

**Access network xDSL transmission filters;  
Part 1: ADSL splitters for European deployment;  
Sub-part 3: Testing methods for ADSL/ISDN splitters**



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Reference

DTR/TM-06027-1-3

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Keywords

ADSL, ISDN, splitter, testing, xDSL

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## Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Transmission and Multiplexing (TM).

The present document is part 1, 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";**

Sub-part 1: "Specification of Testing methods for Low Pass part of ADSL/POTS splitters";

Sub-part 2: "Testing methods for High Pass part of ADSL/POTS splitters";

**Sub-part 3: "Testing methods for ADSL/ISDN splitters";**

Part 2: "VDSL splitters for European deployment".

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

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## Introduction

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

The test methods of the present technical report are based on requirements of different documents describing ADSL/ISDN-BA splitters:

- TS 101 952-1-3 [5]: "Specification of ADSL/ISDN Splitters";
- TS 101 388 [1]: "Transmission and multiplexing (TM); Access transmission systems on metallic access cables; Asymmetric Digital Subscriber LINE (ADSL) - European specific requirements [ITU-T Recommendation G.992.1 modified]".

The proposed test cases for ADSL over ISDN-BA splitters are put together.

The requirements from TS 101 952-1-3 [5] are assessed to be the "essential" or minimum tests. The additional tests that are required in other standards have been assessed as "optional" tests. There are two columns in each test matrix which inform about the "essential" and the "optional" tests.

For each test, the document describes:

- title of the test;
- purpose of the test;
- reference to the specifications;
- test configuration;

- rest setup;
- rest parameters;
- rest results matrix;
- measuring notes.

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# 1 Scope

The present document describes test methods for ADSL/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.

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# 2 References

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

- [1] ETSI TS 101 388: "Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Asymmetric Digital Subscriber LINE (ADSL) - European specific requirements [ITU-T Recommendation G.992.1 modified]".
- [2] ITU-T Recommendation G.992.1: "Asymmetric digital subscriber line (ADSL) transceivers".
- [3] ITU-T Recommendation G.992.3: "Asymmetric digital subscriber line (ADSL) transceivers - 2 (ADSL2)".
- [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] ETSI TS 101 952-1-3: "Access network xDSL transmission filters; Part 1: ADSL splitters for European deployment; Sub-part 3: Specification of ADSL/ISDN splitters".

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# 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:

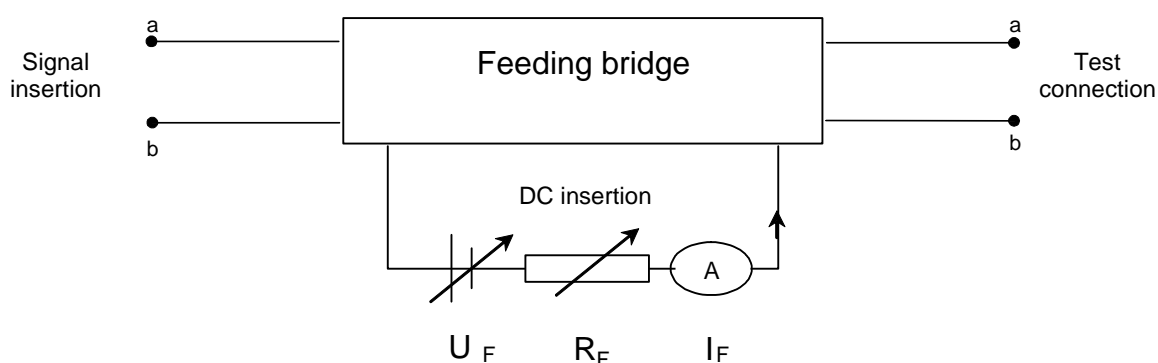
ADSL	Asymmetric Digital Subscriber LINE
CPE	Customer Premises Equipment
dBm	Absolute power level expressed in decibels relative to 1 mW
dBV	Absolute voltage level expressed in decibels relative to 1 Volt
DUT	Device Under Test
emf	electromotive force
HPNA	Home Phonenumber Networking Alliance
I	Current
ISDN-BA	Integrated Services Digital Network-Basic Access
ITU	International Telecommunication Union
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
Z	Impedance

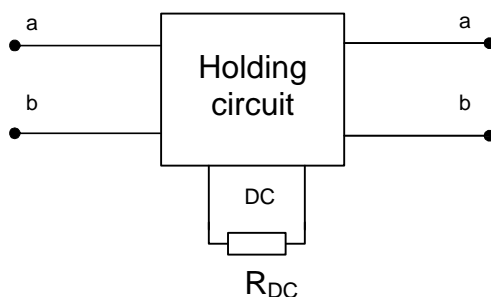
## 4 Void

## 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 1 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 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 which results 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. 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.

NOTE: The splitters which have been evaluated during the validation of the test methods described herein are to be classified in cluster "passive" splitters. No "active" or "passive with current/voltage detection" splitters could be made available for evaluation. The results of the STF 215 work could be validated for the first class, for the second and third class (active splitters) theoretical test case validations have been discussed.

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:

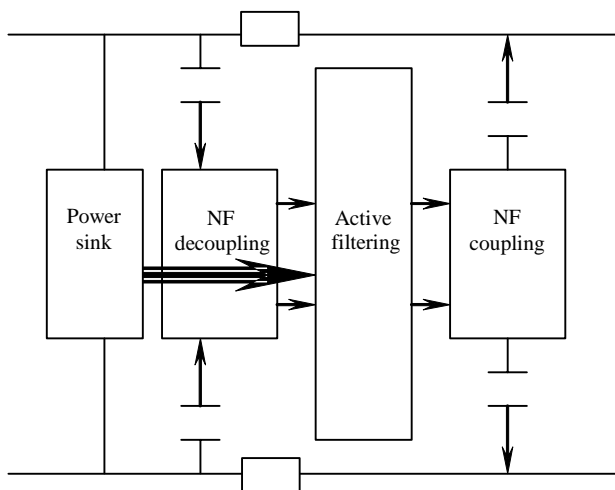


Figure 3: Example for a splitter not breaking the DC path

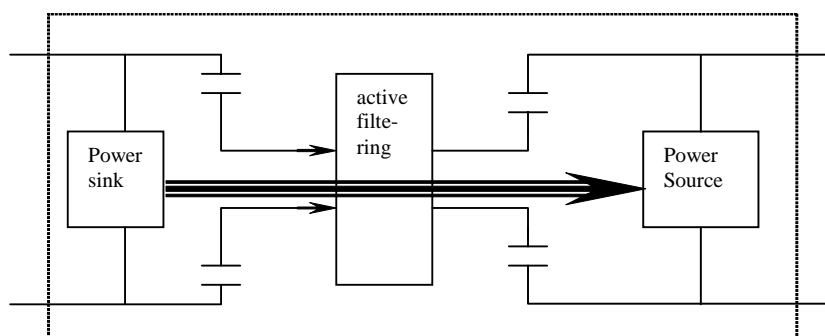


Figure 4: Example for a splitter breaking the DC path

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 ADSL over ISDN-BA splitters

