

## **DSL Consortium**

### **ADSL Rate vs. Reach Interoperability Test Suite (ARR)**

*Version 3.4.0*



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## Modification Report

Version	Date	Editor(s)	Comments
3.4.0	March 21, 2007	Tomas Elder	Altered to accommodate the ability of testing bonded ADSL systems
3.3.4	July 28, 2006	Blessto Baugh	Editorial changes <ul style="list-style-type: none"> <li>• Changed title to ‘ADSL Rate vs. Reach Interoperability Test Suite’.</li> </ul>
3.3.3	March 30, 2006	Tyler Clark	Editorial changes
3.3.2	October 4, 2005	Tyler Clark	Changed consortium name to DSL
3.3.1	December 6, 2004	John Anctil	Removed ‘fast’ path and added a more general low latency path, removed interleaved and added a more general high latency path.
3.3	October 12, 2004	John Anctil Matthew Langlois	<ul style="list-style-type: none"> <li>• Added provisions for ADSL2, ADSL2+, and ADSL2 Annex L.</li> <li>• Added copyright information.</li> <li>• Changed title from ADSL Reach Rate Test Suite to Reach vs. Rate Interoperability Test Suite.</li> <li>• White noise case added as part of the standard procedure; no noise case optional.</li> <li>• Removed 17.5 kft as part of the default test case.</li> </ul>
3.2	June 9, 2004	Jason Walls John Anctil Matthew Langlois	New items added: Annex D – Test procedure diagram. General updates. Euro-K and optional white noise section. Corrected typographical errors.
3.1	October 27, 2003	John Anctil	Added stability failure to the procedure.
3.0	September 29, 2003	Matthew Langlois Padmabala Venugopal	Added test cases for Annex B and restructured test suite.
2.2	June 25, 2003	Padmabala Venugopal	Added new logo.
2.1	April 9, 2003	Fred Mansfield Jr	Added new result grids (Annex A).
2.0	Feb. 6, 2003	Padmabala Venugopal, Deirdre Dinan	Updated format to new test suite template.
1.2	Feb. 13, 2001	Matthew Langlois	Discussion modified.
1.1	June 22, 2000	Stephen Dunhom	White noise test case extracted.
1.0	Feb. 15, 2000	Matthew Langlois Matthew Blake	Creation of document.

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## **Introduction**

### **Overview**

The University of New Hampshire's InterOperability Laboratory (UNH-IOL) is an institution designed to improve the interoperability of standards based products by providing an environment where a product can be tested against other implementations of a standard. This suite of tests has been developed to help implementers evaluate the functioning of their ADSL implementations.

The tests do not determine if a product conforms to the specifications, nor are they purely interoperability tests. Rather, they provide a method to isolate problems within a device. Successful completion of all tests contained in this suite does not guarantee that the tested device will operate with other devices. However, successful completion of these tests should provide a reasonable level of confidence that the device under test will function well in most multi-vendor environments.

### **Organization of Tests:**

Each test contains an identification section that describes the test and provides cross-reference information. The discussion section covers background information and specifies why the test is to be performed. Tests are grouped in order to reduce setup time in the lab environment. Each test contains the following information:

#### **Test number**

The Test Number associated with each test follows a simple grouping structure. Listed first is the Test Group Number followed by the test's number within the group. This allows for the addition of future tests to the appropriate groups of the test suite without requiring the renumbering of the subsequent tests.

#### **Purpose**

The purpose is a brief statement outlining what the test attempts to achieve. This also includes background information on why one needs to perform such a test to show that the device complies with the standard.

#### **References**

The references section lists standards and other documentation that might be helpful in understanding and evaluating the test and results.

#### **Resource requirements**

The requirements section specifies the hardware, and test equipment that will be needed to perform the test. The items contained in this section are special test devices or other facilities, which may not be available on all devices.

#### **Last modification**

This specifies the date of the last modification to this test.

#### **Test setup**

The setup section describes the configuration of the test environment. Small changes in the configuration should be included in the test procedure.

#### **Discussion**

The discussion section is optional. It is a general discussion of the test and relevant section of the specification, including any assumptions made in the design or implementation of the test as well as known limitations.

#### **Procedure**

The procedure section of the test description contains the step-by-step instructions for carrying out the test. It provides a cookbook approach to testing, and may be interspersed with test metrics.

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**Test metrics**

The test metrics section lists occurring events that can be examined by the tester to verify that the DUT is operating properly. When multiple values are possible for a specific event, this section provides a short discussion on how to interpret them. The determination of passing or failing a certain test is often based on the successful (or unsuccessful) detection of a certain predetermined event.

**Possible problems**

This section contains a description of known issues with the test procedure, which may affect test results in certain situations.

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## References

- [1] American National Standards Institute, Inc., Standards Committee T1 – Telecommunications. Standard/Recommendation T1.413-1998, Network and Customer Installation Interfaces – “Asymmetric Digital Subscriber Line (ADSL) Metallic Interface”, November 1998.
- [2] International Telecommunication Union Standardization Sector (ITU-T). Series G: Transmission Systems and Media, Digital Systems and Networks: Digital section and digital line system – Access networks. “Asymmetric digital subscriber line (ADSL) transceivers”, ITU-T Recommendation G.992.1, June 1999.
- [3] International Telecommunication Union Standardization Sector (ITU-T). Series G: Transmission Systems and Media, Digital Systems and Networks: Digital section and digital line system – Access networks. “Splitterless asymmetric digital subscriber line (ADSL) transceivers,” ITU-T Recommendation G.992.2, June 1999.
- [4] International Telecommunication Union Standardization Sector (ITU-T). Series G: Transmission Systems and Media, Digital Systems and Networks: Digital section and digital line system – Access networks. “Test procedures for Digital Subscriber Line (DSL) transceivers,” ITU-T Recommendation G. 996.1, February 2001.
- [5] American National Standards Institute, Inc., Standards Committee T1 – Telecommunications. Standard/Recommendation T1.417-2001, “Spectrum Management For Loop Transmission Systems”, January 2001.
- [6] Clark, Timothy R. “DSL Crosstalk Simulation and Calibration”, University of New Hampshire InterOperability Laboratory, May 11, 2004. Available on the UNH-IOL’s web site: <http://www.iol.unh.edu/Reference/Download.pm/261/Document.DOC>
- [7] DSL Forum Technical Report 067 (TR-067), “ADSL Interoperability Test Plan”, May 2004.
- [8] International Telecommunication Union Standardization Sector (ITU-T). Series G: Transmission Systems and Media, Digital Systems and Networks: Digital section and digital line system – Access networks. “Asymmetric digital subscriber line (ADSL) transceivers – 2 (ADSL2)”, ITU-T Recommendation G.992.3, July 2002.
- [9] International Telecommunication Union Standardization Sector (ITU-T). Series G: Transmission Systems and Media, Digital Systems and Networks: Digital section and digital line system – Access networks. “Asymmetric digital subscriber line (ADSL) transceivers – extended bandwidth ADSL2 (ADSL2+)”, ITU-T Recommendation G.992.5, May 2003.
- [10] International Telecommunication Union Standardization Sector (ITU-T). Series G: Transmission Systems and Media, Digital Systems and Networks: Digital section and digital line system – Access networks. “Multi-pair bonding using time-division inverse multiplexing”, ITU-T Recommendation G.998.3, January 2005.

## Terms, Definitions and Abbreviations

### Definitions

ADSL system overhead	All overhead needed for system control, including CRC, EOC, AOC synchronization bytes, fixed indicator bits for OAM, and FEC; that is, the difference between total data rate and net data rate.
Bonding	The joining of multiple ADSL data streams to create one data stream through the use of time-division inverse multiplexing.
Bridged taps	Sections of unterminated twisted-pair cables connected in parallel across the cable under consideration.
Crest factor	Peak-to-rms-voltage ratio.
Downstream	ATU-C to ATU-R direction.
Line rate	Total data rate plus trellis coding overhead.
Loading coils	Inductors placed in series with the cable at regular intervals in order to improve the voiceband response; removed for DSL use.
Net data rate	Data rate that is available for user data in any one direction.
Showtime	The state of either ATU-C or ATU-R, reached after all initialization and training is complete, in which data is transmitted.
Single latency	Simultaneous transport of one or more bearer channels through either a high or low latency path.
Splitter	Filter that separates the high frequency signals (ADSL) from the voiceband signals.
Total data rate	Aggregate data rate plus Reed-Solomon FEC overhead.
Upstream	ATU-R to ATU-C direction.
Voiceband	0 to 4 kHz; expanded from the traditional 0.3 to 3.4 kHz to deal with voiceband data services wider than POTS.
Voiceband services	POTS and all data services that use the voiceband or some part of it.

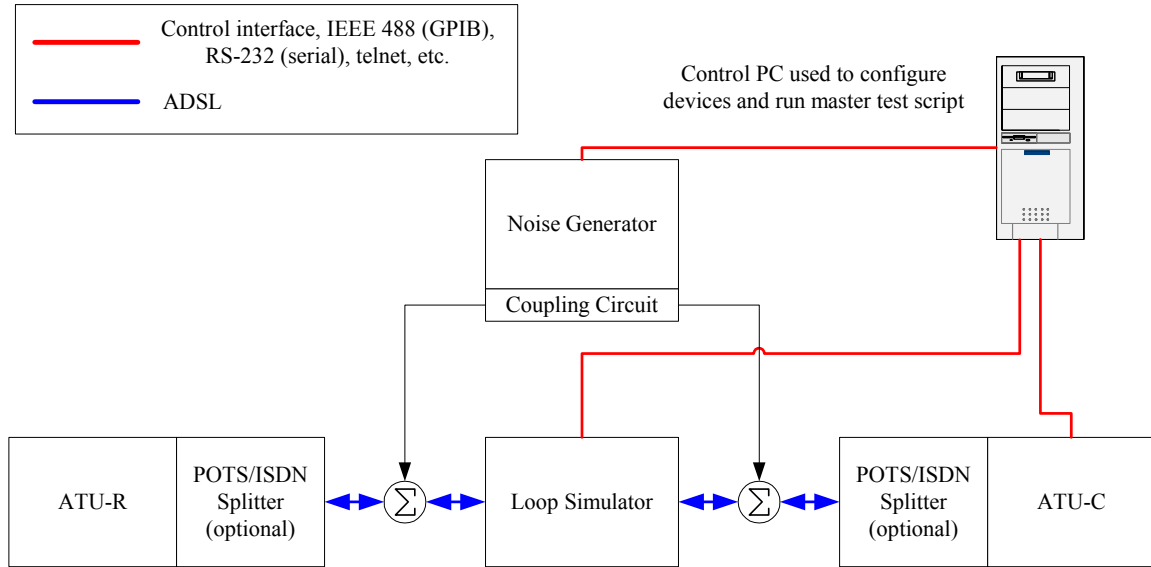
### Abbreviations

ADSL	Asymmetric Digital Subscriber Line
ATU-C	ADSL Transceiver Unit – Central Office End
ATU-R	ADSL Transceiver Unit – Remote End
AWG	American Wire Gauge
AWGN	Additive White Gaussian Noise
Balun	Balance Transformer
BTU-C	Bonded Transceiver Unit – Central Office End
BTU-R	Bonded Transceiver Unit – Remote End
CO	Central Office
CSA	Carrier Serving Area
DMT	Discrete Multi Tone
DSL	Digital Subscriber Line
DUT	Device Under Test
DSLAM	Digital Subscriber Line Access Multiplexer
FEXT	Far End Crosstalk
HDSL	High-bit-rate Digital Subscriber Line
ISDN	Integrated Services Digital Network
Mbps	Megabits per Second
NEXT	Near-End Crosstalk
POTS	Plain Old Telephone Service



