INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

FS-VDSL
FGTS

Full-Service VDSL

Focus Group Technical Specification

Part 4: Physical Layer Specification for Interoperable VDSL Systems

Version 1.04
6 March 2003

ITU-T STUDY GROUP 16 “MULTIMEDIA SERVICES, SYSTEMS AND TERMINALS”

FULL-SERVICE VDSL FOCUS GROUP

FOCUS GROUP TECHNICAL SPECIFICATIONS SERIES

FOCUS GROUP TECHNICAL SPECIFICATIONS FULL-SERVICE VERY HIGH-SPEED DIGITAL SUBSCRIBER LINE		**Version control:**
Part 1:	Operator Requirements	Version 1.00 / 5 June 2002
Part 2:	System Architecture	Version 1.00 / 5 June 2002
Part 3:	Customer Premises Equipment	Version 1.00 / 5 June 2002
Part 4:	Physical Layer Specification for Interoperable VDSL Systems	Version 1.04 / 6 March 2003
Part 5:	Operations, Administration and Maintenance & Provision aspects for FS-VDSL Services	Version 1.00 / 5 June 2002

FOREWORD

The procedures for establishment of a Focus Group are defined in Rec.A.7. After assessment of the requirements in A.7 the TSB Director decided in consultation with the SG 16 management to follow provisions under clause 2.1.1/A.7 for the establishment of Focus Groups between study group meetings. The FGRC for the Full-Service Very-high-speed Digital Subscriber Line (FS-VDSL) Focus Group met on 3 May 2002 and agreed to proceed with the steps for the establishment of the FS-VDSL Focus Group, having ITU-T Study Group 16 as parent stuffy group. The formalities laid down in ITU-T Rec. A.7 were completed on 10 May 2002 and the formal approval of the Focus Group by ITU-T SG 16 took place on [24 October 2002].

Even though Focus Groups have an ITU-T Study Group as a parent organization, Focus Groups are organized independently from the usual operating procedures of the ITU, including financial independence. Texts approved by Focus Groups (including its Technical Specifications) do not have the same status of ITU-T Recommendations.

INTELLECTUAL PROPERTY RIGHTS

The Focus Group draws attention to the possibility that the practice or implementation of this Technical Specification may involve the use of a claimed Intellectual Property Right. The Focus Group takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by Focus Group members or others outside of the Technical Specification development process.

As of the date of approval of this Technical Specification, the had Focus Group received notice of intellectual property, protected by patents, which may be required to implement this Technical Specification. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the FS-VDSL patent database.

ITU-T FS-VDSL Focus Group Technical Specification 1

Part 4: Physical Layer Specification for Interoperable VDSL Systems

Summary
This document is intended to facilitate the deployment of interoperable VDSL systems in carrier-class environments that follow Band Plans 998 or 997. As such, it specifies functional details for the physical layer of typical VDSL deployments. It specifies applicable test conditions and addresses physical layer interoperability for such deployments. It builds upon the appropriate Recommendations from committee T1, ETSI, and the ITU and is intended to serve as a supplement to those Recommendations. This document also specifies physical interface details and other items that are beyond the scope of existing Specifications.

Source
This Technical Specification was produced by the VS Working Group of the ITU-T FS-VDSL Focus Group. Comments on this document are welcome comments. Please refer to the FS-VDSL web site at `http://www.fs-vdsl.net` for contact details and to download comment form.

Keywords
VDSL, Interoperability, FS-VDSL

CONTENTS

ITU-T FS-VDSL Focus Group Technical Specification 1

Part 1: Physical Layer Specification for Interoperable VDSL Systems

1. Scope

This document is intended to facilitate the deployment of interoperable VDSL systems in carrier-class environments that follow Band Plans 998 or 997. As such, it specifies functional details for the physical layer of typical VDSL deployments. It specifies applicable test conditions and addresses physical layer interoperability for such deployments. It builds upon the appropriate Recommendations from committee T1, ETSI, and the ITU and is intended to serve as a supplement to those Recommendations. This document also specifies physical interface details and other items that are beyond the scope of existing Specifications.

