass part test case

Parameter	Value
Level of the test signal U_S	-6 dBV emf
Frequency range of U_S	120 kHz to 12 MHz
Source impedance Z_{Source}	135 Ω (LINE port)
Load impedance Z_{Load}	Z_{VDSL-I} (VDSL port)
ISDN termination Z_{ISDN}	Z_T = 135 Ω for VDSL/ISDN Splitter 2B1Q Z_T = 150 Ω for VDSL/ISDN Splitter 4B3T open for VDSL/ISDN Splitter both 2B1Q and 4B3T
Level of feeding voltage	50 V_{DC}
Load resistance R_{DC}	470 Ω
DC feeding current I_F	0 mA to 60 mA
Polarity of feeding voltage	normal and reversed, alternating between the single measurements
Optional tests	none

Test matrix:

Table 30: Test matrix for the insertion loss requirements for the high pass part test case

	TS 101 952-2-3 [1]	Essential tests
Level of test signal -6 dBV	X	X
Frequency range 120 kHz to 12 MHz	X	X
Termination of ISDN port: Z_T	X (see note)	X (see note)
Termination of ISDN port: open	X	X
DC feeding voltage/current		
+50 V_{DC}/0 mA	X	X
-50 V_{DC}/60 mA	X	X
Number of tests	4 tests	4 tests
NOTE: If a splitter is specially designed to work only for one of the options (with ISDN 4B3T or ISDN 2B1Q) it is sufficient to test it with one of the source/load combinations).		

Test procedure notes:

NOTE 1: The source impedance Z_{SOURCE} shall be realized in a symmetrical way.

NOTE 2: Normally the splitter consists of two parts: low pass filter and high pass filter realized with two blocking capacitors 27 nF each. If the splitter does not contain the blocking capacitors, the two capacitors 27 nF each have to be connected externally.

NOTE 3: During the calibration of the test setup the line impedance Z_T at the ISDN port shall be removed (open end) because the source is loaded by the termination impedance at the ISDN port during the reference measurement. However, during the insertion loss measurement this load will be almost blocked by the low-pass of the splitter.

Test results:

Test result shall be recorded in dB, where $I_L = -20 \log_{10} (U_2/U_1)$, where U_2 is the voltage observed when the splitter is connected as in Test Setup and where U_1 is the voltage observed when the splitter is replaced by a direct wire connection of less than 0,01 Ω.

Measuring notes:

NOTE: The inaccuracy of the measurement that results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

History

Document history		
V1.1.1	July 2004	Publication