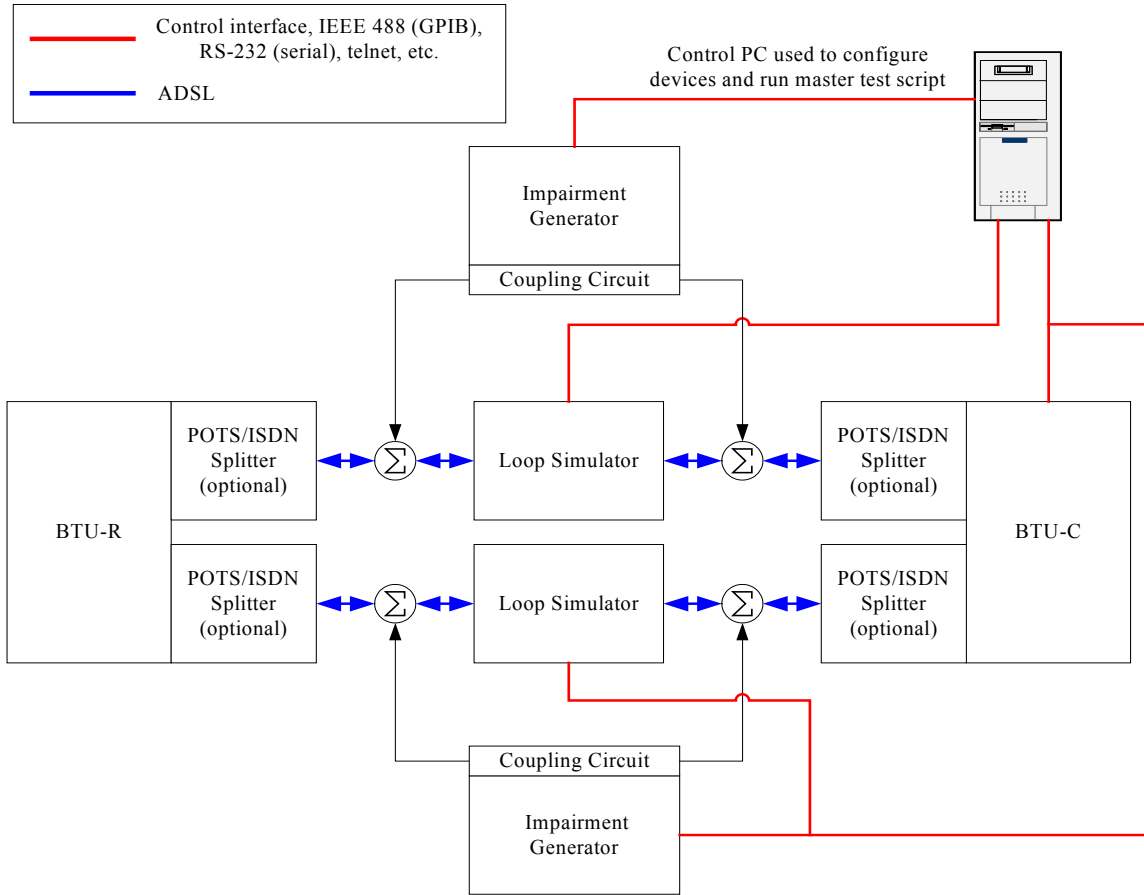
## Test Setups

### Test Setup 1: Generic Test Setup



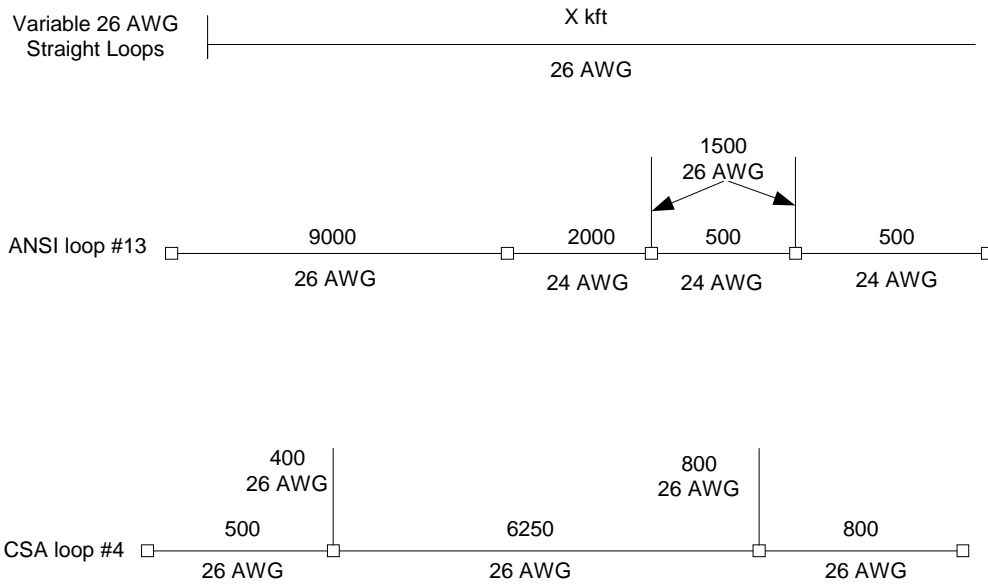
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**Test Setup 2: Bonding Test Setup**



# Test Loops

## North American Test Loops:



## ETSI Test Loops:



## Group 1: Rate vs. Reach Tests for ADSL over POTS

### Scope:

The procedures defined in Group 1 are designed to test the interoperability and stability of an ATU-R/ATU-C in an ADSL system operating in ANSI T1.413-1998 [1], ITU-T G.992.1 (G.dmt) Annex A [2], ITU-T G.992.2 (G.lite) [3], ITU-T G.992.3 (ADSL2 / ADSL2 Extended Reach) [8], or ITU-T G.992.5 (ADSL2+) [9] on various test loops with and without the presence of impairments.

### Notes:

- All tests in Group 1 are applicable to single pair ADSL systems and multi-pair bonded ADSL systems.
- In this group, the terms ATU-R and ATU-C refer to the BTU-R and BTU-C when considering a bonded ADSL system.
- In this group, the terms “crosstalk” and “impairments” are used interchangeably.
- The Group 1 tests are defined for North American test loops. The ADSL over POTS tests can also be performed on ETSI loops upon request.
- The default maximum train time of 60 seconds (120 seconds for bonded systems), the default stability period of 60 seconds, and the default line reset delay of 10 seconds (the amount of time the ATU-C port is administratively disabled) can be changed to any reasonable value upon request. These values are listed in the test report.
- The default maximum interleave delay for the high and low latency path functions (a.k.a. “fast” path in G.dmt [2] terminology) is 16 ms and 1 ms, respectively. These values can be changed to any reasonable value upon request and will be recorded in the test report.
- The tests defined in this document represent only a subset of all possible test cases. Additional test cases can be added upon request.
- Loop simulator and impairment generator compensation should be applied, as defined in Section 4 “Test Tools Requirements and Calibration” of DSL Forum TR-067 [7], whenever possible.
- Testing in ITU-T G.992.5 (ADSL2+) [9] or auto-mode requires a line simulator and noise generator with extended bandwidth capabilities (these devices must be able to simulate cable and impairments over a frequency range of 0 – 2.208 MHz).

Mode of Operation	Test Loops	Impairments
ADSL <ul style="list-style-type: none"> <li>• ANSI T1.413-1998 [1]</li> <li>• ITU-T G.992.1 (G.dmt) [2]</li> <li>• ITU-T G.992.2 (G.lite) [3]</li> <li>• Multi-mode</li> </ul>	26 AWG: 0 – 18 kft. in 1 kft increments; CSA #4; ANSI #13	<ul style="list-style-type: none"> <li>• -140 dBm/Hz white noise</li> <li>• 24 DSL</li> <li>• 24HDSL</li> <li>• 5 adjacent binder T1</li> <li>• No noise (optional)</li> </ul>
ADSL2 [8]	26 AWG: 0 – 20 kft. in 1 kft increments; CSA #4; ANSI #13	Same as ADSL
ADSL2 Ext. Reach (Annex L) [8]	26 AWG: 0 kft – 23 kft in 1kft increments; CSA #4; ANSI #13	Same as ADSL
ADSL2+ [9]	26 AWG: 0 kft – 20 kft in 1 kft increments; CSA 4, ANSI 13 <ul style="list-style-type: none"> <li>• Requires extended bandwidth line simulator</li> </ul>	Same as ADSL: <ul style="list-style-type: none"> <li>• Requires extended bandwidth noise generator</li> </ul>
Auto-mode	Same as ADSL2 Annex L: <ul style="list-style-type: none"> <li>• Requires extended bandwidth line simulator</li> </ul>	Same as ADSL2+

**Table 1 – ADSL over POTS technologies and default test conditions.**

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**Test RR.1.1: Rate Reach Test with –140 dB AWGN Impairment**

**Purpose:** The purpose of this test is to determine the maximum net data rate at which an ATU-R/ATU-C initializes on various test loops in the presence of –140 dB additive white Gaussian noise (AWGN) impairment.

**References:**

- [1] ANSI T1.413-1998
- [2] ITU-T G.992.1 (1999)
- [3] ITU-T G.992.2 (1999)
- [4] ITU-T G.996.1 (2001)
- [5] ANSI T1.417-2001
- [8] ITU-T G.992.3 (2002)
- [9] ITU-T G.992.5 (2003)
- [10] ITU-T G.998.3 (2005)

**Resource requirements:**

- ATU-R
- ATU-C
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 1 for the desired mode of operation.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Coupling circuits

**Last modification:** March 21, 2007

**Test setup:**

- Test Setup 1 for single pair ADSL systems
- Test Setup 2 for bonded ADSL systems

**Discussion:**

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate in ADSL is primarily limited by factors such as loop length (attenuation), channel characteristics (presence of bridge taps, load coils) and the presence of noise impairments (crosstalk, white noise) on the line. This test provides insight into the maximum net data rate attained by a pair of ADSL devices for different loop configurations in the presence of –140 dB AWGN impairment, and is used as a baseline for the results obtained in Tests RR.1.2 through RR.1.4.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 1 as defined in G.test [4]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ANSI T1.417 [5]. To ensure the robustness of the ADSL connection a target noise margin of 6 dB should be configured in the ATU-C and three iterations of each test case should be performed.

Simulated –140 dB AWGN impairment should be injected in both the upstream and downstream directions simultaneously using a high impedance crosstalk injection circuit. The impairments are simulated based on the theoretical power spectral density as defined in ANSI T1.413 [1] and G.test [4] [For detailed information on impairment simulation using an Arbitrary Waveform Generator (AWG), see Annex B]. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in G.test [4] [For detailed information on a coupling circuit for use with an AWG as an impairment generator, see Annex C].

A test case refers to a single loop and impairment scenario. For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed using a single latency path function only. High latency (maximum interleave delay set 16 ms by default) and low latency (maximum interleave delay to set 1 ms by default) connections should be tested separately. The

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interleave delay for both latency path functions (high and low) can be changed upon request and will be recorded in the report. Annex D provides a graphical representation of the test procedure detailed below.

This test can be performed on any ADSL system that operates in accordance to ANSI T1.413-1998 [1], ITU-T G.992.1 (G.dmt) Annex A [2], ITU-T G.992.2 (G.lite) [3], ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9]. If a G.lite implementation is being tested, testing in the low latency path is not applicable and should be omitted. If an ADSL2+ or auto-mode implementation is being tested, an extended bandwidth line simulator and noise generator are required. POTS splitters should be included in this test, however POTS service is optional.

When testing multi-pair bonded ADSL systems, multiple line simulators and noise generators shall be used to provide each ADSL interface with a separate simulated physical connection between the BTU-C and BTU-R. The constraint placed on the time required for the bonded group to reach SHOWTIME shall be extended to 120 seconds to accommodate for any necessary additional operations performed by the bonded group. All interfaces of a bonded ADSL system shall be configured to use identical physical layer profiles.

**Procedure:**

1. Configure the ATU-C port(s) to be used for testing for a single high latency path with a maximum interleave delay of 16 ms, rate adaptive mode, and with a target noise margin of 6 dB.
2. Configure the ATU-R either for a single mode of operation, i.e. ANSI T1.413-1998 [1], ITU-T G.992.1 (G.dmt) Annex A [2], ITU-T G.992.2 (G.lite) [3], ITU-T G.992.3 (ADSL2) [8], ITU-T G.992.5 (ADSL2+) [9], or for auto-mode operation.
3. Connect the ATU-R to the ATU-C as shown in Test Setup 1 or 2.
4. Inject impairments on both upstream and downstream directions.
5. Configure the line simulator for a straight 26AWG loop of 0 kft.
6. Administratively enable or activate the ATU-C port(s).
7. Allow the maximum train time for the link to initialize.
8. If the link is not established (does not reach SHOWTIME) within the maximum train time, record “NC” – no connect for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain), record the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second period) record “SF” – stability failure for the test case and proceed to the next test case.
10. Administratively disable the ATU-C port for 10 seconds.
11. Repeat steps 6 to 11 until all loops for the desired mode of operation in Table 1 have been tested.
12. Repeat steps 5 through 11 two more times, for a total of three iterations.
13. If the ATU-R and ATU-C are configured for ANSI T1.413-1998 [1] or ITU-T G.992.1 (G.dmt) Annex A [2] configure the ATU-C port for a single low latency path. If the ATU-R and ATU-C are configured for ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9] configure the ATU-C port for a single low latency path with a maximum interleave delay of 1 ms and repeat steps 5 to 12.