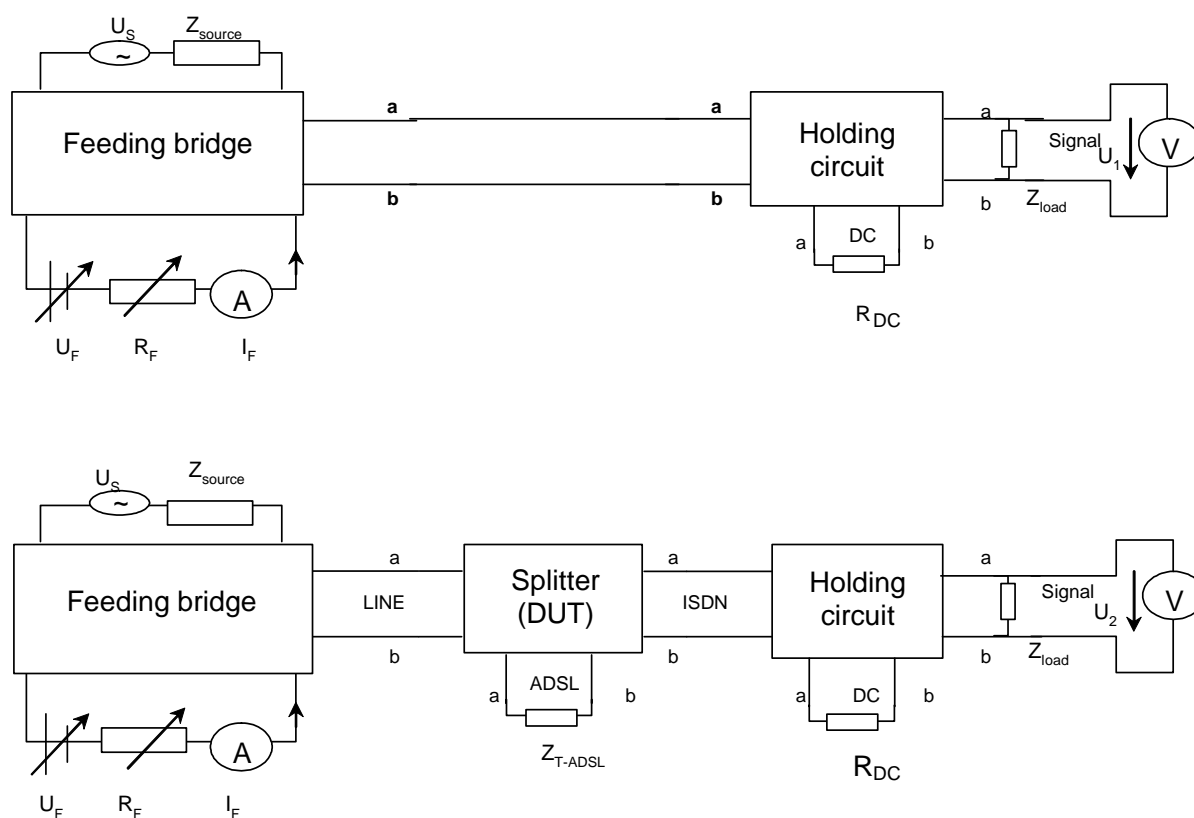
The test cases described include:

- 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 1 104 kHz;
- unbalance about earth;
- noise;
- impedance at the ISDN port between 2 MHz and 10 MHz (HPNA protection);
- 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**

<b>Test case name:</b>	insertion loss in the pass band (ISDN)
<b>Reference:</b>	TS 101 952-1-3 [5], clause 6.3
<b>Test purpose:</b>	to evaluate the insertion loss in the pass band (ISDN-BA) when tested with the test parameters as given in the related standards
<b>Test configuration:</b>	see test setup; DUT not configured

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

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 $U_s$	-10 dBm
Frequency of the test signal $U_s$	1 kHz to 80 kHz
Combination of source and load Impedances	combination 1: $Z_{source} = 135 \Omega$ ; $Z_{load} = 135 \Omega$ ; $R_{DC} = 470 \Omega$ (2B1Q) combination 2: $Z_{source} = 150 \Omega$ ; $Z_{load} = 150 \Omega$ ; $R_{DC} = 470 \Omega$ (4B3T)
Termination at ADSL: $Z_{T-ADSL}$	$Z_{T-ADSL} = Z_{ADSL-I}$ $Z_{T-ADSL} = \text{open circuit}$
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	$I_F = 0 \text{ mA}$ $I_F = 60 \text{ mA}$
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 101 952-1-3 [5]	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	X (see note)	X (see note)
Source/load combination 2	X (see note)	X (see note)
DC feeding voltage / current		
+50 V <sub>DC</sub> /0 mA	X	X
-50 V <sub>DC</sub> /60 mA	X	X
Z <sub>T-ADSL</sub> = Z <sub>ADSL-I</sub>	X	X
Z <sub>T-ADSL</sub> = open circuit	X	X
Transmission Direction ISDN - LINE	active and passive	active and passive
Transmission Direction LINE - ISDN	active only	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 expected not 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 ADSL-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 ADSL-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:  $I_L = -20 \log_{10} (U_2/U_1)$ , 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:**

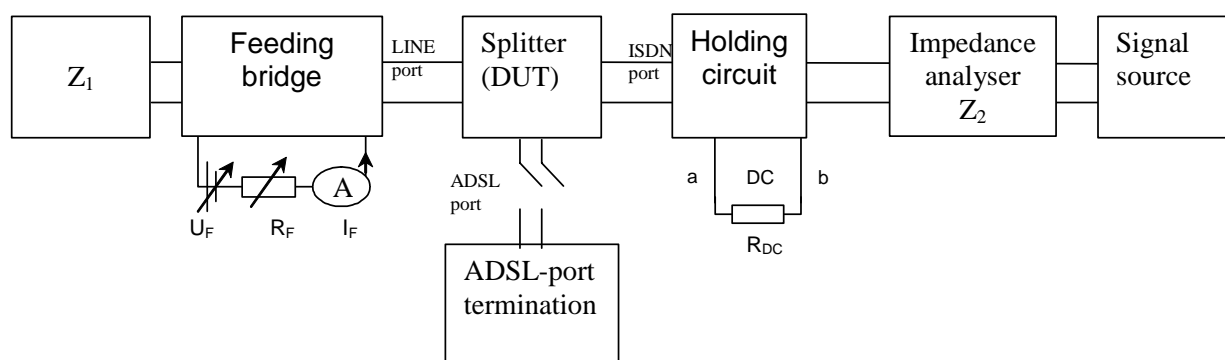
The inaccuracy of the measurement which results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

## 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**

<b>Test case name:</b>	return loss in the pass band (ISDN-BA)
<b>Reference:</b>	TS 101 952-1-3 [5], clause 6.4
<b>Test purpose:</b>	to evaluate the return loss in the pass band (ISDN-BA) when tested with the test parameters as given in the related standards
<b>Test configuration:</b>	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: $Z_1 = 135 \Omega$ for ADSL/ISDN Splitter 2B1Q combination 2: $Z_1 = 150 \Omega$ for ADSL/ISDN Splitter 4B3T
Termination at ADSL	ADSL load = $Z_{ADSL-I}$ ADSL load = open circuit
Load resistance $R_{DC}$	470 $\Omega$
Level of feeding voltage $U_F$	50 V <sub>DC</sub>
DC feeding current $I_F$	0 mA 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 101 952-1-3 [5]	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: $Z_1 = 135\Omega$ / ISDN 2B1Q	X (see note)	X (see note)
Combination 2: $Z_1 = 150\Omega$ / ISDN 4B3T	X (see note)	X (see note)
DC feeding voltage/current		
+50 V <sub>DC</sub> /0 mA	X	X
-50 V <sub>DC</sub> /60 mA	X	X
ADSL load = $Z_{ADSL-I}$	X	X
ADSL load = open circuit	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 expected not 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.