2. References

[1] ETSI TS101 270-1,VDSL Technical Specification, Part 1: Functional Requirements.

[2] ETSI TS101 270-2, VDSL Technical Specification, Part 2: Transceiver Specification.

[3] Committee T1 T1.424/trial-use, American National Standard for Telecommunication Interface Between Networks and Customer Installations – Very-high Speed Digital Subscriber Lines (VDSL) Metallic Interface, 2002

[4] ANSI TIA/EIA-568A, “Commercial Building Telecommunication Standard”

[5] FS-VDSL Specification Part 2: System Architecture

[6] ITU-T G.993.1 VDSL Foundation

3. Abbreviations and Definitions

3.1. Abbreviations

ANSI	American national standards institute
ATM	Asynchronous transfer mode
AWG	American wire gauge
BER	Bit error ratio
CO	Central office (or local exchange)
CPE	Customer premise equipment
D/S	Downstream
DSL	Digital subscriber line (or loop)
EOC	Embedded operation channel
ETSI	European telecommunication standards institute
FEC	Forward error correction
FS-VDSL	Full service VDSL
FTTCab	Fiber to the cabinet
FTTEx	Fiber to the exchange
ISDN	Integrated services digital network
Mbps	Mega bits per second (1 Mbps =1000 kbits/second)
MCM	Multi-carrier modulation
NT	Network termination
OC	Operation channel
ONU	Optical network unit
PMD	Physical medium-dependent
PMS	Physical medium specific
POTS	Plain old telephone service
PRBS	Pseudo-random binary sequence
PSD	Power spectral density
SCM	Single-carrier modulation
SNR	Signal-to-noise ratio
STP	Set of transmission parameters
TC	Transmission convergence
TPS	Transport protocol specific
UPBO	Upstream power back off
U/S	Upstream
Utopia	Universal test & operations phy interface for ATM
VDSL	Very-high-bit-rate digital subscriber line
VOC	VDSL operation channel
VTPD	VDSL modem with protocol processing and decoding
VTU	VDSL transceiver unit
VTU-C	VTU at the CO
VTU-R	VTU at the remote customer site

4. Reference Model

The VDSL system reference model is shown in Figure 1. The ten vertical dashed lines indicate the ten interfaces for specification.