**Test metrics:**

1. The ATU-R and ATU-C should reach SHOWTIME within the maximum train time and remain in SHOWTIME for no less than 60 seconds.
2. Recorded noise margins should be greater than or equal to 6 dB.

**Possible Problems:** If the ATU-R and ATU-C does not reach SHOWTIME within the maximum train time seconds a no connect, or “NC,” shall be recorded for the test case in the test report. If the ATU-R and ATU-C do not remain stable (they do not retrain) for 60 seconds after the link has been established, stability failure, or “SF,” shall be recorded for the test case in the test report.

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**Test RR.1.2: Rate Reach Test with 24-disturber DSL NEXT Impairment**

**Purpose:** The purpose of this test is to determine the maximum net data rate at which an ATU-R/ATU-C initializes on various test loops in the presence of 24-disturber DSL NEXT impairment.

**References:**

- [1] ANSI T1.413-1998
- [2] ITU-T G.992.1 (1999)
- [3] ITU-T G.992.2 (1999)
- [4] ITU-T G.996.1 (2001)
- [5] ANSI T1.417-2001
- [8] ITU-T G.992.3 (2002)
- [9] ITU-T G.992.5 (2003)
- [10] ITU-T G.998.3 (2005)

**Resource requirements:**

- ATU-R
- ATU-C
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 1 for the desired mode of operation.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Coupling circuits

**Last modification:** March 21, 2007

**Test setup:**

- Test Setup 1 for single pair ADSL systems
- Test Setup 2 for bonded ADSL systems

**Discussion:**

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate in ADSL is primarily limited by factors such as loop length (attenuation), channel characteristics (presence of bridge taps, load coils) and the presence of noise impairments (crosstalk, white noise) on the line. This test provides insight into the maximum net data rate attained by a pair of ADSL devices for different loop configurations in the presence of 24-disturber DSL NEXT impairment and additive white Gaussian noise (AWGN). The results obtained in this test case can be compared with the baseline case results (Test RR.1.1) to draw inferences.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 1 as defined in G.test [4]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ANSI T1.417 [5]. To ensure the robustness of the ADSL connection a target noise margin of 6 dB should be configured in the ATU-C and three iterations of each test case should be performed.

Simulated AWGN noise and 24-disturber DSL NEXT impairments should be injected in both the upstream and downstream directions simultaneously using a high impedance crosstalk coupling circuit. The impairments are simulated based on the theoretical power spectral density as defined in ANSI T1.413 [1] and G.test [4] [For detailed information on impairment simulation using an Arbitrary Waveform Generator (AWG), see Annex B]. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in G.test [4] [For detailed information on a coupling circuit for use with an AWG as an impairment generator, see Annex C].

A test case refers to a single loop and impairment scenario. For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed using a single latency path function only. High latency (maximum interleave delay set 16 ms by default) and low latency (maximum interleave delay to set 1 ms by default) connections should be tested separately. The

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interleave delay for both latency path functions (high and low) can be changed upon request and will be recorded in the report. Annex D provides a graphical representation of the test procedure detailed below.

This test can be performed on any ADSL system that operates in accordance to ANSI T1.413-1998 [1], ITU-T G.992.1 (G.dmt) Annex A [2], ITU-T G.992.2 (G.lite) [3], ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9]. If a G.lite implementation is being tested, testing in the low latency path is not applicable and should be omitted. If an ADSL2+ or auto-mode implementation is being tested, an extended bandwidth line simulator and noise generator are required. POTS splitters should be included in this test, however POTS service is optional.

When testing multi-pair bonded ADSL systems, multiple line simulators and noise generators shall be used to provide each ADSL interface with a separate simulated physical connection between the BTU-C and BTU-R. The constraint placed on the time required for the bonded group to reach SHOWTIME shall be extended to 120 seconds to accommodate for any necessary additional operations performed by the bonded group. All interfaces of a bonded ADSL system shall be configured to use identical physical layer profiles.

**Procedure:**

1. Configure the ATU-C port(s) to be used for testing for a single high latency path with a maximum interleave delay of 16 ms, rate adaptive mode, and with a target noise margin of 6 dB.
2. Configure the ATU-R either for a single mode of operation, i.e. ANSI T1.413-1998 [1], ITU-T G.992.1 (G.dmt) Annex A [2], ITU-T G.992.2 (G.lite) [3], ITU-T G.992.3 (ADSL2) [8], ITU-T G.992.5 (ADSL2+) [9], or for auto-mode operation.
3. Connect the ATU-R to the ATU-C as shown in Test Setup 1 or 2.
4. Inject impairments on both upstream and downstream directions.
5. Configure the line simulator for a straight 26AWG loop of 0 kft.
6. Administratively enable or activate the ATU-C port(s).
7. Allow the maximum train time for the link to initialize.
8. If the link is not established (does not reach SHOWTIME) within the maximum train time, record “NC” – no connect for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain), record the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second period) record “SF” – stability failure for the test case and proceed to the next test case.
10. Administratively disable the ATU-C port for 10 seconds.
11. Repeat steps 6 to 11 until all loops for the desired mode of operation in Table 1 have been tested.
12. Repeat steps 5 through 11 two more times, for a total of three iterations.
13. If the ATU-R and ATU-C are configured for ANSI T1.413-1998 [1] or ITU-T G.992.1 (G.dmt) Annex A [2] configure the ATU-C port for a single low latency path. If the ATU-R and ATU-C are configured for ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9] configure the ATU-C port for a single low latency path with a maximum interleave delay of 1 ms and repeat steps 5 to 12.

**Test metrics:**

1. The ATU-R and ATU-C should reach SHOWTIME within the maximum train time and remain in SHOWTIME for no less than 60 seconds.
2. Recorded noise margins should be greater than or equal to 6 dB.

**Possible Problems:** If the ATU-R and ATU-C does not reach SHOWTIME within the maximum train time a no connect, or “NC,” shall be recorded for the test case in the test report. If the ATU-R and ATU-C do not remain stable (they do not retrain) for 60 seconds after the link has been established stability failure, or “SF,” shall be recorded for the test case in the test report.



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**Test RR.1.3: Rate Reach Test with 24-disturber HDSL NEXT Impairment**

**Purpose:** The purpose of this test is to determine the maximum net data rate at which an ATU-R/ATU-C initializes on various test loops in the presence of 24-disturber HDSL NEXT impairment.

**References:**

- [1] ANSI T1.413-1998
- [2] ITU-T G.992.1 (1999)
- [3] ITU-T G.992.2 (1999)
- [4] ITU-T G.996.1 (2001)
- [5] ANSI T1.417-2001
- [8] ITU-T G.992.3 (2002)
- [9] ITU-T G.992.5 (2003)
- [10] ITU-T G.998.3 (2005)

**Resource requirements:**

- ATU-R
- ATU-C
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 1 for the desired mode of operation.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Coupling circuits

**Last modification:** March 21, 2007

**Test setup:**

- Test Setup 1 for single pair ADSL systems
- Test Setup 2 for bonded ADSL systems

**Discussion:**

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate in ADSL is primarily limited by factors such as loop length (attenuation), channel characteristics (presence of bridge taps, load coils) and the presence of noise impairments (crosstalk, white noise) on the line. This test provides insight into the maximum net data rate attained by a pair of ADSL devices for different loop configurations in the presence of 24-disturber HDSL NEXT impairment and additive white gaussian noise (AWGN). The results obtained in this test case can be compared with the baseline case results (Test RR.1.1) to draw inferences.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 1 as defined in G.test [4]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ANSI T1.417 [5]. To ensure the robustness of the ADSL connection a target noise margin of 6 dB should be configured in the ATU-C and three iterations of each test case should be performed.

Simulated AWGN noise and 24-disturber HDSL NEXT impairments should be injected in both the upstream and downstream directions simultaneously using a high impedance crosstalk coupling circuit. The impairments are simulated based on the theoretical power spectral density as defined in ANSI T1.413 [1] and G.test [4] [For detailed information on impairment simulation using an Arbitrary Waveform Generator (AWG), see Annex B]. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in G.test [4] [For detailed information on a coupling circuit for use with an AWG as an impairment generator, see Annex C].

A test case refers to a single loop and impairment scenario. For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed using a single latency path function only. High latency (maximum interleave delay set 16 ms by default) and low latency (maximum interleave delay to set 1 ms by default) connections should be tested separately. The

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interleave delay for both latency path functions (high and low) can be changed upon request and will be recorded in the report. Annex D provides a graphical representation of the test procedure detailed below.

This test can be performed on any ADSL system that operates in accordance to ANSI T1.413-1998 [1], ITU-T G.992.1 (G.dmt) Annex A [2], ITU-T G.992.2 (G.lite) [3], ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9]. If a G.lite implementation is being tested, testing in the low latency path is not applicable and should be omitted. If an ADSL2+ or auto-mode implementation is being tested, an extended bandwidth line simulator and noise generator are required. POTS splitters should be included in this test, however POTS service is optional.

When testing multi-pair bonded ADSL systems, multiple line simulators and noise generators shall be used to provide each ADSL interface with a separate simulated physical connection between the BTU-C and BTU-R. The constraint placed on the time required for the bonded group to reach SHOWTIME shall be extended to 120 seconds to accommodate for any necessary additional operations performed by the bonded group. All interfaces of a bonded ADSL system shall be configured to use identical physical layer profiles.

**Procedure:**

1. Configure the ATU-C port(s) to be used for testing for a single high latency path with a maximum interleave delay of 16 ms, rate adaptive mode, and with a target noise margin of 6 dB.
2. Configure the ATU-R either for a single mode of operation, i.e. ANSI T1.413-1998 [1], ITU-T G.992.1 (G.dmt) Annex A [2], ITU-T G.992.2 (G.lite) [3], ITU-T G.992.3 (ADSL2) [8], ITU-T G.992.5 (ADSL2+) [9], or for auto-mode operation.
3. Connect the ATU-R to the ATU-C as shown in Test Setup 1 or 2.
4. Inject impairments on both upstream and downstream directions.
5. Configure the line simulator for a straight 26AWG loop of 0 kft.
6. Administratively enable or activate the ATU-C port(s).
7. Allow the maximum train time for the link to initialize.
8. If the link is not established (does not reach SHOWTIME) within the maximum train time, record “NC” – no connect for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain), record the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second period) record “SF” – stability failure for the test case and proceed to the next test case.
10. Administratively disable the ATU-C port for 10 seconds.
11. Repeat steps 6 to 11 until all loops for the desired mode of operation in Table 1 have been tested.
12. Repeat steps 5 through 11 two more times, for a total of three iterations.
13. If the ATU-R and ATU-C are configured for ANSI T1.413-1998 [1] or ITU-T G.992.1 (G.dmt) Annex A [2] configure the ATU-C port for a single low latency path. If the ATU-R and ATU-C are configured for ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9] configure the ATU-C port for a single low latency path with a maximum interleave delay of 1 ms and repeat steps 5 to 12.

**Test metrics:**

1. The ATU-R and ATU-C should reach SHOWTIME within the maximum train time and remain in SHOWTIME for no less than 60 seconds.
2. Recorded noise margins should be greater than or equal to 6 dB.

**Possible Problems:** If the ATU-R and ATU-C does not reach SHOWTIME within the maximum train time a no connect, or “NC,” shall be recorded for the test case in the test report. If the ATU-R and ATU-C do not remain stable (they do not retrain) for 60 seconds after the link has been established stability failure, or “SF,” shall be recorded for the test case in the test report.

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**Test RR.1.4: Rate Reach Test with 5-disturber T1 NEXT Impairment**

**Purpose:** The purpose of this test is to determine the maximum net data rate at which an ATU-R/ATU-C initializes on various test loops in the presence of 5-disturber T1 NEXT impairment.

**References:**

- [1] ANSI T1.413-1998
- [2] ITU-T G.992.1 (1999)
- [3] ITU-T G.992.2 (1999)
- [4] ITU-T G.996.1 (2001)
- [5] ANSI T1.417-2001
- [8] ITU-T G.992.3 (2002)
- [9] ITU-T G.992.5 (2003)
- [10] ITU-T G.998.3 (2005)

**Resource requirements:**

- ATU-R
- ATU-C
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 1 for the desired mode of operation.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Coupling circuits

**Last modification:** March 21, 2007

**Test setup:**

- Test Setup 1 for single pair ADSL systems
- Test Setup 2 for bonded ADSL systems

**Discussion:**

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate in ADSL is primarily limited by factors such as loop length (attenuation), channel characteristics (presence of bridge taps, load coils) and the presence of noise impairments (crosstalk, white noise) on the line. This test provides insight into the maximum net data rate attained by a pair of ADSL devices for different loop configurations in the presence of 5-disturber T1 NEXT impairment and additive white Gaussian noise (AWGN). The results obtained in this test case can be compared with the baseline case results (Test RR.1.1) to draw inferences.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 1 as defined in G.test [4]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ANSI T1.417 [5]. To ensure the robustness of the ADSL connection a target noise margin of 6 dB should be configured in the ATU-C and three iterations of each test case should be performed.