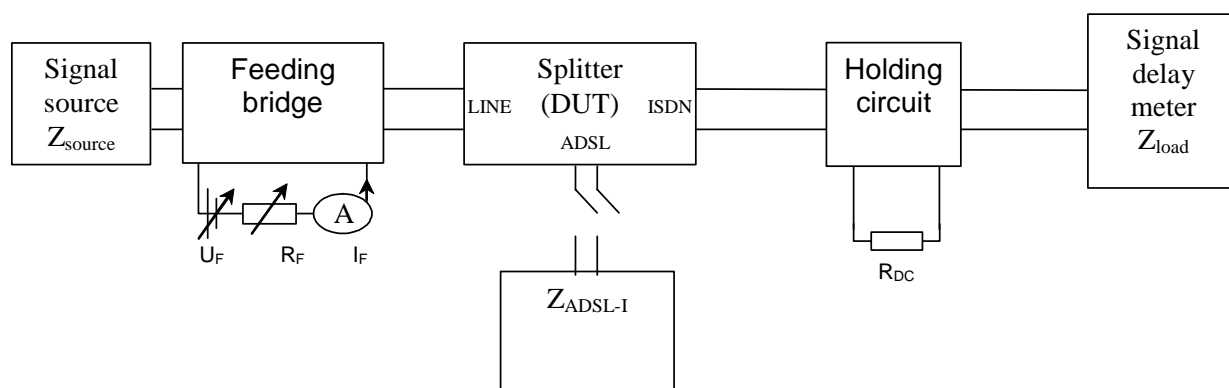
**Measuring notes:**

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**

<b>Test case name:</b>	delay distortion in the pass band (ISDN-BA)
<b>Reference:</b>	TS 101 952-1-3 [5], clause 6.8
<b>Test purpose:</b>	to evaluate the delay distortion in the pass band (ISDN-BA) when tested with the test parameters as given in the related standards
<b>Test configuration:</b>	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	-10dBV
Frequency range	1 kHz to 80 kHz
Level of feeding voltage	50V <sub>DC</sub>
Feeding current	0 mA to 60 mA
Polarity of feeding voltage	normal and reversed, alternating between the single measurements
Load resistance R <sub>DC</sub>	470 Ω
Source impedance	135 Ω resistive (2B1Q) 150 Ω resistive (4B3T)
Load impedance	135 Ω resistive (2B1Q) 150 Ω resistive (4B3T)
ADSL termination	Z <sub>ADSL-I</sub> Open circuit

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

	TS 101 952-1-3 [5]	Essential tests
Source and Load 135 Ω	X (see note)	X (see note)
Source and Load 150 Ω	X (see note)	X (see note)
DC feeding voltage/current		
+50V <sub>DC</sub> /0 mA	X	X
-50V <sub>DC</sub> /60 mA	X	X
ADSL: Z <sub>ADSL-I</sub>	X	X
ADSL: Open circuit	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 expected not 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:

$SDD_f$  is the Signal Delay Distortion at frequency  $f$

$SD_{nf}$  is the normalized Signal Delay at frequency  $f$

$SD_{\min}$  is the minimum normalized Signal Delay for all frequencies for that load

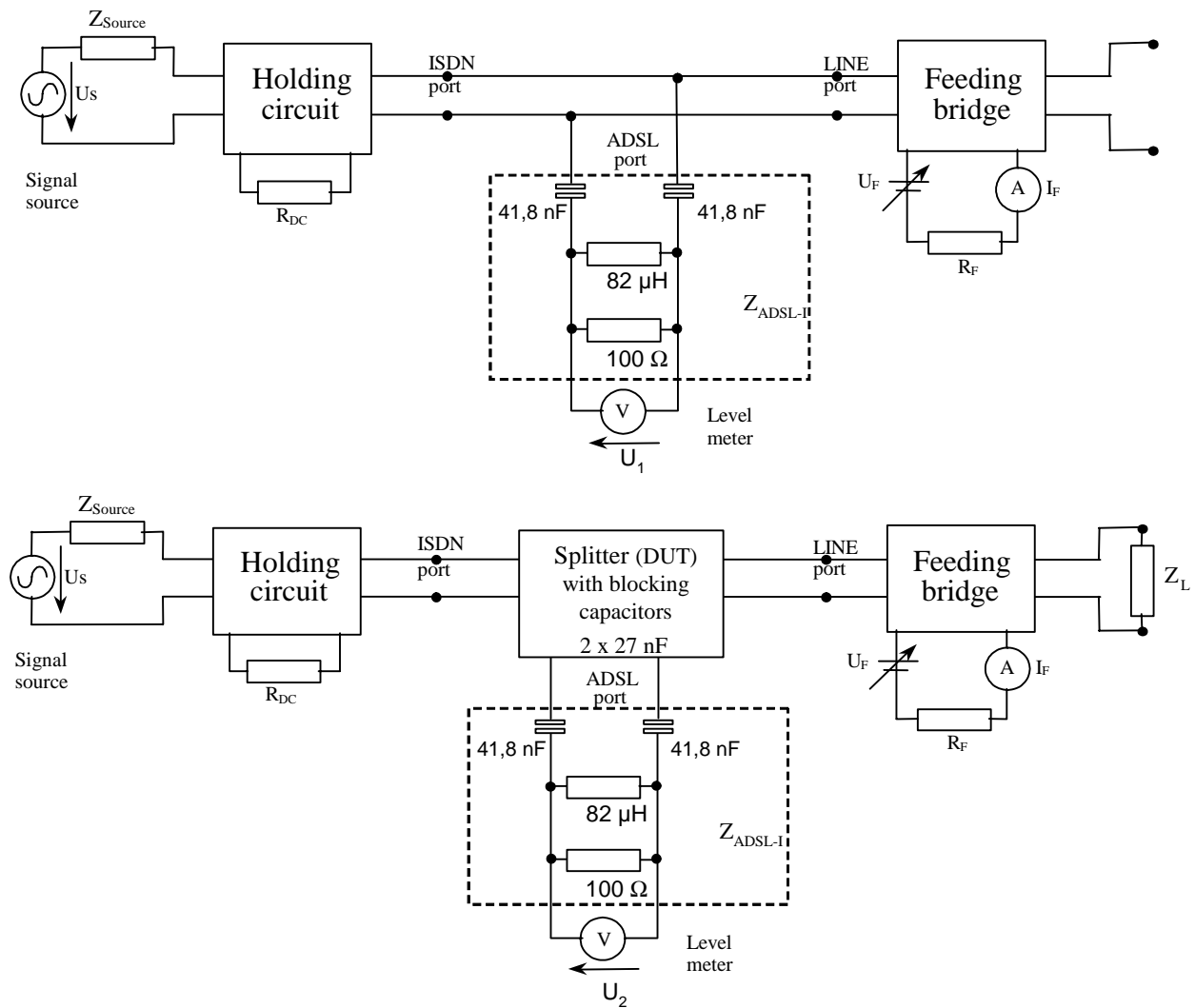
**Measuring notes:**

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.