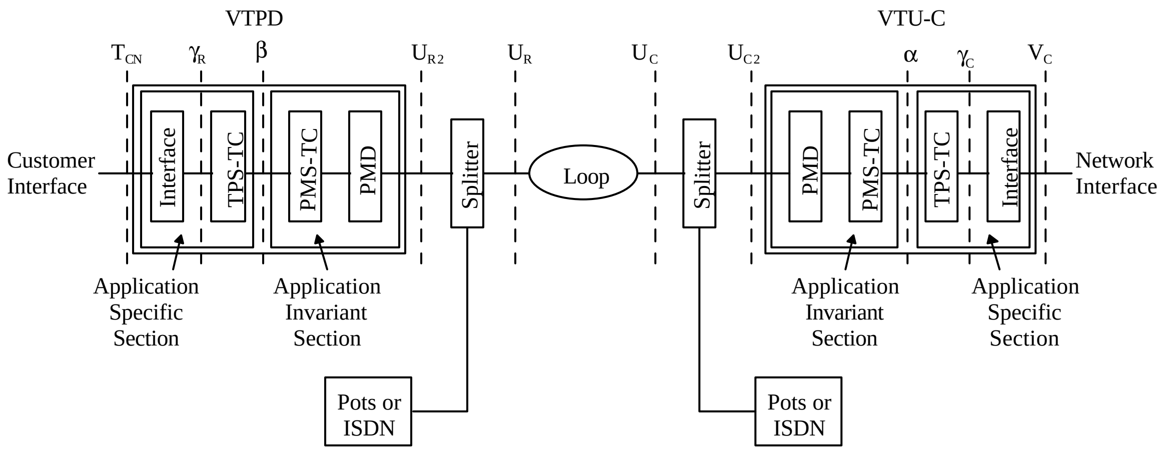

Figure 1 – VDSL System Reference Model

The T_{CN} interface is between the customer and the VTPD. The γ_R interface is between the application and the Transport Protocol-Specific (TPS) processing at the customer end of the line. The TPS-TC interface to the Physical Medium Specific PMS-TC at the customer end of the line is the β interface. U_{R2} interfaces the customer's PMD to the POTS/ISDN Splitter, and U_R is the interface between the customer's splitter to the loop plant.

The V_C interface is between the network and the VTU-C. The γ_C interface is between the application and the Transport Protocol-Specific (TPS) processing at the service-provider end of the line. The TPS-TC interface to the Physical Medium Specific PMS-TC at the service-provider end of the line is the α interface. U_{C2} interfaces the VTU-C's PMD to the POTS/ISDN splitter, and U_C is the interface between the VTU-C's splitter to the loop plant.

5. Physical Interfaces

5.1. Line Interface

The physical implementation of the U_{R2} reference point for interoperable VDSL equipment should be RJ45, as defined in section 10.4.5 of [4]. Pins 4 and 5 shall be used (pair 1 in [4]).

5.2. Utopia Interface

If a physical implementation of the γ_R reference point is provided (that is the ATM cells are readily available for ATM transmission tests), the use of a Utopia interface, as defined in Annex A of [2] is recommended for testing interoperable VDSL equipment. Alternatively the use of an ATM25 interface for systems type A (as defined in section 6.4.3) or an Ethernet interface for systems type B (as defined in section 6.4.3) can be used for that purpose. The ATM or Ethernet interfaces may or may not be a physical implementation of the T_{CN} reference point.

5.3. Customer Interface

The definition of the T_{CN} interface between the customer and the VTPD is given in Part 2 of the FS-VDSL specification [5].

6. Interoperability

6.1. Overview

This section defines the required tests that should be performed in order to verify physical layer interoperability of equipment supplied by different VDSL vendors.
Since both Single- and Multi-Carrier-Modulation-based (SCM and MCM) technologies are defined for VDSL, this section defines interoperability tests for each of these two line codes, maintaining same testing framework where possible.
Tests are defined in ascending order of communication layers and implementation complexity, starting from the PMD functionality.
Tests are applicable to ETSI TS101 270-1 [1], ETSI TS101 270-2 [2] and Committee T1 [3] recommendations that use band plans 998 or 997.

6.2. Tests Scope

The prime purpose of this document is to allow basic physical layer interoperability between different vendors. Rather than testing compliance with all options specified in the VDSL standards, the following modes shall be used:
The band plan to be used in all tests is either 998 or 997.
The PSD masks to be used are defined in Table 11.

The tests defined in this section are designed to demonstrate the following aspects of physical layer interoperability:

- Successful link activation
- Stable steady state transmission
- Exchange of VOC and EOC messages
- ATM cell transport
- Ethernet over ATM transport

6.3. Test Setup

6.3.1 Required Test Equipment

Table 1, below, summarizes the required test equipment for the interoperability tests described in this section. The specific models that are referred to in the table are not mandatory.