Simulated AWGN noise and 5-disturber, adjacent-binder, T1 NEXT impairments should be injected in both the upstream and downstream directions simultaneously using a high impedance crosstalk coupling circuit. The impairments are simulated based on the theoretical power spectral density as defined in ANSI T1.413 [1] and G.test [4] [For detailed information on impairment simulation using an Arbitrary Waveform Generator (AWG), see Annex B]. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in G.test [4] [For detailed information on a coupling circuit for use with an AWG as an impairment generator, see Annex C].

A test case refers to a single loop and impairment scenario. For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed using a single latency path function only. High latency (maximum interleave delay set 16 ms by default) and low latency (maximum interleave delay to set 1 ms by default) connections should be tested separately. The

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interleave delay for both latency path functions (high and low) can be changed upon request and will be recorded in the report. Annex D provides a graphical representation of the test procedure detailed below.

This test can be performed on any ADSL system that operates in accordance to ANSI T1.413-1998 [1], ITU-T G.992.1 (G.dmt) Annex A [2], ITU-T G.992.2 (G.lite) [3], ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9]. If a G.lite implementation is being tested, testing in the low latency path is not applicable and should be omitted. If an ADSL2+ or auto-mode implementation is being tested, an extended bandwidth line simulator and noise generator are required. POTS splitters should be included in this test, however POTS service is optional.

When testing multi-pair bonded ADSL systems, multiple line simulators and noise generators shall be used to provide each ADSL interface with a separate simulated physical connection between the BTU-C and BTU-R. The constraint placed on the time required for the bonded group to reach SHOWTIME shall be extended to 120 seconds to accommodate for any necessary additional operations performed by the bonded group. All interfaces of a bonded ADSL system shall be configured to use identical physical layer profiles.

**Procedure:**

1. Configure the ATU-C port(s) to be used for testing for a single high latency path with a maximum interleave delay of 16 ms, rate adaptive mode, and with a target noise margin of 6 dB.
2. Configure the ATU-R either for a single mode of operation, i.e. ANSI T1.413-1998 [1], ITU-T G.992.1 (G.dmt) Annex A [2], ITU-T G.992.2 (G.lite) [3], ITU-T G.992.3 (ADSL2) [8], ITU-T G.992.5 (ADSL2+) [9], or for auto-mode operation.
3. Connect the ATU-R to the ATU-C as shown in Test Setup 1 or 2.
4. Inject impairments on both upstream and downstream directions.
5. Configure the line simulator for a straight 26AWG loop of 0 kft.
6. Administratively enable or activate the ATU-C port(s).
7. Allow the maximum train time for the link to initialize.
8. If the link is not established (does not reach SHOWTIME) within the maximum train time, record “NC” – no connect for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain), record the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second period) record “SF” – stability failure for the test case and proceed to the next test case.
10. Administratively disable the ATU-C port for 10 seconds.
11. Repeat steps 6 to 11 until all loops for the desired mode of operation in Table 1 have been tested.
12. Repeat steps 5 through 11 two more times, for a total of three iterations.
13. If the ATU-R and ATU-C are configured for ANSI T1.413-1998 [1] or ITU-T G.992.1 (G.dmt) Annex A [2] configure the ATU-C port for a single low latency path. If the ATU-R and ATU-C are configured for ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9] configure the ATU-C port for a single low latency path with a maximum interleave delay of 1 ms and repeat steps 5 to 12.

**Test metrics:**

1. The ATU-R and ATU-C should reach SHOWTIME within the maximum train time and remain in SHOWTIME for no less than 60 seconds.
2. Recorded noise margins should be greater than or equal to 6 dB.

**Possible Problems:** If the ATU-R and ATU-C does not reach SHOWTIME within the maximum train time a no connect, or “NC,” shall be recorded for the test case in the test report. If the ATU-R and ATU-C do not remain stable (they do not retrain) for 60 seconds after the link has been established stability failure, or “SF,” shall be recorded for the test case in the test report.

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**Test RR.1.5: Optional Rate Reach Test with No Impairment**

**Purpose:** The purpose of this test is to determine the maximum net data rate at which an ATU-R/ATU-C initializes on various test loops without the presence of impairments.

**References:**

- [1] ANSI T1.413-1998
- [2] ITU-T G.992.1 (1999)
- [3] ITU-T G.992.2 (1999)
- [4] ITU-T G.996.1 (2001)
- [5] ANSI T1.417-2001
- [8] ITU-T G.992.3 (2002)
- [9] ITU-T G.992.5 (2003)
- [10] ITU-T G.998.3 (2005)

**Resource requirements:**

- ATU-R
- ATU-C
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 1 for the desired mode of operation.

**Last modification:** March 21, 2007

**Test setup:**

- Test Setup 1 for single pair ADSL systems
- Test Setup 2 for bonded ADSL systems

**Discussion:**

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate in ADSL is primarily limited by factors such as loop length (attenuation), channel characteristics (presence of bridge taps, load coils) and the presence of noise impairments (crosstalk, white noise) on the line. This test provides insight into the maximum net data rate attained by a pair of ADSL devices for different loop configurations in the absence of impairments, and can be used as additional baseline data to compare the results of tests RR.1.1 through RR.1.4.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 1 as defined in G.test [4]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ANSI T1.417 [5]. To ensure the robustness of the ADSL connection a target noise margin of 6 dB should be configured in the ATU-C and three iterations of each test case should be performed.

A test case refers to a single loop and impairment scenario. For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed using a single latency path function only. High latency (maximum interleave delay set 16 ms by default) and low latency (maximum interleave delay to set 1 ms by default) connections should be tested separately. The interleave delay for both latency path functions (high and low) can be changed upon request and will be recorded in the report. Annex D provides a graphical representation of the test procedure detailed below.

This test can be performed on any ADSL system that operates in accordance to ANSI T1.413-1998 [1], ITU-T G.992.1 (G.dmt) Annex A [2], ITU-T G.992.2 (G.lite) [3], ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9]. If a G.lite implementation is being tested, testing in the low latency path is not applicable and should be omitted. If an ADSL2+ or auto-mode implementation is being tested, an extended bandwidth line simulator and noise generator are required. POTS splitters should be included in this test, however POTS service is optional.

When testing multi-pair bonded ADSL systems, multiple line simulators shall be used to provide each ADSL interface with a separate simulated physical connection between the BTU-C and BTU-R. The constraint placed on the time required for the bonded group to reach SHOWTIME shall be extended to 120

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seconds to accommodate for any necessary additional operations performed by the bonded group. All interfaces of a bonded ADSL system shall be configured to use identical physical layer profiles.

**Procedure:**

1. Configure the ATU-C port(s) to be used for testing for a single high latency path with a maximum interleave delay of 16 ms, rate adaptive mode, and with a target noise margin of 6 dB.
2. Configure the ATU-R either for a single mode of operation, i.e. ANSI T1.413-1998 [1], ITU-T G.992.1 (G.dmt) Annex A [2], ITU-T G.992.2 (G.lite) [3], ITU-T G.992.3 (ADSL2) [8], ITU-T G.992.5 (ADSL2+) [9], or for auto-mode operation.
3. Connect the ATU-R to the ATU-C as shown in Test Setup 1 or 2.
4. Configure the line simulator for a straight 26AWG loop of 0 kft.
5. Administratively enable or activate the ATU-C port(s).
6. Allow the maximum train time for the link to initialize.
7. If the link is not established (does not reach SHOWTIME) within the maximum train time, record “NC” – no connect for this the case and proceed to the next test case, as detailed in step 9.
8. If the link is established and is stable for 60 seconds (does not retrain), record the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second period) record “SF” – stability failure for the test case and proceed to the next test case.
9. Administratively disable the ATU-C port for 10 seconds.
10. Repeat steps 6 to 10 until all loops for the desired mode of operation in Table 1 have been tested.
11. Repeat steps 4 through 10 two more times, for a total of three iterations.
12. If the ATU-R and ATU-C are configured for ANSI T1.413-1998 [1] or ITU-T G.992.1 (G.dmt) Annex A [2] configure the ATU-C port for a single low latency path. If the ATU-R and ATU-C are configured for ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9] configure the ATU-C port for a single low latency path with a maximum interleave delay of 1 ms and repeat steps 5 to 11.

**Test metrics:**

1. The ATU-R and ATU-C should reach SHOWTIME within the maximum train time and remain in SHOWTIME for no less than 60 seconds.
2. Recorded noise margins should be greater than or equal to 6 dB.

**Possible Problems:** If the ATU-R and ATU-C does not reach SHOWTIME within the maximum train time a no connect, or “NC,” shall be recorded for the test case in the test report. If the ATU-R and ATU-C do not remain stable (they do not retrain) for 60 seconds after the link has been established stability failure, or “SF,” shall be recorded for the test case in the test report.

## Group 2: Rate vs. Reach Tests for ADSL over ISDN

### Scope:

The procedures in Group 2 are designed to test the interoperability and stability of an ATU-R/ATU-C in an ADSL system operating in ITU-T G.992.1 (G.dmt) Annex B [2], ITU-T G.992.3 (ADSL2) Annex B [8], or ITU-T G.992.5 (ADSL2+) Annex B [9], on various test loops with and without the presence of impairments

### Notes:

- All tests in Group 2 are applicable to single pair ADSL systems and multi-pair bonded ADSL systems.
- In this group, the terms ATU-R and ATU-C refer to the BTU-R and BTU-C when considering a bonded ADSL system.
- In this group, the terms “crosstalk” and “impairments” are used interchangeably.
- The Group 2 tests are defined for ETSI test loops. The ADSL over ISDN tests can also be performed on North American loops upon request.
- The default maximum train time of 60 seconds (120 seconds for bonded systems), the default stability period of 60 seconds, and the default line reset delay of 10 seconds (the amount of time the ATU-C port is administratively disabled) can be changed to any reasonable value upon request. These values are listed in the test report.
- The default maximum interleave delay for the high and low latency path functions (a.k.a. “fast” path in G.dmt [2] terminology) is 16 ms and 1 ms, respectively. These values can be changed to any reasonable value upon request and will be recorded in the test report.
- The tests defined in this document represent only a subset of all possible test cases. Additional test cases can be added upon request.
- Loop simulator and impairment generator compensation should be applied, as defined in Section 4 “Test Tools Requirements and Calibration” of DSL Forum TR-067 [7], whenever possible.
- Testing in ITU-T G.992.5 (ADSL2+) [9] or auto-mode require a line simulator and noise generator with extended bandwidth capabilities (these devices must be able to simulate cable and impairments over a frequency range of 0 – 2.208 MHz).

Mode of Operation	Test Loops	Impairments
ADSL <ul style="list-style-type: none"> <li>• ITU-T G.992.1 (G.dmt) [2]</li> </ul>	0.4 mm ETSI Loop #1: 0 – 4400 meters in 200-meter increments.	<ul style="list-style-type: none"> <li>• -140 dBm/Hz white noise</li> <li>• ETSI-A</li> <li>• ETSI-B</li> <li>• Euro-K</li> <li>• No noise (optional)</li> </ul>
ADSL2 [8]	0.4 mm ETSI Loop #1: 0 – 5000 meters in 200-meter increments.	Same as ADSL
ADSL2+ [9]	0.4 mm ETSI Loop #1: 0 – 5000 meters in 200-meter increments. <ul style="list-style-type: none"> <li>• Requires extended bandwidth line simulator</li> </ul>	Same as ADSL, with extended bandwidth
Auto-mode	Same as ADSL2+	Same as ADSL2+

**Table 2 – ADSL over ISDN technologies and default test conditions.**

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**Test RR.2.1: Rate Reach Test with -140 dB AWGN Impairment**

**Purpose:** The purpose of this test is to determine the maximum net data rate at which an ATU-R/ATU-C initializes on ETSI Loop #1, at different loop lengths in the presence of –140 dB additive white gaussian noise (AWGN) impairment.