## 6.4 Isolation (insertion loss) at 150 kHz to 1 104 kHz

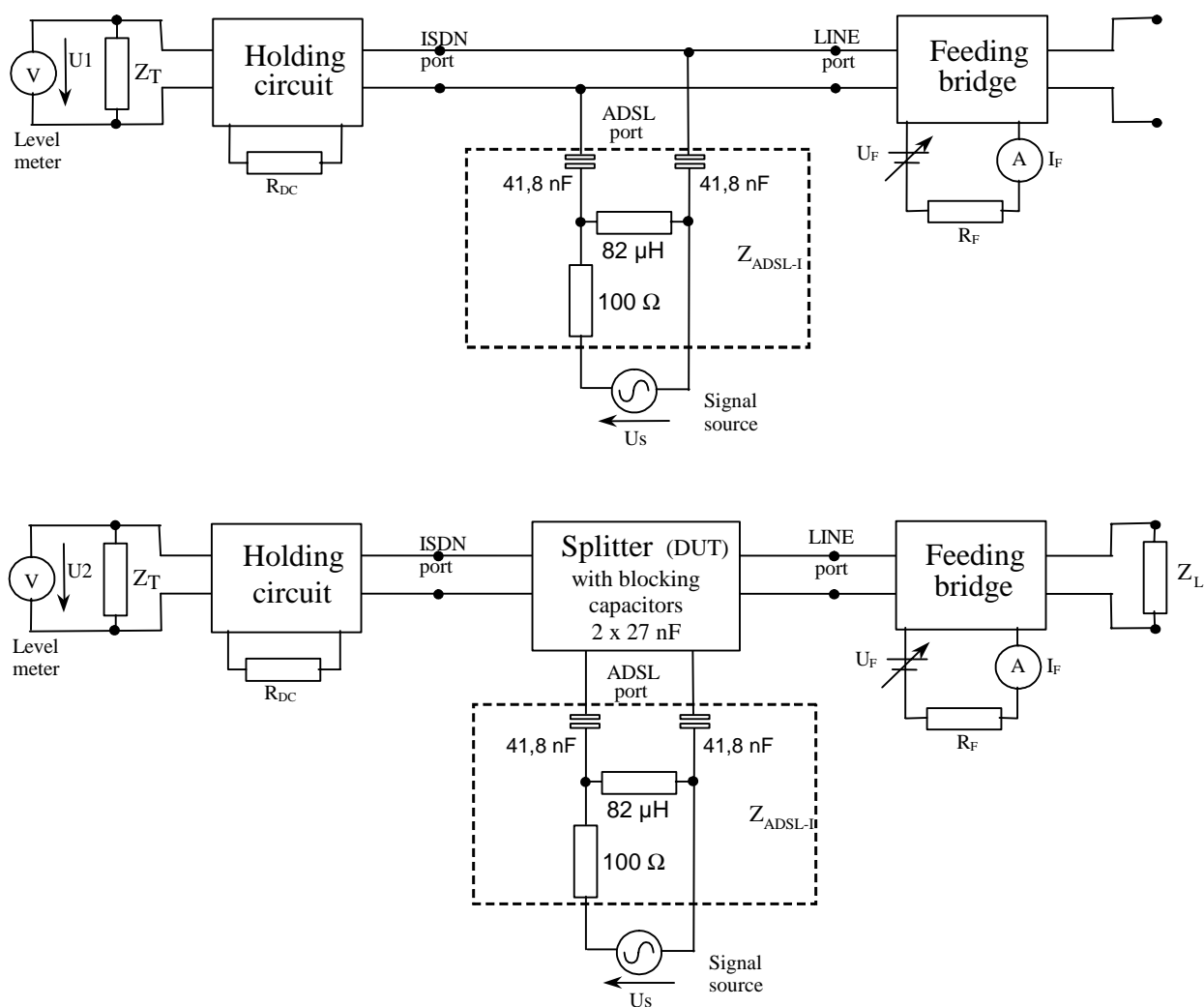
**Table 10: Description of the isolation (insertion loss) at 150 kHz to 1 104 kHz test case**

<b>Test case name:</b>	isolation (insertion loss) at 150 kHz to 1 104 kHz
<b>Reference:</b>	TS 101 952-1-3 [5], clause 6.6
<b>Test purpose:</b>	to measure the isolation of the ISDN port from the ADSL signals and vice versa in the frequency range from 150 kHz to 1 104 kHz which may impact the ISDN or ADSL transmission
<b>Test configuration:</b>	see test setup; DUT not configured

**Test setup:**

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





**Figure 9: Test setup for isolation testing on a splitter from ADSL port to ISDN 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 ADSL specific frequency band.

**Test parameters:****Table 11: Test parameters for the isolation (insertion loss) at 150 kHz to 1 104 kHz test case**

Parameter	Value
Level of the test signal $U_s$	-6 dBV emf
Frequency range of $U_s$	150 kHz to 1 104 kHz
Combinations of directions	combination 1: ISDN to ADSL combination 2: ADSL to ISDN
Source impedance $Z_{Source}$	combination 1: $Z_T = 135 \Omega$ for ADSL/ISDN Splitter 2B1Q $Z_T = 150 \Omega$ for ADSL/ISDN Splitter 4B3T combination 2: $100 \Omega$ as a part of $Z_{ADSL-I}$
Load impedance $Z_{Load}$	combination 1: $Z_{ADSL-I}$ combination 2: $Z_T = 135 \Omega$ for ADSL/ISDN Splitter 2B1Q $Z_T = 150 \Omega$ for ADSL/ISDN Splitter 4B3T
LINE termination $Z_{T-LINE}$	$Z_L = 100 \Omega$
Level of feeding voltage	$50 V_{DC}$
Load resistance $R_{DC}$	$470 \Omega$
DC feeding current $I_F$	0 mA 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 1 104 kHz test case**

	TS 101 952-1-3 [5]	Essential tests
Level of test signal -6 dBV	X	X
Frequency range 150 to 1 104 kHz	X	X
Combination 1: ISDN to ADSL	X (see note)	X (see note)
Combination 2: ADSL to ISDN	X (see note)	X (see note)
Source and load $135 \Omega$	X	X
Source and load $150 \Omega$	X	X
DC feeding voltage/current		
+50 $V_{DC}$ /0 mA	X	X
-50 $V_{DC}$ /60 mA	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  $0.01 \Omega$ .

**Measuring notes:**

NOTE 1: 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.

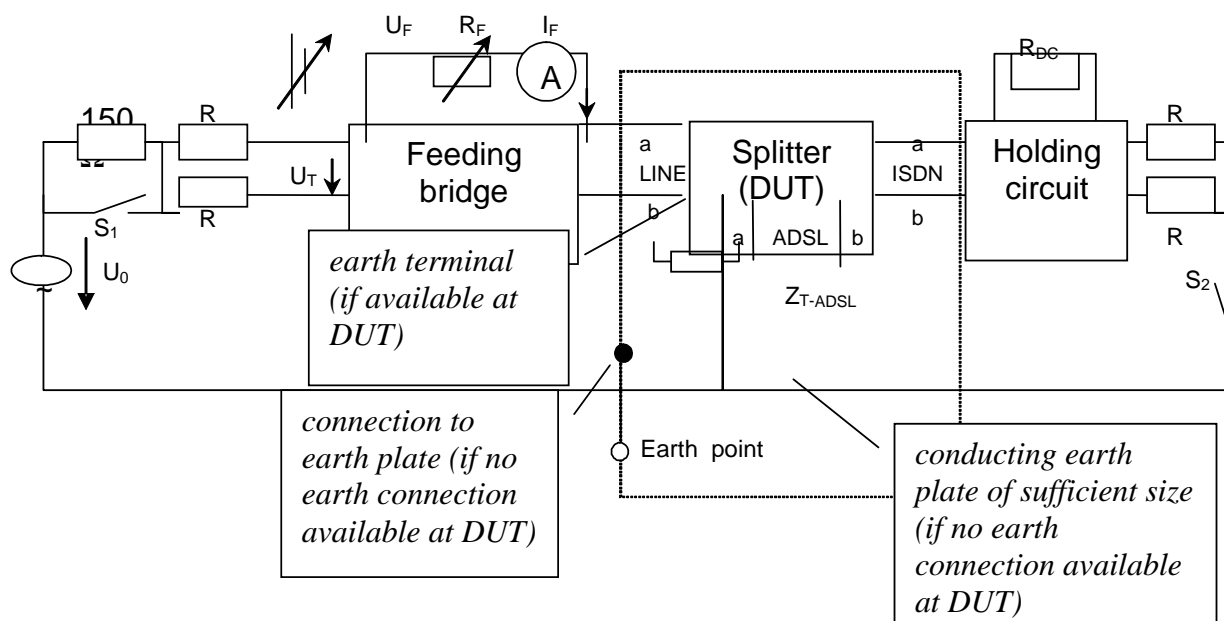
NOTE 2: The difference in the measurement result dependent on the measurement direction

(ISDN -> ADSL or ADSL -> ISDN) is theoretically 3.5 dB for ISDN (4B3T, 150  $\Omega$ ) and 2.6 dB for ISDN (2B1Q, 135  $\Omega$ ) due to the different impedances of the signal source (100  $\Omega$ , 135  $\Omega$  or 150  $\Omega$ ).