Table 1 – Required Test Equipment

Test Equipment	Requirements	Models
Line Simulator -or- Real cables	If a Line Simulator is used, simulation of all loops defined in this document is required. If real cables are used, multiple lengths have to be made available without jointing pairs belonging to the same binder.	DLS-8100 (a.k.a HLS-30), DLS-8200 or any kind of real loops as long as the attenuation function of the loops is made available.
BER tester	Bit Error Ratio measurement, Data rate of up to 40Mbps, All-ones and PRBS generation	Fireberd 6100A
ATM tester	Utopia[1] and ATM25.6 interfaces, Cell loss ratio, Cell error ratio, Dropped cells	Adtech AX-4000
Impairment generator	Capable of generating VDSL impairment noise to ETSI TS101 270-1 [2] and Committee T1 T1.424-trial use [3]	DLS-5200 or any other procedure to generate and inject noise with predefined spectral characteristics into a VDSL receiver, as long as the spectral characteristics can be verified using a spectrum analyzer.
VDSL splitter	Compliant to [1] or [3] as appropriate	Supplied by participant
ATM/Ethernet Frame Tester	Ethernet interface, Performance Measurements	Adtech AX-4000 Smartbits
Spectrum Analyzer	VDSL frequency range (up to 12 MHz) and resolution BW better or equal to 10KHz and high input impedance	Wandel & Goltermann PSM-139 (Sel. Lev. Meas. Set)
Network Analyzer	VDSL frequency range (up to 12MHz)	HP4195A

[1] If Utopia Interface is the only I/F available on the modems, the respective vendor can be asked to provide a way to access it. This could include: 1) a Utopia interface for Adtech AX-4000; 2) a full ATM tester equipped with Utopia interface.

6.3.2 Requirements from Proprietary Monitoring Equipment

Naturally, only the vendors themselves can supply the best monitoring and control tools for the VDSL modem under test.

6.3.3 Typical Test Setup

Figure 2 depicts a typical test setup for the physical layer interoperability tests[2].

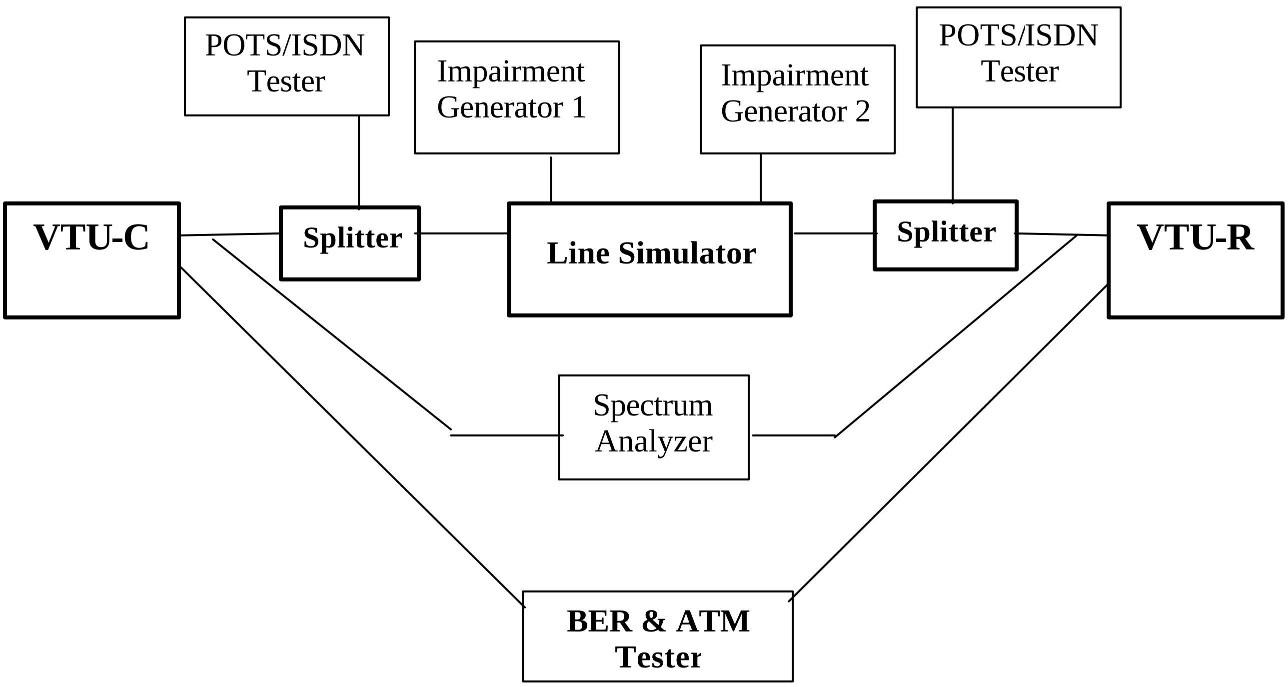

Figure 2 – Test Setup

6.3.4 Physical Interfaces

For BER measurements, test participants may use a vendor-specific interface to a test data generator defined in Table 1. Test participants may use other means to generate test data, as long as they generate common data patterns such as All-ones and common pseudo-random bit sequences.