**References:**

- [2] ITU-T G.992.1 (1999)
- [4] ITU-T G.996.1 (2001)
- [8] ITU-T G.992.3 (2002)
- [9] ITU-T G.992.5 (2003)
- [10] ITU-T G.998.3 (2005)

**Resource requirements:**

- ATU-R
- ATU-C
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 1 for the desired mode of operation.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Coupling circuits

**Last modification:** March 21, 2007

**Test setup:**

- Test Setup 1 for single pair ADSL systems
- Test Setup 2 for bonded ADSL systems

**Discussion:**

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate in ADSL is primarily limited by factors such as loop length (attenuation), channel characteristics (presence of bridge taps, load coils) and the presence of noise impairments (crosstalk, white noise) on the line. This test provides insight into the maximum net data rate attained by a pair of ADSL devices for different loop configurations in the presence of –140 dB AWGN impairment, and is used as a baseline for the results obtained in Tests RR.2.2 through RR.2.4.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 2 as defined in G.test [4]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ITU-T G.996.1 [4]. To ensure the robustness of the ADSL connection a target noise margin of 6 dB should be configured in the ATU-C and three iterations of each test case should be performed.

Simulated –140 dB AWGN impairment is injected in both the upstream and downstream directions using a high impedance crosstalk injection circuit. The impairment is simulated based on the theoretical power spectral density as defined in G.test [4] [For detailed information on impairment simulation using an Arbitrary Waveform Generator (AWG), see Annex B]. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in G.test [4] [For detailed information on a coupling circuit for use with an AWG as an impairment generator, see Annex C].

For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed using a single latency path function only. High latency (maximum interleave delay set 16 ms by default) and low latency (maximum interleave delay to set 1 ms by default) connections should be tested separately. The interleave delay for both latency path functions (high and low) can be changed upon request and will be recorded in the report. Annex D provides a graphical representation of the test procedure detailed below.

This test can be performed on any ADSL system that operates in accordance to ITU-T G.992.1 (G.dmt) Annex B [2], ITU-T G.992.3 (ADSL2) Annex B [8], or ITU-T G.992.5 (ADSL2+) Annex B [9].



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If an ADSL2+ or auto-mode implementation is being tested, an extended bandwidth line simulator and noise generator are required. ISDN splitters should be included in this test; however ISDN service is optional.

When testing multi-pair bonded ADSL systems, multiple line simulators and noise generators shall be used to provide each ADSL interface with a separate simulated physical connection between the BTU-C and BTU-R. The constraint placed on the time required for the bonded group to reach SHOWTIME shall be extended to 120 seconds to accommodate for any necessary additional operations performed by the bonded group. All interfaces of a bonded ADSL system shall be configured to use identical physical layer profiles.

**Procedure:**

1. Configure the ATU-C port(s) to be used for testing for a single high latency path with a maximum interleave delay of 16 ms, rate adaptive mode, and with a target noise margin of 6 dB.
2. Configure the ATU-R and ATU-C for ITU-T G.992.1 (G.dmt) Annex B [2], ITU-T G.992.3 (ADSL2) Annex B [8], ITU-T G.992.5 (ADSL2+) Annex B [9], or for auto-mode operation.
3. Connect the ATU-R to the ATU-C as shown in Test Setup 1 or 2.
4. Inject Impairment on both upstream and downstream directions
5. Configure the line simulator for a straight 0.4 mm ETSI loop #1 of 0 meters.
6. Administratively enable or activate the ATU-C port(s).
7. Allow the maximum train time for the link to initialize.
8. If the link is not established (does not reach SHOWTIME) within the maximum train time, record “NC” – no connect for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain), record the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second period) record “SF” – stability failure for the test case and proceed to the next test case.
10. Administratively disable the ATU-C port for 10 seconds.
11. Repeat steps 6 to 11 until all loop lengths for the desired mode of operation in Table 2 have been tested.
12. Repeat steps 5 through 11 two more times, for a total of three iterations.
13. If the ATU-R and ATU-C is configured for ITU-T G.992.1 (G.dmt) Annex A [2] configure the ATU-C port for a single low latency path. If the ATU-R and ATU-C are configured for ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9] configure the ATU-C port for a single low latency path with a maximum interleave delay of 1 ms and repeat steps 5 to 12.

**Test metrics:**

1. The ATU-R and ATU-C should reach SHOWTIME within the maximum train time and remain in SHOWTIME for no less than 60 seconds.
2. Recorded noise margins should be greater than or equal to 6 dB.

**Possible Problems:** If the ATU-R and ATU-C does not reach SHOWTIME within the maximum train time “NC,” no connect, shall be recorded for that test case in the test report. If the ATU-R and ATU-C does not remain stable for 60 seconds after a link has be established “SF”, stability failure, shall be recorded for that test case in the test report.

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**Test RR.2.2: Rate Reach Test with ETSI-A Impairment**

**Purpose:** The purpose of this test is to determine the maximum net data rate at which an ATU-R/ATU-C initializes on ETSI Loop #1, at different loop lengths in the presence of ETSI-A impairment.

**References:**

- [2] ITU-T G.992.1 (1999)
- [4] ITU-T G.996.1 (2001)
- [8] ITU-T G.992.3 (2002)
- [9] ITU-T G.992.5 (2003)
- [10] ITU-T G.998.3 (2005)

**Resource requirements:**

- ATU-R
- ATU-C
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 1 for the desired mode of operation.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Coupling circuits

**Last modification:** December 6, 2004

**Test setup:**

- Test Setup 1 for single pair ADSL systems
- Test Setup 2 for bonded ADSL systems

**Discussion:**

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate in ADSL is primarily limited by factors such as loop length (attenuation), channel characteristics (presence of bridge taps, load coils) and the presence of noise impairments (crosstalk, white noise) on the line. This test provides insight into the maximum net data rate attained by a pair of ADSL devices for different loop configurations in the presence of ETSI-A impairment. The results obtained in this test case can be compared with the baseline case results (Test RR.2.1) to draw inferences.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 2 as defined in G.test [4]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ITU-T G.996.1 [4]. To ensure the robustness of the ADSL connection a target noise margin of 6 dB should be configured in the ATU-C and three iterations of each test case should be performed. Simulated ETSI-A impairment is injected in both the upstream and downstream directions using a high impedance crosstalk injection circuit. The impairment is simulated based on the theoretical power spectral density as defined in G.test [4] [For detailed information on impairment simulation using an Arbitrary Waveform Generator (AWG), see Annex B]. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in G.test [4] [For detailed information on a coupling circuit for use with an AWG as an impairment generator, see Annex C].

For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed using a single latency path function only. High latency (maximum interleave delay set 16 ms by default) and low latency (maximum interleave delay to set 1 ms by default) connections should be tested separately. The interleave delay for both latency path functions (high and low) can be changed upon request and will be recorded in the report. Annex D provides a graphical representation of the test procedure detailed below.

This test can be performed on any ADSL system that operates in accordance to ITU-T G.992.1 (G.dmt) Annex B [2], ITU-T G.992.3 (ADSL2) Annex B [8], or ITU-T G.992.5 (ADSL2+) Annex B [9]. If an ADSL2+ or auto-mode implementation is being tested, an extended bandwidth line simulator and

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noise generator are required. ISDN splitters should be included in this test; however ISDN service is optional.

When testing multi-pair bonded ADSL systems, multiple line simulators and noise generators shall be used to provide each ADSL interface with a separate simulated physical connection between the BTU-C and BTU-R. The constraint placed on the time required for the bonded group to reach SHOWTIME shall be extended to 120 seconds to accommodate for any necessary additional operations performed by the bonded group. All interfaces of a bonded ADSL system shall be configured to use identical physical layer profiles.

**Procedure:**

1. Configure the ATU-C port(s) to be used for testing for a single high latency path with a maximum interleave delay of 16 ms, rate adaptive mode, and with a target noise margin of 6 dB.
2. Configure the ATU-R and ATU-C for ITU-T G.992.1 (G.dmt) Annex B [2], ITU-T G.992.3 (ADSL2) Annex B [8], ITU-T G.992.5 (ADSL2+) Annex B [9], or for auto-mode operation.
3. Connect the ATU-R to the ATU-C as shown in Test Setup 1 or 2.
4. Inject Impairment on both upstream and downstream directions
5. Configure the line simulator for a straight 0.4 mm ETSI loop #1 of 0 m.
6. Administratively enable or activate the ATU-C port(s).
7. Allow the maximum train time for the link to initialize.
8. If the link is not established (does not reach SHOWTIME) within the maximum train time, record “NC” – no connect for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain), record the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second period) record “SF” – stability failure for the test case and proceed to the next test case.
10. Administratively disable the ATU-C port for 10 seconds.
11. Repeat steps 6 to 11 until all loop lengths for the desired mode of operation in Table 2 have been tested.
12. Repeat steps 5 through 11 two more times, for a total of three iterations.
13. If the ATU-R and ATU-C is configured for ITU-T G.992.1 (G.dmt) Annex A [2] configure the ATU-C port for a single low latency path. If the ATU-R and ATU-C are configured for ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9] configure the ATU-C port for a single low latency path with a maximum interleave delay of 1 ms and repeat steps 5 to 12.

**Test metrics:**

1. The ATU-R and ATU-C should reach SHOWTIME within the maximum train time and remain in SHOWTIME for no less than 60 seconds.
2. Recorded noise margins should be greater than or equal to 6 dB.

**Possible Problems:** If the ATU-R and ATU-C does not reach SHOWTIME within the maximum train time “NC,” no connect, shall be recorded for that test case in the test report. If the ATU-R and ATU-C does not remain stable for 60 seconds after a link has be established “SF”, stability failure, shall be recorded for that test case in the test report.

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**Test RR.2.3: Rate Reach Test with ETSI-B Impairment**

**Purpose:** The purpose of this test is to determine the maximum net data rate at which an ATU-R/ATU-C initializes on ETSI Loop #1, at different loop lengths in the presence of ETSI-B impairment.

**References:**

- [2] ITU-T G.992.1 (1999)
- [4] ITU-T G.996.1 (2001)
- [8] ITU-T G.992.3 (2002)
- [9] ITU-T G.992.5 (2003)
- [10] ITU-T G.998.3 (2005)

**Resource requirements:**

- ATU-R
- ATU-C
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 1 for the desired mode of operation.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Coupling circuits

**Last modification:** March 21, 2007

**Test setup:**

- Test Setup 1 for single pair ADSL systems
- Test Setup 2 for bonded ADSL systems

**Discussion:**

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate in ADSL is primarily limited by factors such as loop length (attenuation), channel characteristics (presence of bridge taps, load coils) and the presence of noise impairments (crosstalk, white noise) on the line. This test provides insight into the maximum net data rate attained by a pair of ADSL devices for different loop configurations in the presence of ETSI-B impairment. The results obtained in this test case can be compared with the baseline case results (Test RR.2.1) to draw inferences.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 2 as defined in G.test [4]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ITU-T G.996.1 [4]. To ensure the robustness of the ADSL connection a target noise margin of 6 dB should be configured in the ATU-C and three iterations of each test case should be performed. Simulated ETSI-B impairment is injected in both the upstream and downstream directions using a high impedance crosstalk injection circuit. The impairment is simulated based on the theoretical power spectral density as defined in G.test [4] [For detailed information on impairment simulation using an Arbitrary Waveform Generator (AWG), see Annex B]. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in G.test [4] [For detailed information on a coupling circuit for use with an AWG as an impairment generator, see Annex C].

For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed using a single latency path function only. High latency (maximum interleave delay set 16 ms by default) and low latency (maximum interleave delay to set 1 ms by default) connections should be tested separately. The interleave delay for both latency path functions (high and low) can be changed upon request and will be recorded in the report. Annex D provides a graphical representation of the test procedure detailed below.

This test can be performed on any ADSL system that operates in accordance to ITU-T G.992.1 (G.dmt) Annex B [2], ITU-T G.992.3 (ADSL2) Annex B [8], or ITU-T G.992.5 (ADSL2+) Annex B [9]. If an ADSL2+ or auto-mode implementation is being tested, an extended bandwidth line simulator and

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noise generator are required. ISDN splitters should be included in this test; however ISDN service is optional.

When testing multi-pair bonded ADSL systems, multiple line simulators and noise generators shall be used to provide each ADSL interface with a separate simulated physical connection between the BTU-C and BTU-R. The constraint placed on the time required for the bonded group to reach SHOWTIME shall be extended to 120 seconds to accommodate for any necessary additional operations performed by the bonded group. All interfaces of a bonded ADSL system shall be configured to use identical physical layer profiles.