## 6.5 Unbalance about Earth

**Table 13: Description of the unbalance about Earth test case**

<b>Test case name:</b>	unbalance about Earth
<b>Reference:</b>	TS 101 952-1-3 [5]; clause 6.5
<b>Test purpose:</b>	to evaluate the symmetry (unbalance) of the splitter about earth when tested with the test parameters as given in the related standards
<b>Test configuration:</b>	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**

Parameter	Value
Level of the test signal $U_0$	-10 dBm
Frequency of the test signal $U_0$	frequency range 1: 300 Hz to 30 kHz frequency range 2: 30 kHz to 5 MHz
Combination of source and load Impedances	combination 1: $R = Z_L/2 = 135 \Omega/2 = 67,5 \Omega$ ; $R_{DC} = 470 \Omega$ combination 2: $R = Z_L/2 = 150 \Omega/2 = 75 \Omega$ ; $R_{DC} = 470 \Omega$ combination 3: $R = 50 \Omega$ ; $R_{DC} = 470 \Omega$
Status of S1	open closed
Status of S2	open closed
Termination at ADSL: $Z_{T-ADSL}$	$Z_{T-ADSL} = 100 \Omega$
Level of feeding voltage	$U_F = 50 V_{DC}$
Value of feeding current	$I_F = 0 \text{ mA}$ $I_F = 60 \text{ mA}$
Polarity of feeding voltage	normal and reversed, alternating between the current values
Optional tests	none

**Test matrix:****Table 15: Test matrix for the unbalance about Earth test case**

	TS 101 952-1-3 [5]	Essential tests
Level of the test signal -10 dBm	X	X
Frequency Range 1 (300 Hz to 30 kHz)	X	X
Frequency Range 2 (30 kHz to 5 MHz)	X	X
Impedance combination 1 (see note)	X	X
Impedance combination 2 (see note)	X	X
Impedance combination 3	X	X
Status of S1 = open	X	X
Status of S1 = closed	X	X
Measured at ISDN port; S2 = open	X	X
Measured at ISDN port; S2 = closed	X	X
Measured at LINE port; S2 = open	X	X
Measured at LINE port; S2 = closed	X	X
DC feeding voltage/current		
+50 $V_{DC}$ /0 mA	X	X
-50 $V_{DC}$ /60 mA	X	X
$Z_{T-ADSL} = 100 \Omega$	X	X
Number of tests	18 tests	18 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: It was noted that in commonly used specifications (e.g. TBR 038 [4]) the performance of the feeding bridge and holding circuit is only considered for voice-band operation. In test cases where measurements are required at much higher frequencies, the performance of the feeding bridge and holding circuit must be more critically considered. Exact specifications are for further study.

It is felt to be reasonable to require the insertion loss of the feeding bridge and the holding circuit to be less than 1 dB in the addressed frequency range. The balance about earth of the test setup shall be at least 15 dB greater than the tested requirement.

NOTE 2: It was observed that changes in feeding current or polarity had no significant effect on the balance measurements. In view of this only minimum and maximum currents need to be employed on the device under test.

NOTE 3: 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.

NOTE 4: 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.

### Test results:

Test result should be recorded in dB, where:  $\text{unbalance} = 20 \log_{10} (U_0/U_T)$ , 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 (DUT replaced by straight connection between feeding bridge and holding circuit). The unbalance achieved at this measurement shall be at least 15 dB greater than the tested requirement.

Furthermore it is advisable to check the AC noise which is produced by the feeding bridge.

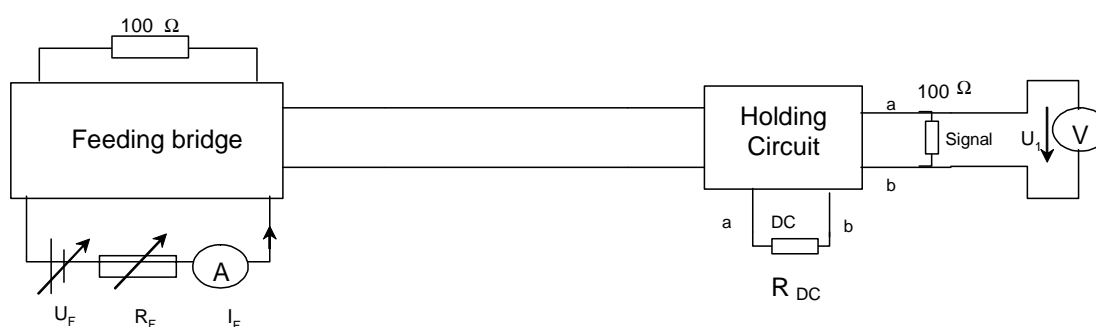
The inaccuracy of the measurement which results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

## 6.6 Noise

**Table 16: Description of the noise test case**

<b>Test case name:</b>	noise
<b>Reference:</b>	TS 101 952-1-3 [5], clause 6.7
<b>Test purpose:</b>	to evaluate the noise generated by the splitter at the ADSL and LINE ports when tested with the test parameters as given in the related standard
<b>Test configuration:</b>	see test setup; DUT not configured