Interoperability tests are performed over the Utopia interface. For ATM tests, test participants may use a vendor-specific interface to the test equipment specified in Table 1. If they use interfaces other than those specified in Table 1, the test participant is responsible for supplying test equipment to source and monitor data. Test participants may use other means to generate and monitor test data, as long as they generate common data patterns such as 0x55, 0xAA and common pseudo-random bit sequences.

[2] Inclusion of POTS/ISDN splitters for interoperability testing is for further study

6.3.5 Test Validation

Each test is associated with success criteria.
It is required that modems shall meet the success criteria of all tests. It is intended that these tests will be performed at an FS-VDSL operator facility and that results will be certified by that operator.

Tests Set B (Link Activation Tests) defined in section 6.4.2 are divided into 3 types:

M - Mandatory for 2,3 and 4-band-FS-VDSL-compliance certification
M3 - Mandatory for 3 and 4-band-FS-VDSL-compliance certification
M4 - Mandatory for 4-band-FS-VDSL-compliance certification

For each test, the pair of systems under test will be certified as 2,3 or 4-band as described in Table 2 below.

Table 2 – Mandatory interoperability tests

		LT		
		2-band	3-band	4-band
NT	2-band	M	M	M
	3-band	M	M,M3	M,M3
	4-band	M	M,M3	M,M3,M4

A 2-band system uses bands 1D and 1U.
A 3-band system uses bands 1D, 1U and 2D.
A 4-band system uses bands 1D,1U, 2D and 2U.

6.4. Test Procedures

6.4.1 Basic Electrical Tests (Tests Set A)

All basic electrical tests defined in this subsection are mandatory. Tests A.1 and A.3 shall be carried out for each of the Services defined in Table 5 or Table 6.

Table 3 – Basic Electrical Tests

Test #	*Test Purpose*	*Test Setup and Procedure*	*Success Criteria*
A.1	Ensure TX PSD mask and Transmit Power compliance	1. Connect Modems with a long loop 2. Make sure UPBO mechanism at VTU-R is disabled or UPBO is not applied at the chosen distance 3. Connect Spectrum Analyzer to the loop at the transmit side of the relevant VTU (VTU-R for upstream and VTU-C for downstream) 4. Begin initialization 5. Measure PSD and calculate the Transmit Power 6. Repeat steps #1- #5 for all the transmission profiles (bit rates) specified in Table 5 / Table 6, or Table 8 /Table 9.	PSD mask and Transmit Power compliant to relevant standard in upstream and downstream.
A.2	Ensure Transceivers impedance, Return Loss compliance	1. Connect the modem under test to a Network analyzer 2. Power up the system without transmitting any signal 3. Measure input impedance over the whole VDSL frequency band (25 kHz to 12 MHz). 4. Calculate the Return Loss	Return Loss and impedance meet relevant standard.
A.3	Ensure UPBO compliance	1. Connect Modems using null loop. 2. Enable UPBO mechanism at VTU-R 3. Connect Spectrum Analyzer to the loop 4. Begin initialization 5. Verify compliance of UPBO according to the testing method specified in the relevant standard 6. Repeat steps #1- #5 for all the transmission profiles (bit rates) specified in Table 5 / Table 6, or Table 8 /Table 9 using the relevant lengths specified in the same tables. 7. Repeat steps #1- #5 for all the transmission profiles (bit rates) specified in Table 5 / Table 6, or Table 8 /Table 9 using the half the lengths specified in the same tables.	UPBO is compliant to relevant standard