**Procedure:**

1. Configure the ATU-C port(s) to be used for testing for a single high latency path with a maximum interleave delay of 16 ms, rate adaptive mode, and with a target noise margin of 6 dB.
2. Configure the ATU-R and ATU-C for ITU-T G.992.1 (G.dmt) Annex B [2], ITU-T G.992.3 (ADSL2) Annex B [8], ITU-T G.992.5 (ADSL2+) Annex B [9], or for auto-mode operation.
3. Connect the ATU-R to the ATU-C as shown in Test Setup 1 or 2.
4. Inject Impairment on both upstream and downstream directions
5. Configure the line simulator for a straight 0.4 mm ETSI loop #1 of 0 m.
6. Administratively enable or activate the ATU-C port(s).
7. Allow the maximum train time for the link to initialize.
8. If the link is not established (does not reach SHOWTIME) within the maximum train time, record “NC” – no connect for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain), record the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second period) record “SF” – stability failure for the test case and proceed to the next test case.
10. Administratively disable the ATU-C port for 10 seconds.
11. Repeat steps 6 to 11 until all loop lengths for the desired mode of operation in Table 2 have been tested.
12. Repeat steps 5 through 11 two more times, for a total of three iterations.
13. If the ATU-R and ATU-C is configured for ITU-T G.992.1 (G.dmt) Annex A [2] configure the ATU-C port for a single low latency path. If the ATU-R and ATU-C are configured for ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9] configure the ATU-C port for a single low latency path with a maximum interleave delay of 1 ms and repeat steps 5 to 12.

**Test metrics:**

1. The ATU-R and ATU-C should reach SHOWTIME within the maximum train time and remain in SHOWTIME for no less than 60 seconds.
2. Recorded noise margins should be greater than or equal to 6 dB.

**Possible Problems:** If the ATU-R and ATU-C does not reach SHOWTIME within the maximum train time “NC,” no connect, shall be recorded for that test case in the test report. If the ATU-R and ATU-C does not remain stable for 60 seconds after a link has be established “SF”, stability failure, shall be recorded for that test case in the test report.

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**Test RR.2.4: Rate Reach Test with Euro-K Impairment**

**Purpose:** The purpose of this test is to determine the maximum net data rate at which an ATU-R/ATU-C initializes on ETSI Loop #1, at different loop lengths in the presence of Euro-K impairment.

**References:**

- [2] ITU-T G.992.1 (1999)
- [4] ITU-T G.996.1 (2001)
- [8] ITU-T G.992.3 (2002)
- [9] ITU-T G.992.5 (2003)
- [10] ITU-T G.998.3 (2005)

**Resource requirements:**

- ATU-R
- ATU-C
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 1 for the desired mode of operation.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Coupling circuits

**Last modification:** March 21, 2007

**Test setup:**

- Test Setup 1 for single pair ADSL systems
- Test Setup 2 for bonded ADSL systems

**Discussion:**

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate in ADSL is primarily limited by factors such as loop length (attenuation), channel characteristics (presence of bridge taps, load coils) and the presence of noise impairments (crosstalk, white noise) on the line. This test provides insight into the maximum net data rate attained by a pair of ADSL devices for different loop configurations in the presence of Euro-K impairment. The results obtained in this test case can be compared with the baseline case results (Test RR.2.1) to draw inferences.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 2 as defined in G.test [4]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ITU-T G.996.1 [4]. To ensure the robustness of the ADSL connection a target noise margin of 6 dB should be configured in the ATU-C and three iterations of each test case should be performed. Simulated Euro-K impairment is injected in both the upstream and downstream directions using a high impedance crosstalk injection circuit. The impairment is simulated based on the theoretical power spectral density as defined in G.test [4] [For detailed information on impairment simulation using an Arbitrary Waveform Generator (AWG), see Annex B]. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in G.test [4] [For detailed information on a coupling circuit for use with an AWG as an impairment generator, see Annex C].

For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed using a single latency path function only. High latency (maximum interleave delay set 16 ms by default) and low latency (maximum interleave delay to set 1 ms by default) connections should be tested separately. The interleave delay for both latency path functions (high and low) can be changed upon request and will be recorded in the report. Annex D provides a graphical representation of the test procedure detailed below.

This test can be performed on any ADSL system that operates in accordance to ITU-T G.992.1 (G.dmt) Annex B [2], ITU-T G.992.3 (ADSL2) Annex B [8], or ITU-T G.992.5 (ADSL2+) Annex B [9]. If an ADSL2+ or auto-mode implementation is being tested, an extended bandwidth line simulator and

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noise generator are required. ISDN splitters should be included in this test; however ISDN service is optional.

When testing multi-pair bonded ADSL systems, multiple line simulators and noise generators shall be used to provide each ADSL interface with a separate simulated physical connection between the BTU-C and BTU-R. The constraint placed on the time required for the bonded group to reach SHOWTIME shall be extended to 120 seconds to accommodate for any necessary additional operations performed by the bonded group. All interfaces of a bonded ADSL system shall be configured to use identical physical layer profiles.

**Procedure:**

1. Configure the ATU-C port(s) to be used for testing for a single high latency path with a maximum interleave delay of 16 ms, rate adaptive mode, and with a target noise margin of 6 dB.
2. Configure the ATU-R and ATU-C for ITU-T G.992.1 (G.dmt) Annex B [2], ITU-T G.992.3 (ADSL2) Annex B [8], ITU-T G.992.5 (ADSL2+) Annex B [9], or for auto-mode operation.
3. Connect the ATU-R to the ATU-C as shown in Test Setup or 2.
4. Inject Impairment on both upstream and downstream directions
5. Configure the line simulator for a straight 0.4 mm ETSI loop #1 of 0 m.
6. Administratively enable or activate the ATU-C port(s).
7. Allow the maximum train time for the link to initialize.
8. If the link is not established (does not reach SHOWTIME) within the maximum train time, record “NC” – no connect for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain), record the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second period) record “SF” – stability failure for the test case and proceed to the next test case.
10. Administratively disable the ATU-C port for 10 seconds.
11. Repeat steps 6 to 11 until all loop lengths for the desired mode of operation in Table 2 have been tested.
12. Repeat steps 5 through 11 two more times, for a total of three iterations.
13. If the ATU-R and ATU-C is configured for ITU-T G.992.1 (G.dmt) Annex A [2] configure the ATU-C port for a single low latency path. If the ATU-R and ATU-C are configured for ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9] configure the ATU-C port for a single low latency path with a maximum interleave delay of 1 ms and repeat steps 5 to 12.

**Test metrics:**

1. The ATU-R and ATU-C should reach SHOWTIME within the maximum train time and remain in SHOWTIME for no less than 60 seconds.
2. Recorded noise margins should be greater than or equal to 6 dB.

**Possible Problems:** If the ATU-R and ATU-C does not reach SHOWTIME within the maximum train time “NC,” no connect, shall be recorded for that test case in the test report. If the ATU-R and ATU-C does not remain stable for 60 seconds after a link has be established “SF”, stability failure, shall be recorded for that test case in the test report.

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**Test RR.2.5: Optional Rate Reach Test with No Impairment**

**Purpose:** The purpose of this test is to determine the maximum net data rate at which an ATU-R/ATU-C initializes on ETSI Loop #1, at different loop lengths without the presence of impairment.

**References:**

- [2] ITU-T G.992.1 (1999)
- [4] ITU-T G.996.1 (2001)
- [8] ITU-T G.992.3 (2002)
- [9] ITU-T G.992.5 (2003)
- [10] ITU-T G.998.3 (2005)

**Resource requirements:**

- ATU-R
  - ATU-C
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 1 for the desired mode of operation.

**Last modification:** March 21, 2007

**Test setup:**

- Test Setup 1 for single pair ADSL systems
- Test Setup 2 for bonded ADSL systems

**Discussion:**

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate in ADSL is primarily limited by factors such as loop length (attenuation), channel characteristics (presence of bridge taps, load coils) and the presence of noise impairments (crosstalk, white noise) on the line. This test provides insight into the maximum net data rate attained by a pair of ADSL devices for different loop configurations in the absence of impairment, and can be used as additional baseline data to compare the results of tests RR.2.1 through RR.2.4.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 2 as defined in G.test [4]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ITU-T G.996.1 [4]. To ensure the robustness of the ADSL connection a target noise margin of 6 dB should be configured in the ATU-C and three iterations of each test case should be performed. A test case refers to a single loop and impairment scenario.

For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed using a single latency path function only. High latency (maximum interleave delay set 16 ms by default) and low latency (maximum interleave delay to set 1 ms by default) connections should be tested separately. The interleave delay for both latency path functions (high and low) can be changed upon request and will be recorded in the report. Annex D provides a graphical representation of the test procedure detailed below.

This test can be performed on any ADSL system that operates in accordance to ITU-T G.992.1 (G.dmt) Annex B [2], ITU-T G.992.3 (ADSL2) Annex B [8], or ITU-T G.992.5 (ADSL2+) Annex B [9]. If an ADSL2+ or auto-mode implementation is being tested, an extended bandwidth line simulator and noise generator are required. ISDN splitters should be included in this test; however ISDN service is optional.

When testing multi-pair bonded ADSL systems, multiple line simulators shall be used to provide each ADSL interface with a separate simulated physical connection between the BTU-C and BTU-R. The constraint placed on the time required for the bonded group to reach SHOWTIME shall be extended to 120 seconds to accommodate for any necessary additional operations performed by the bonded group. All interfaces of a bonded ADSL system shall be configured to use identical physical layer profiles.



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**Procedure:**

1. Configure the ATU-C port(s) to be used for testing for a single high latency path with a maximum interleave delay of 16 ms, rate adaptive mode, and with a target noise margin of 6 dB.
2. Configure the ATU-R and ATU-C for ITU-T G.992.1 (G.dmt) Annex B [2], ITU-T G.992.3 (ADSL2) Annex B [8], ITU-T G.992.5 (ADSL2+) Annex B [9], or for auto-mode operation.
3. Connect the ATU-R to the ATU-C as shown in Test Setup 1 or 2.
4. Configure the line simulator for a straight 0.4 mm ETSI loop #1 of 0 meters.
5. Administratively enable or activate the ATU-C port(s).
6. Allow the maximum train time for the link to initialize.
7. If the link is not established (does not reach SHOWTIME) within the maximum train time, record “NC” – no connect for the test case and proceed to the next test case, as detailed in step 9.
8. If the link is established and is stable for 60 seconds (does not retrain), record the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second period) record “SF” – stability failure for the test case and proceed to the next test case.
9. Administratively disable the ATU-C port for 10 seconds.
10. Repeat steps 5 to 10 until all loop lengths for the desired mode of operation in Table 2 have been tested.
11. Repeat steps 4 through 10 two more times, for a total of three iterations.
12. If the ATU-R and ATU-C is configured for ITU-T G.992.1 (G.dmt) Annex A [2] configure the ATU-C port for a single low latency path. If the ATU-R and ATU-C are configured for ITU-T G.992.3 (ADSL2) [8], or ITU-T G.992.5 (ADSL2+) [9] configure the ATU-C port for a single low latency path with a maximum interleave delay of 1 ms and repeat steps 5 to 11.

**Test metrics:**

1. The ATU-R and ATU-C should reach SHOWTIME within the maximum train time and remain in SHOWTIME for no less than 60 seconds.
2. Recorded noise margins should be greater than or equal to 6 dB.

**Possible Problems:** If the ATU-R and ATU-C does not reach SHOWTIME within the maximum train time “NC,” no connect, shall be recorded for that test case in the test report. If the ATU-R and ATU-C does not remain stable for 60 seconds after a link has be established “SF”, stability failure, shall be recorded for that test case in the test report.

## Annex A: Results Grids

### Results Grid Legend

Test RR.#.#, Noise Impairment XXXX, Low or High Latency Path, IOL Test ID: XXXX													
Length (feet)	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
Iteration 1	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Length (feet)	13000	14000	15000	16000	17000	18000	19000	20000	21000	22000	23000	CSA #4	ANSI #13
Iteration 1	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												

Where:

- UDR = Upstream Data Rate in kbps.
- UNM = Upstream Noise Margin in dB.
- DDR = Downstream Data Rate in kbps.
- DNM = Downstream Noise Margin in dB.
- Time = Time in seconds required to reach SHOWTIME.
- Mode = ANSI (ANSI T1.413-1998), DMT (ITU-T G.992.1 Annex A/B), LITE (ITU-T G.992.2), A2 (ITU-T G.992.3 Annex A/B), A2 L (ITU-T G.992.3 Annex L) or A2+ (ITU-T G.992.5).