### Test setup:



**Figure 11: Verification of the test setup**

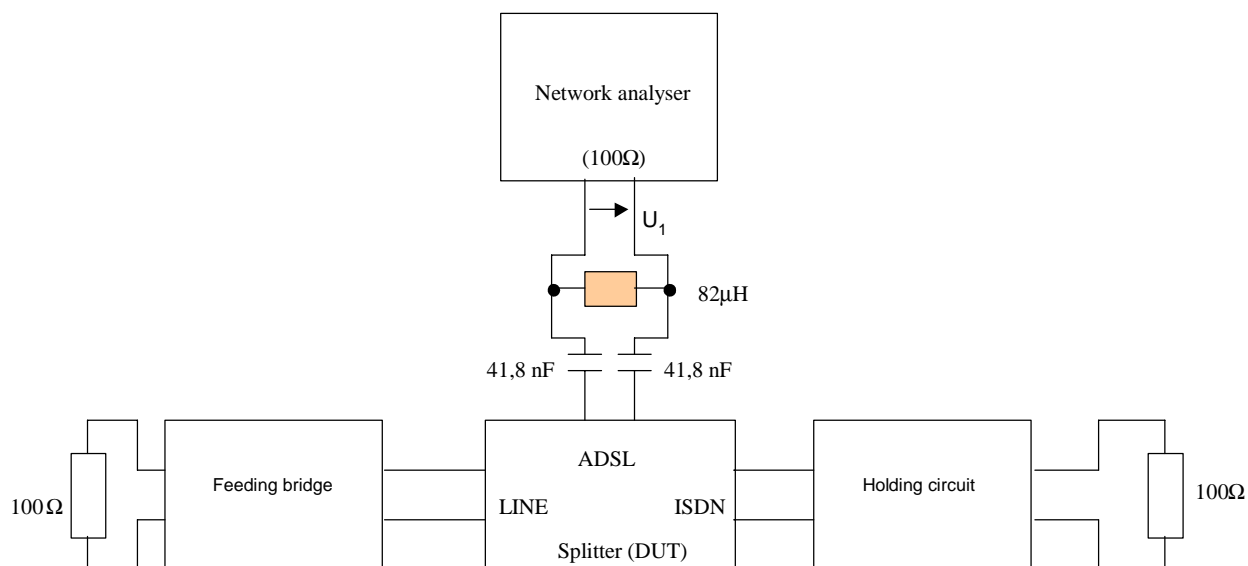


Figure 12: Test setup for noise testing at the ADSL port

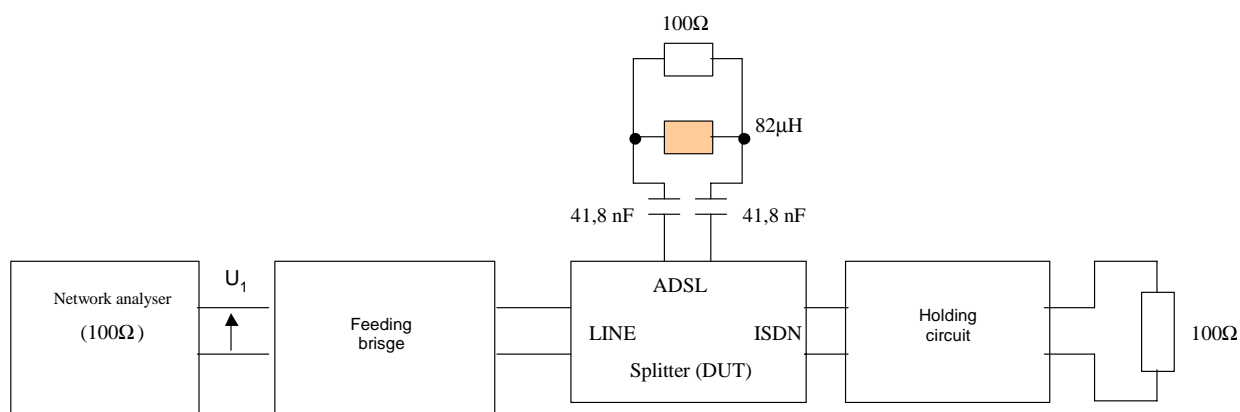


Figure 13: Test setup for noise testing at the LINE port

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 138kHz to 1 104kHz.

#### Test Parameters:

Table 17: Test parameters for the noise test case

Parameter	Value
Frequency range	138 kHz to 1 104 kHz
Termination at ADSL: $Z_{T-ADSL}$	$Z_{T-ADSL} = Z_{ADSL-I}$
Level of feeding voltage	50 V <sub>DC</sub>
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 ADSL
Optional tests	none

**Test matrix:****Table 18: Test matrix for the noise test case**

	<b>TS 101 952-1-3 [5]</b>	<b>Essential tests</b>
Frequency range 138 kHz to 1 104 kHz	X	X
DC feeding voltage/current		
+50 V <sub>DC</sub> /0 mA	X	X
-50 V <sub>DC</sub> /20 mA	X	X
+50 V <sub>DC</sub> /40 mA	X	X
-50 V <sub>DC</sub> /60 mA	X	X
Z <sub>T-ADSL</sub> = Z <sub>ADSL-I</sub>	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 U<sub>1</sub> as shown in the test setup is an appropriate way to do so. The observed value for U<sub>1</sub> (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<sub>F</sub> are set by adjusting the values of the external circuitry (namely U<sub>F</sub>, R<sub>F</sub> and R<sub>DC</sub>).

**Test results:**

Test result shall be recorded as follows:

U<sub>1</sub> in dBm/Hz, where U<sub>1</sub> is the voltage observed, when the splitter is connected as in test setup.

**Measuring notes:**

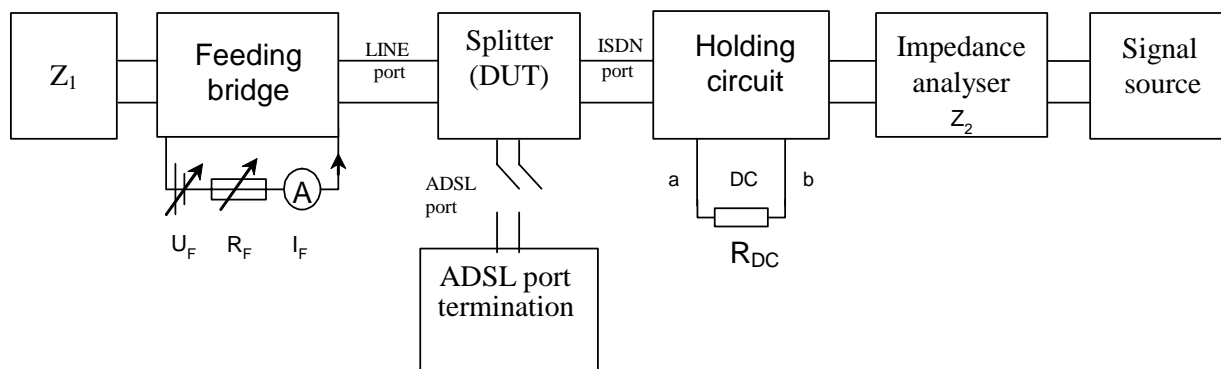
The inaccuracy of the measurement which results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

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.

## 6.7 Impedance at the ISDN port between 2 MHz and 10 MHz (HPNA protection)

**Table 19: Description of the impedance at the ISDN port between 2 MHz and 10 MHz (HPNA protection) test case**

<b>Test case name:</b>	Impedance at the ISDN port from 2 MHz to 10 MHz (HPNA protection)
<b>Reference:</b>	ITU-T recommendation G992.3 - ADSL2, clause E.1.1
<b>Test purpose:</b>	to evaluate the impedance of the splitter at the ISDN port from 2 MHz to 10 MHz when tested with the test parameters as given in the related standards
<b>Test configuration:</b>	see test setup
<b>NOTE:</b>	This clause give a requirements for ADSL over POTS splitters, however, the requirement is valid for ADSL over ISDN splitters also).

**Test setup:**

**Figure 14: Test setup for impedance testing at the ISDN 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 high frequency band from 2 MHz to 10 MHz.

**Test parameters:**

**Table 20: Test parameters for the impedance at the ISDN port between 2 MHz and 10 MHz (HPNA protection) test case**

Parameter	Value
Level of test signal	-10dBV
Frequency range of test signal	2 MHz to 10 MHz
DC current	$I_{DC} = 0 \text{ mA}$ $I_{DC} = 60 \text{ mA}$ $R_{DC} = 470 \Omega$
Load Impedances	$Z_1 = 100 \Omega$
Termination at ADSL	ADSL load = $Z_{ADSL-I}$ ADSL load = open circuit
Level of feeding voltage	$50 V_{DC}$
DC feeding current $I_F$	0 mA 60 mA
Polarity of feeding voltage	normal and reversed, alternating between the single measurements
NOTE:	These values of DC current are set by adjusting the values of the external circuitry (namely $U_F$ and $R_F$ ) shown in figure 14.



**Test matrix:****Table 21: Test matrix parameters for the impedance at the ISDN port between 2 MHz and 10 MHz (HPNA protection) test case**

	ITU-T Recommendation G.992.3 [3]	Optional tests
Level of test signal -10dBV	X	X
Frequency range 2 MHz to 10 MHz	X	X
$Z_1 = 100 \Omega$	X	X
DC feeding voltage/current		
+50 V <sub>DC</sub> /0 mA	X	X
-50 V <sub>DC</sub> /60 mA	X	X
ADSL load = $Z_{ADSL-I}$	X	X
ADSL load = open circuit	X	X
Number of tests	4 tests	4 tests

**Test procedure notes:**

NOTE 1: Direction of the feeding current should not greatly impact the Impedance at the ISDN port of passive splitters.

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

**Test results:**

Test result should be recorded as follows:

Impedance  $Z_2$  observed, when the splitter is connected as in test setup.