6.4.2 Link Activation Tests (Tests Set B)

The interoperability link activation tests are divided into two tables, one per each line code: Table 4 is for SCM and Table 7 is for MCM. The format used for tests numbering is *B.x.y*, where *x* denotes the link activation test type and *y* denotes the y^{th} test in that type. The following test types (except *B.3.y*) are defined for both SCM and MCM:

B.1.*y* - Basic convergence of a low VDSL rate under relaxed loop conditions
B.2.*y* - Convergence of "FS-VDSL rates" under moderate loop conditions
B.3.*y* - Change of rate tests
B.4.*y* - Failure to converge tests
B.5.*y* - Stability test after convergence
B.6.*y* - Deactivation tests
B.7.*y* - Link Activation procedures functionality tests

In all tests in this section, the PSD and noise models (if used) shall be as specified in Table 11 for the applicable deployment scenario. Units designed for FTTEx and FTTCab applications shall be tested independently for interoperability, as shall units implementing ETSI and Committee T1 Recommendations. For ETSI-based FTTEx applications, the Pex.P1.M1 or Pex.P1.M2 PSD should be chosen where units are expected to coexist with ADSL over ISDN services, and the Pex.P2.M1 or Pex.P2.M2 PSD should be chosen otherwise. All tests in this section shall be done with UPBO enabled, according to the relevant standard.

Notes:

1. Throughout this section, the term "Steady State Transmission" (used in Committee T1 document [3]) is equivalent to the term "Full Duplex Transmission" (used in the ETSI document [2]); both describe the same state in the link activation state diagram. The same applies for the term "Idle" (used in [3]) which is equivalent to "Deactivated Power Save" (used in [2]), and for the term "Power-Off" (used in [3]) which is equivalent to "Installation or Service Change" (used in [2]).
2. Only achievement of "Steady State Transmission" is required in all Link Activation Tests – ATM data transport is not required.
3. The MCM activation tests are split in two groups of tests. In the first series (B.1 tests) the modems are required to achieve a given fixed rate ("Fixed rate tests"). In the second series of tests (B.2 to B.7), the two modems will negotiate the achievable bit rate ("Rate adaptive tests").
4. Data rates #2, #3 and #4 specified in Table 5 and Table 6 are taken from the relevant ETSI and Committee T1 standards. These data rates have been pointed out by operators as relevant to their deployment objectives. On the other hand, each of them is suitable to check interoperability between modems that use respectively two, three and four bands. Data rate #1 has been considered as it is useful to check the interoperability at a very basic stage (*Basic convergence under relaxed conditions*).
5. During the MCM activation tests, the maximum number of bits per carrier should be negotiated and can be between 8 and 15 bits.

Table 4 – Link Activation Tests – SCM procedures

Test #	***M***	***Test Purpose***	***SCM Test Setup and Procedure***	***SCM Success Criteria***
B.1.1	M	Basic convergence under relaxed conditions	1. Connect the modems with null loop with impairment generators turned off (no noise[3]) 2. Configure the modems to work at lowest rate (#1 in Table 5 or Table 6) 3. Start initialization	"Steady State Transmission"
B.1.2	M	Basic convergence under moderate noiseless conditions	1. Connect the modems with the loop specified in column 1 of Table 5 or Table 6 and with impairment generators turned off 2. Configure modems to work at lowest rate (#1 in Table 5 or Table 6) 3. Start initialization	"Steady State Transmission"
B.1.3	M	Basic convergence under moderate noise conditions	1. Connect the modems with the loop specified in column 1 of Table 5 or Table 6 and apply the noise specified the appropriate column of Table 11 2. Configure the modems to work at lowest rate (#1 in Table 5 or Table 6) 3. Start initialization	"Steady State Transmission"
B.1.4[4]	M	Basic convergence using Interleaver	1. Connect modems as in B.1.3, but with interleaver set to I= 25 and M=10 2. Configure the modems to work at lowest rate (#1 in Table 5 or Table 6) 3. Start initialization	"Steady State Transmission"
B.2.1[5]	M	Convergence of 2-band	1. Connect the modems with the loop specified in column 2 of Table 5 or Table 6 and apply the noise specified the appropriate column of Table 11 2. Configure the modems to work at rate #2 in Table 5 or Table 6 3. Start initialization	"Steady State Transmission"
B.2.2[4]	M3	Convergence of 3-band	1. Connect the modems with the loop specified in column 3 of Table 5 or Table 6 and apply the noise specified in the appropriate column of Table 11 2. Configure the modems to work at rate #3 in Table 5 or Table 6 3. Start initialization	"Steady State Transmission"
B.2.3[4]	M4	Convergence of 4-band	1. Connect the modems with the loop specified in column 4 of Table 5 or Table 6 and apply the noise specified in the appropriate column of Table 11 2. Configure the modems to work at rate #4 in Table 5 or Table 6 3. Start initialization	"Steady State Transmission"
B.3.1	M	Change to a	1. Achieve steady state transmission with rate #1 in	"Steady State Transmission"