Test RR.X.X, Noise Impairment XXXX, Low or High Latency Path, IOL Test ID: XXXX									
Length (feet)	Iteration 1			Iteration 2			Iteration 3		
	AUDR	ADDR	Time	AUDR	ADDR	Time	AUDR	ADDR	Time
0									
1000									
2000									
3000									

Where:

- AUDR = Aggregate Upstream Data Rate in kbps.
- ADDR = Aggregate Downstream Data Rate in dB.
- Time = Time in seconds required to reach SHOWTIME.

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**Group 1: Rate Reach Test for ADSL over POTS (Single Pair System)**

Test RR.1.#, Noise Impairment XXXX, Low or High Latency Path, IOL Test ID: XXXX													
Length (feet)	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
Iteration 1	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Iteration 2	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Iteration 3	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Length (feet)	13000	14000	15000	16000	17000	18000	19000	20000	21000	22000	23000	CSA #4	ANSI #13
Iteration 1	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Iteration 2	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Iteration 3	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												

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**Group 1: Rate Reach Test for ADSL over POTS (Bonded System)**

<b>Test RR.1.#, Noise Impairment XXXX, Low or High Latency Path, IOL Test ID: XXXX</b>									
<b>Length (feet)</b>	<b>Iteration 1</b>			<b>Iteration 2</b>			<b>Iteration 3</b>		
	<b>AUDR</b>	<b>ADDR</b>	<b>Time</b>	<b>AUDR</b>	<b>ADDR</b>	<b>Time</b>	<b>AUDR</b>	<b>ADDR</b>	<b>Time</b>
0									
1000									
2000									
3000									
4000									
5000									
6000									
7000									
8000									
9000									
10000									
11000									
12000									
13000									
14000									
15000									
16000									
17000									
18000									
19000									
20000									
21000									
22000									
23000									
CSA #4									
ANSI #13									

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Test RR.1.#, Noise Impairment XXXX, Low or High Latency Path, Iteration X,IOL Test ID: XXXX													
Length (feet)	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
AUDR													
ADDR													
Time													
Pair #1	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Pair #2	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Length (feet)	13000	14000	15000	16000	17000	18000	19000	20000	21000	22000	23000	CSA #4	ANSI #13
AUDR													
ADDR													
Time													
Pair #1	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Pair #2	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												

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**Group 2: Rate Reach Test for ADSL over ISDN (Single Pair System)**

Test RR.2.#, Noise Impairment XXXX, Low or High Latency Path, IOL Test ID: XXXX													
Length (meters)	0	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400
Iteration 1	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Iteration 2	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Iteration 3	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Length (meters)	2600	2800	3000	3200	3400	3600	3800	4000	4200	4400	4600	4800	5000
Iteration 1	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Iteration 2	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Iteration 3	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												

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**Group 2: Rate Reach Test for ADSL over ISDN (Bonded System)**

<b>Test RR.2.#, Noise Impairment XXXX, Low or High Latency Path, IOL Test ID: XXXX</b>									
<b>Length (feet)</b>	<b>Iteration 1</b>			<b>Iteration 2</b>			<b>Iteration 3</b>		
	<b>AUDR</b>	<b>ADDR</b>	<b>Time</b>	<b>AUDR</b>	<b>ADDR</b>	<b>Time</b>	<b>AUDR</b>	<b>ADDR</b>	<b>Time</b>
0									
200									
400									
600									
800									
1000									
1200									
1400									
1600									
1800									
2000									
2200									
2400									
2600									
2800									
3000									
3200									
3400									
3600									
3800									
4000									
4200									
4400									
4600									
4800									
5000									

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Test RR.2.#, Noise Impairment XXXX, Low or High Latency Path, Iteration X, IOL Test ID: XXXX													
Length (feet)	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
AUDR													
ADDR													
Time													
Pair #1	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Pair #2	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Length (feet)	13000	14000	15000	16000	17000	18000	19000	20000	21000	22000	23000	CSA #4	ANSI #13
AUDR													
ADDR													
Time													
Pair #1	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												
Pair #2	UDR												
	DDR												
	UNM												
	DNM												
	Time												
	Mode												



## **Annex B: Impairments Simulation**

The performance of DSL transceivers can be impaired by interference from other transceivers operating over wires in the same binder group. It is therefore important to test DSL transceivers in the presence of crosstalk, which can be simulated in MATLAB. The simulated crosstalk is exported to an arbitrary waveform generator (AWG) for injection onto the line through a high-impedance noise injection circuit. This document describes a method of crosstalk simulation and calibration whereby white gaussian noise (WGN) is passed through a frequency-domain filter that gives the noise the spectral characteristics of crosstalk. The crosstalk is calibrated by measuring its power with a vector signal analyzer (VSA) and adjusting the output level on the AWG to achieve the desired noise power. By using MATLAB to estimate the simulated crosstalk power in the same manner as the VSA, the calibration can be performed in MATLAB without taking actual measurements [6]. For more information refer to “DSL Crosstalk Simulation and Calibration.” [6]

Figures B.1, B.2, and B.3 show a comparison of theoretical and simulated 24-disturber DSL, 24-disturber HDSL and 5-disturber T1 NEXT impairments used in Group 1 tests. The simulated NEXT impairments occupy a band of 0 to 2.5 MHz. 24 – disturber DSL noise simulates a scenario in which the loop under test is in a binder where 24 other pairs carry ISDN/DSL signals. 24 – disturber HDSL noise simulates a scenario in which the loop under test is in a binder where 24 other pairs carry HDSL signals. 5-disturber T1 noise simulates a case where a binder adjacent to the binder in which the test loop is present is carrying 5 T1 AMI signals. The term “loop under test” or “test loop” refers to a pair of wires. The impairments for Group 1 tests include –140 dBm/Hz white gaussian noise.

Figures B.4, B.5, and B.6 show a comparison of theoretical and simulated ETSI-A, ETSI-B, and EURO-K impairments used in Group 2 tests. White gaussian noise is not added to the simulated ETSI-A, ETSI-B, and EURO-K impairments.

Note that all power levels in the following figures are 3 dB higher than the theoretical plots, which are referenced to 100  $\Omega$ . This is to account for the fact that the noise is injected across two 100  $\Omega$  loads in parallel. The power delivered by the noise to each 100  $\Omega$  load is therefore 3 dB lower than the power levels in the figures.

For DSL and HDSL impairments that are referenced to 135  $\Omega$  (the characteristic impedance of ISDN and HDSL lines), an additional 1.3 dB of power is added to compensate for the ADSL line’s 100  $\Omega$  impedance ( $10\log_{10}(135/100) = 1.3$  dB).