**Measuring notes:**

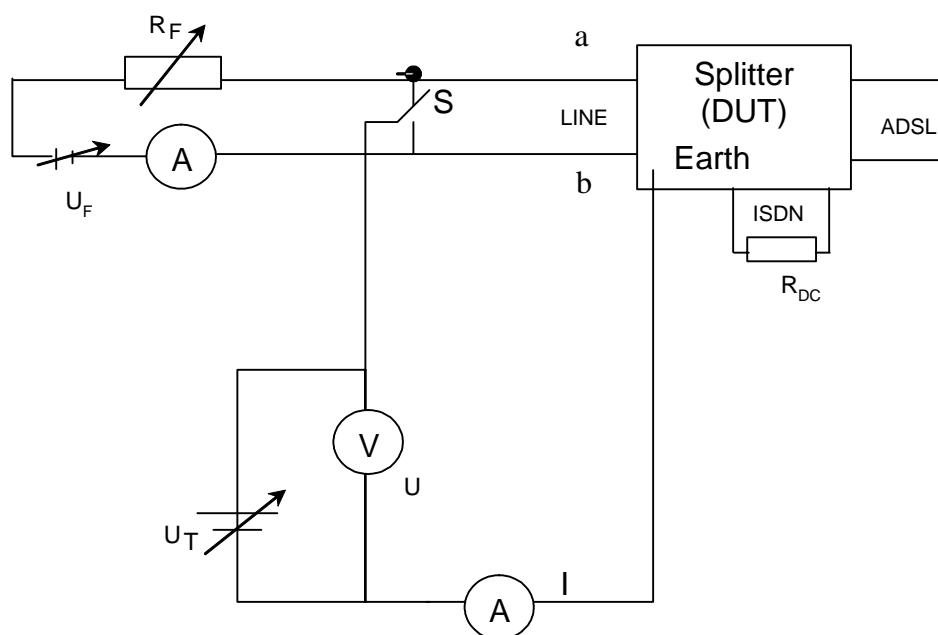
The inaccuracy of the measurement which results from tolerances in the test setup and its containing equipment shall be carefully considered. When giving a verdict on the test results with respect to the requirement in the related standard this tolerance in the test results need to be taken into account.

## 6.8 DC requirements

### 6.8.1 DC resistance to Earth

**Table 22: Description of the DC resistance to Earth test case**

<b>Test case name:</b>	DC resistance to earth
<b>Reference:</b>	TS 101 952-1-3 [5] clause 6.1.1
<b>Test purpose:</b>	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)
<b>Test configuration:</b>	see test setup; DUT not configured
<b>NOTE:</b>	A splitter is considered to provide a 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 15: Test setup for DC resistance to earth (LINE port)****Test parameters:****Table 23: Test parameters for the DC Resistance to Earth test case**

Parameter	Value
Level of the DC test voltage $U_t$	+120 V <sub>DC</sub> -120 V <sub>DC</sub>
Level of feeding voltage	50 VDC
Level of feeding current	0 mA 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	R <sub>DC</sub> = 470 Ω
Termination at ADSL port	open circuit
Ports to be tested	LINE ISDN ADSL

**Test Matrix:****Table 24: Test matrix for the DC resistance to Earth test case**

	TS 101 952-1-3 [5]	Essential tests
DC source voltage +120 V <sub>DC</sub>	X	X
DC source voltage -120 V <sub>DC</sub>	X	X
U <sub>T</sub> applied to LINE	X	X
U <sub>T</sub> applied to ISDN (only with DC path break)	X	X
U <sub>T</sub> applied to ADSL	X	X
Switch in position a	X	X
Switch in position b	X	X
DC feeding voltage/current		
+50 V <sub>DC</sub> /0 mA	X	X
-50 V <sub>DC</sub> /60mA	X	X
Termination at ISDN R <sub>DC</sub> = 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<sub>DC</sub> 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 ADSL port and the LINE port.

NOTE 3: At the ADSL 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 flooding into the branch under test

R<sub>DC-wire-earth</sub>, where R<sub>DC-wire-earth</sub> = U<sub>T</sub>/I

**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.

**6.8.2 Isolation resistance between A-wire and B-wire****Table 25: Description of the isolation resistance between A-wire and B-wire test case**

<b>Test case name:</b>	isolation resistance between A-wire and B-wire
<b>Reference:</b>	TS 101 952-1-3 [5]clause 6.1.2
<b>Test purpose:</b>	to measure the isolation resistance between the A-wire and B-wire.
<b>Test configuration:</b>	see test setup; DUT not configured

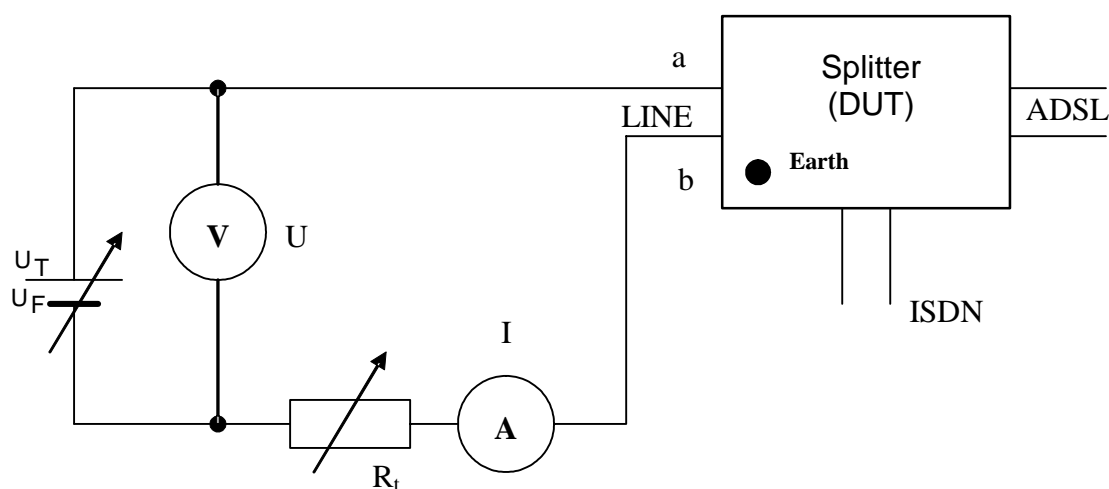
**Test setup:**

Figure 16: Test setup for isolation resistance between A-wire and B-wire (LINE port)

**Test parameters:**

Table 26: 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 <sub>DC</sub> -120 V <sub>DC</sub>
Termination at ports under test	open circuit
Termination at ports not under test	open circuit
Ports to be tested	LINE ISDN ADSL

**Test matrix:**

Table 27: Test matrix for the isolation resistance between A-wire and B-wire test case

	TS 101 952-1-3 [5]	Essential tests
DC source voltage +120 V <sub>DC</sub>	X	X
DC source voltage -120 V <sub>DC</sub>	X	X
V <sub>DC</sub> applied to LINE	X	X
V <sub>DC</sub> applied to ISDN	X	X
V <sub>DC</sub> applied to ADSL	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 ADSL port and therefore it may be appropriate to delete the requirement for DC resistance between open wires at the ADSL port.

**Test results:**

Test result should be recorded as follows:

$I$  in  $\mu\text{A}$ , where:  $I$  is the value of the observed current, which is flooding into the branch under test

$R_{\text{DC-A-wire-B-wire}}$ , where  $R_{\text{DC-A-wire-B-wire}} = U_T/I$

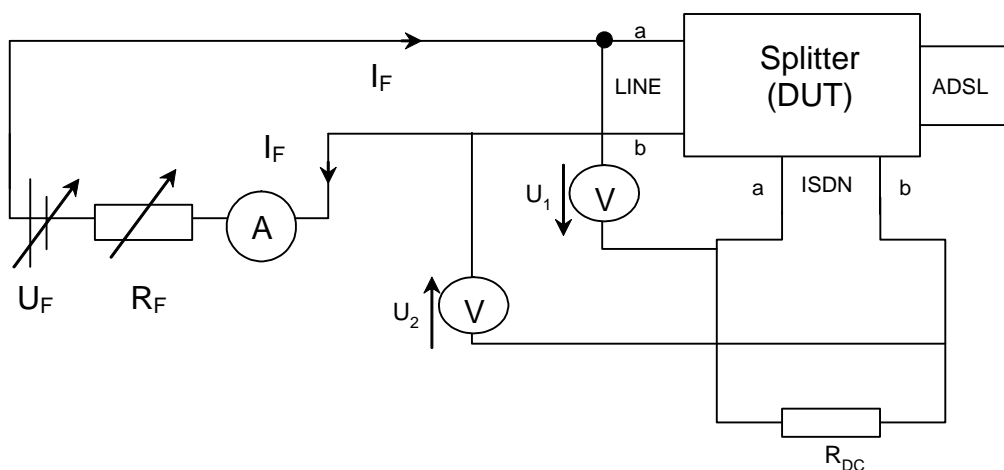
**Measuring notes:**

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.

### 6.8.3 DC series resistance

**Table 28: Description of the DC series resistance test case**

<b>Test case name:</b>	DC series resistance
<b>Reference:</b>	TS 101 952-1-3 [5], clause 6.1.3
<b>Test purpose:</b>	to measure the DC series resistance of the splitter
<b>Test configuration:</b>	see test setup; DUT not configured

**Test setup:**

**Figure 17: Test setup for series resistance between A-wire and B-wire (LINE to ISDN)**

**Test parameters:**

**Table 29: Test parameters for the DC series resistance test case**

Parameter	Value
Level of feeding voltage $U_F$	50 V <sub>DC</sub>
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 ADSL port	Open circuit
Termination at port not under test ( $R_{\text{DC}} = 0 \Omega$ )	Short circuit
Ports to be tested	LINE ISDN

**Test matrix:****Table 30: Test matrix for the DC series resistance test case**

	TS 101 952-1-3 [5]	Essential tests
DC feeding voltage / current		
+50 V <sub>DC</sub> /40mA	X	X
-50 V <sub>DC</sub> /60mA	X	X
Termination at ADSL open circuit	X	X
LINE to ISDN (ISDN port short circuit)	X	X
ISDN to LINE (LINE port short circuit)	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

$R_{DC-series}$ , where  $R_{DC-series} = (U_1 + U_2)/I_F$

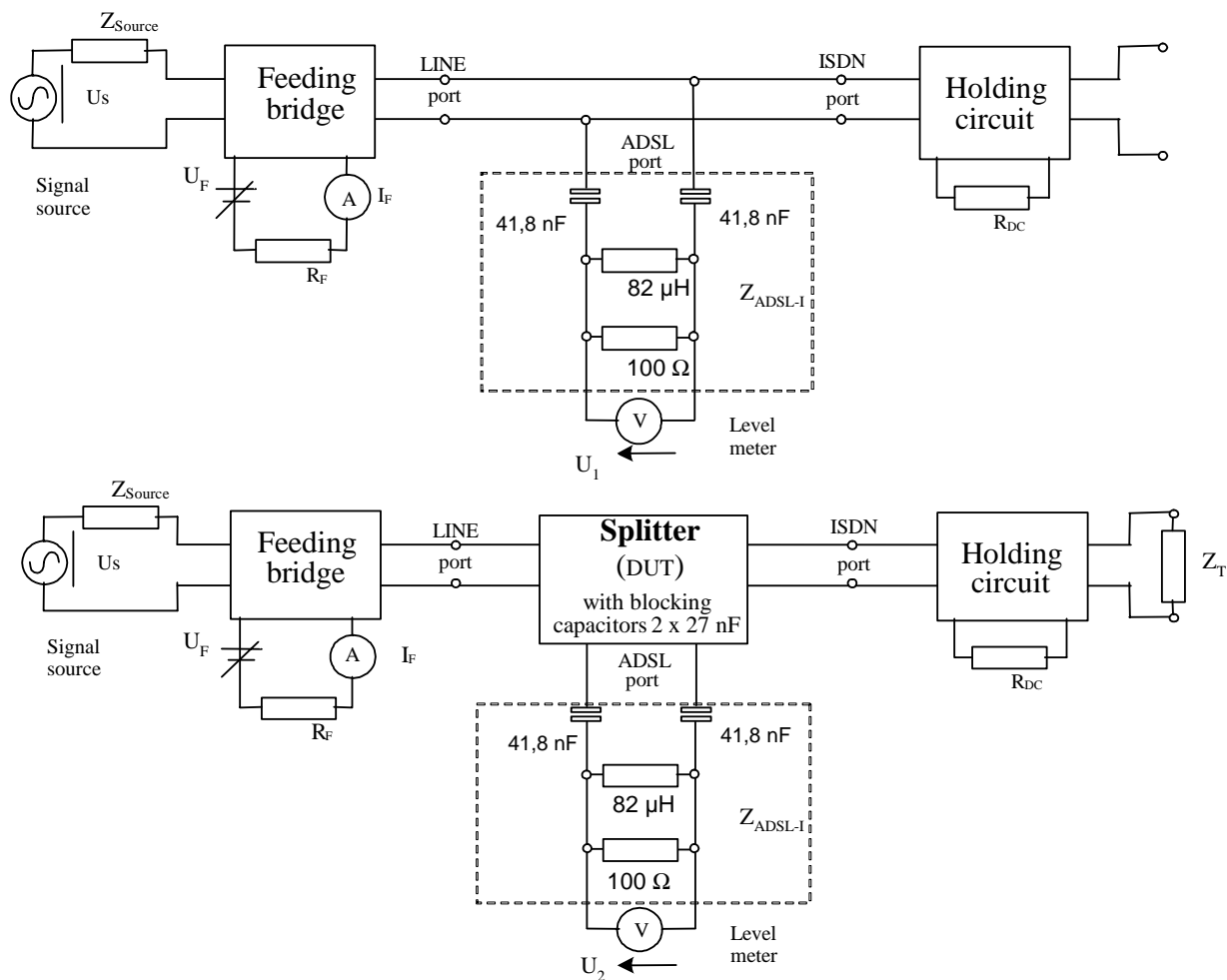
**Measuring notes:**

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.

## 6.9 Insertion loss requirements for the high pass part

**Table 31: Description of the insertion loss requirements for the high pass part test case**

<b>Test case name:</b>	insertion loss requirements
<b>Reference:</b>	TS 101 952-1-3 [5], clause 6.9.1
<b>Test purpose:</b>	to measure the insertion loss between the LINE port and the ADSL port of the high pass part of the ADSL over ISDN-BA splitters in the frequency range from 120 kHz to 1104 kHz
<b>Test configuration:</b>	see test setup; DUT not configured

**Test setup:**

**Figure 18: Test setup for insertion loss testing on a splitter from LINE to ADSL 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 ADSL specific frequency band.

**Test parameters:****Table 32: 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 1 104 kHz
Source impedance $Z_{Source}$	100 $\Omega$ (LINE port)
Load impedance $Z_{Load}$	$Z_{ADSL-I}$ (ADSL port)
ISDN termination $Z_{ISDN}$	$Z_T = 135 \Omega$ for ADSL/ISDN Splitter 2B1Q $Z_T = 150 \Omega$ for ADSL/ISDN Splitter 4B3T open for ADSL/ISDN Splitter both 2B1Q and 4B3T
Level of feeding voltage	50 $V_{DC}$
Load resistance $R_{DC}$	470 $\Omega$
DC feeding current $I_F$	0 mA 60 mA
Polarity of feeding voltage	normal and reversed, alternating between the single measurements
Optional tests	none

**Test matrix:****Table 33: Test matrix for the insertion loss requirements for the high pass part test case**

	TS 101 952-1-3 [5]	Essential tests
Level of test signal -6 dBV	X	X
Frequency range 120 to 1 104 kHz	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  $\Omega$ .



**Measuring notes:**

NOTE: 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.

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## Annex A (informative): Bibliography

- ETSI ETR 328: "Transmission and Multiplexing (TM); Asymmetric Digital Subscriber LINE (ADSL); Requirements and performance".
- ETSI TR 102 139: "Compatibility of POTS terminal equipment with xDSL systems".
- ETSI TR 101 728: "Access and Terminals (AT); Study for the specification of low pass filter section of POTS/ADSL splitters".
- ETSI TS 102 080: "Transmission and Multiplexing (TM); Integrated Services Digital Network (ISDN) basic rate access; Digital transmission system on metallic local lines".

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## History

<b>Document history</b>		
V1.1.1	June 2003	Publication