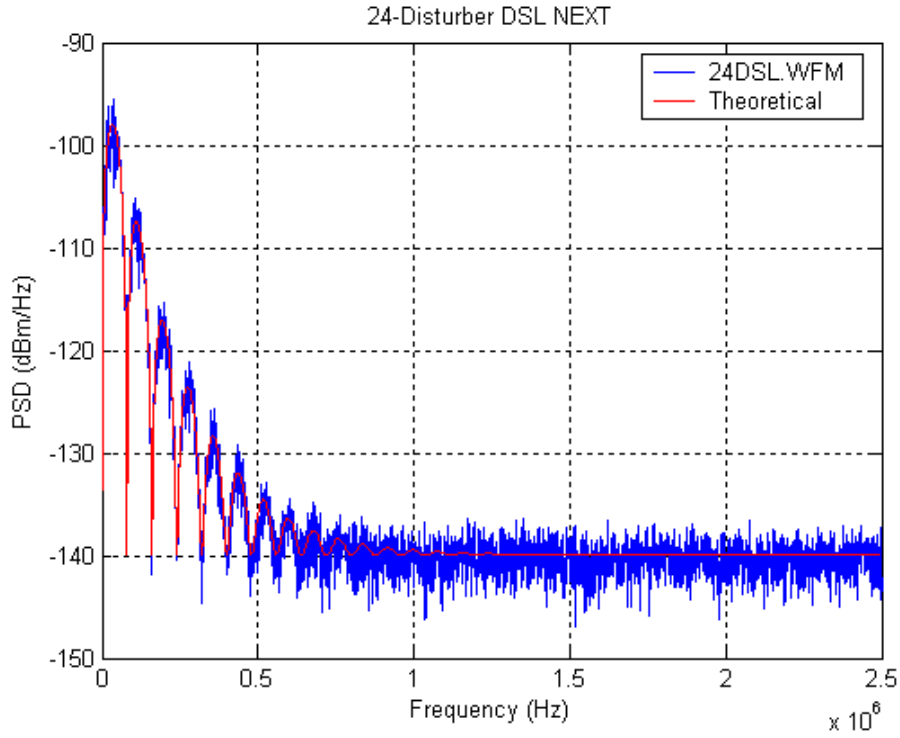


Figure B.3 – Theoretical and Simulated 24-disturber DSL NEXT

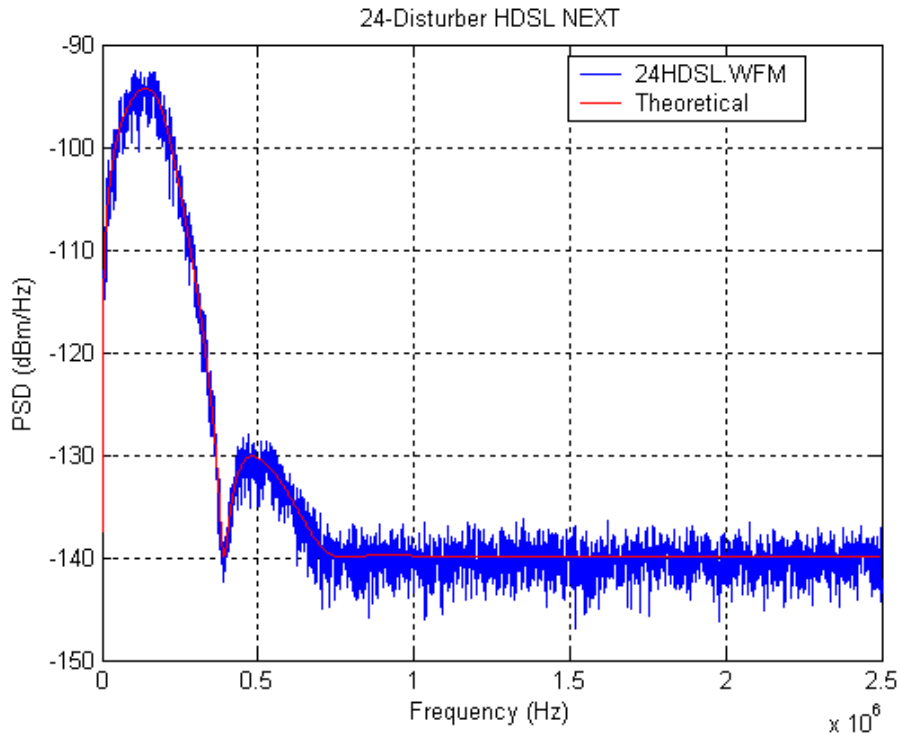


Figure B.4 – Theoretical and Simulated 24-disturber HDSL NEXT

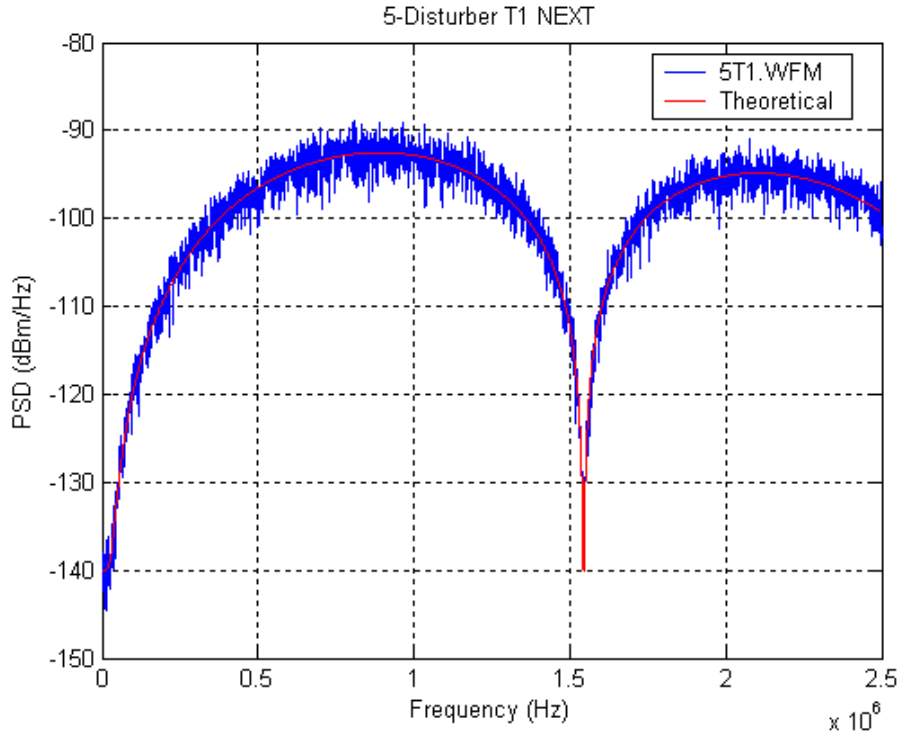


Figure B.5 – Theoretical and Simulated 5-disturber T1 NEXT

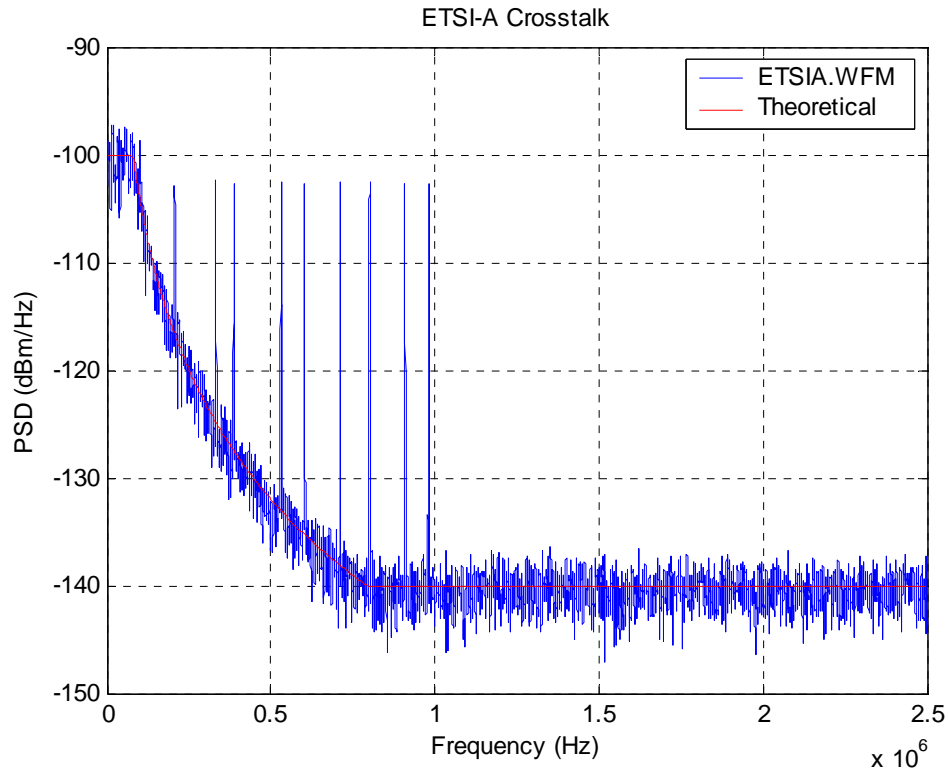


Figure B.6 – Theoretical and Simulated ETSI-A Crosstalk

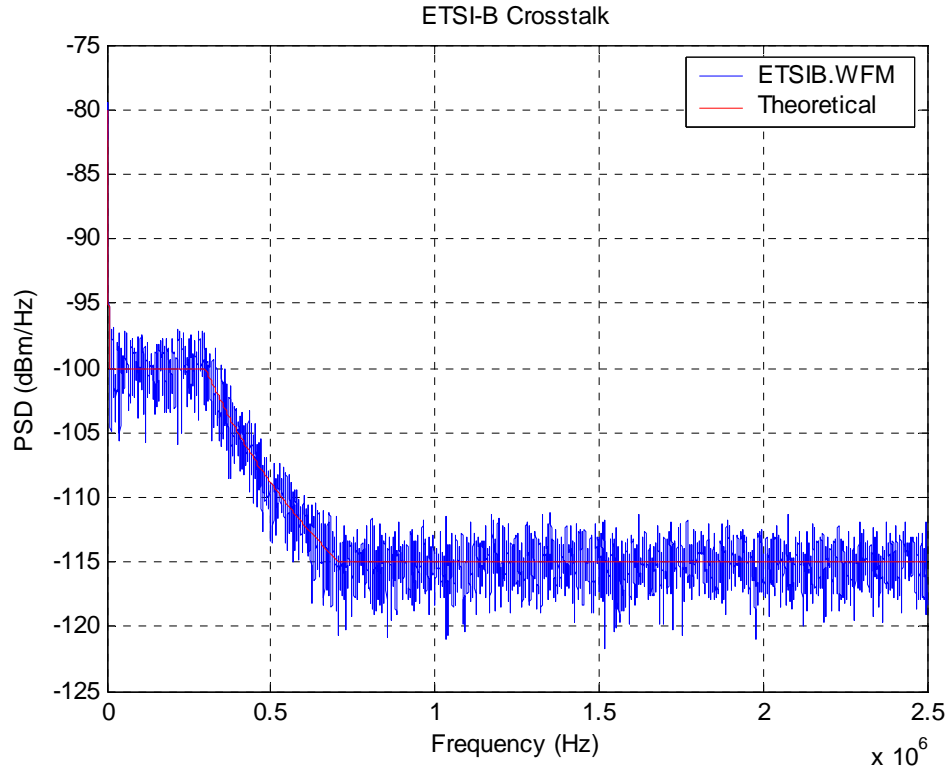


Figure B.7 – Theoretical and Simulated ETSI-B Crosstalk

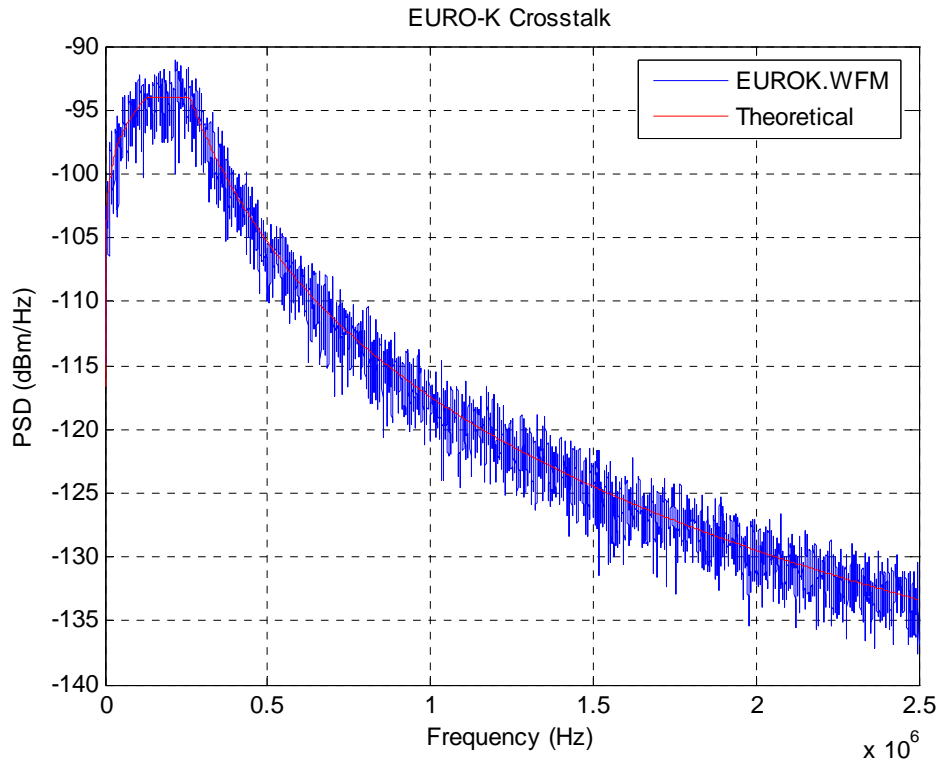


Figure B.8 – Theoretical and Simulated Euro-K Crosstalk

## Annex C: High Impedance Crosstalk Coupling Circuit

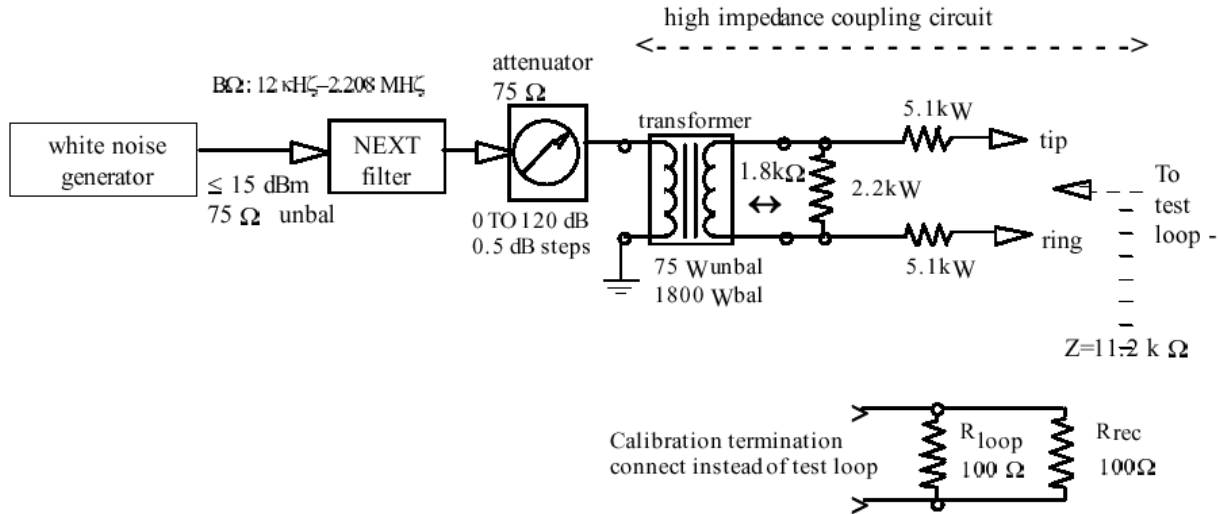


Figure C.1 – High Impedance Crosstalk Injection Circuit from G.test [4]

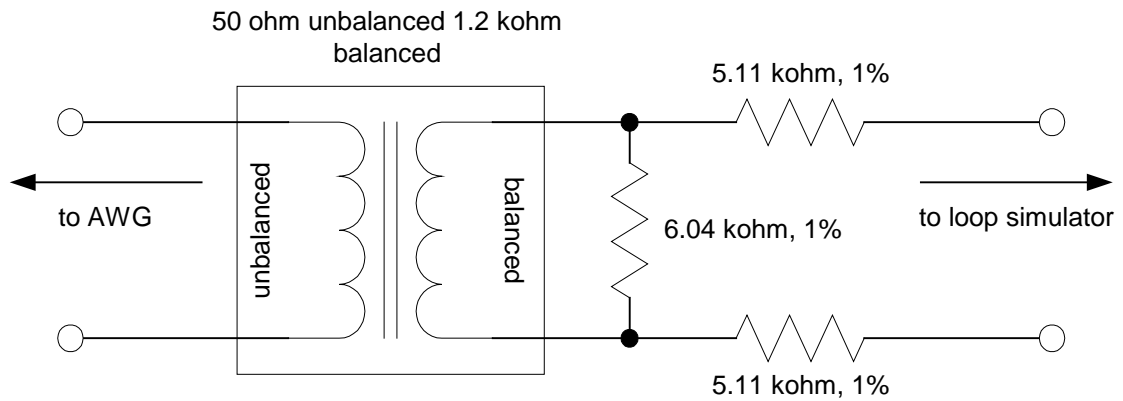


Figure C.2 – High Impedance Crosstalk Injection Circuit Used For Testing

Figure C.1 shows the proposed crosstalk injection circuit defined in G.test [4]. Figure C.2 shows the high impedance crosstalk injection circuit used to perform the tests in this Test Suite. The circuit shown in Figure C.2 is a modified version of the circuit shown in Figure C.1. The following modifications were made:

- The unbalanced side of the crosstalk injection circuit is connected to a 50 ohm AWG. Therefore a balun with an unbalanced impedance of 50 ohms was chosen for this application.
- Due to the availability of baluns, a 50:1200 ohm balun with a bandwidth of 1 kHz to 6 MHz was chosen for this application.

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- The resistor values on the balanced side of the crosstalk injection circuit were modified to properly match the impedance of the 50:1200 ohm balun (used in place of the recommended 75:1800 balun) while maintaining an input impedance of 11.2 kohm.

## Annex D: Graphical Representation of the Test Procedure