[3] Also no self -Xtalk from other adjacent modems (e.g. on the same line card, etc.)

[4] All SCM tests include FEC. There is only one setting, so multiple FEC tests are not required

[5] This test shall be performed without notched PSDs using the "loop length" defined in Table 5 or Table 6. For modems that are required to support notched PSDs this test shall be performed also using the loop lengths for notched PSD" defined in table 5

Test #	*M*	*Test Purpose*	*SCM Test Setup and Procedure*	*SCM Success Criteria*
		2-band rate	Table 5 or Table 6 using half the loop specified in column 2 of Table 5 or Table 6 and the noise specified in the appropriate column of Table 11 2. Change to rate #2 in Table 5 or Table 6	
B.3.2	M3	Change to a 3-band rate	1. Achieve steady state transmission with rate #2 in Table 5 or Table 6 using the loop specified in column 3 of Table 5 or Table 6 and the noise specified the appropriate column of Table 11 2. Change to rate #3 in Table 5 or Table 6	"Steady State Transmission"
B.3.3	M4	Change to a 4-band rate	1. Achieve steady state transmission with rate #2 in Table 5 or Table 6 using the loop specified in column 4 of Table 5 or Table 6 and the noise specified the appropriate column of Table 11 2. Change to rate #4 in Table 5 or Table 6	"Steady State Transmission"
B.4	M	Failure to converge	1. Terminate the loop with an open circuit 2. Start initialization from "Cold Start" and attempt to converge at rate #2 in Table 5 or Table 6 - link (both modems) should fall to "Power-Off"	"Power-Off" in both VTU-C and VTU-R
B.5.1	M	Stability test	1. Achieve steady state transmission as in B.1.3 2. Stay converged for 10 minutes, with $BER<10^{-7}$	Stay at "Steady State Transmission" for 10 minutes
B.5.2	M	Recovery from noise-impair ment test	1. Achieve steady state transmission" as in B.1.3 2. Increase noise at VTU-C to an excessive level in purpose to cause a loss of link 3. Remove the excessive level of noise	"Steady State Transmission" re-established after 5.5,10.5 or 35.5 seconds, depending on standard and on duration of interference (Warm Start or Cold Start)
B.5.3	M	Recovery from disconnection	1. Achieve steady state transmission as in B.1.3 2. Physically disconnect the line connection between the VTU-C and VTU-R 3. Re-connect	"Steady State Transmission" re-established after 5.5,10.5 or 35.5 seconds, depending on standard and on duration of disconnection (Warm Start or Cold Start)
B.6	M	Deactivation	1. Achieve "Steady State Transmission" as in B.2.1. 2. Issue a "Quiet" command.	"Power-Down" in both VTU-C and VTU-R
B.7.1	M	Cold start functionality	1. Connect the modems as in B.1.3 2. Verify that both VTU-C and VTU-R are in "Power-Off" 3. Issue "power-up request"	"Steady State Transmission" after no more than 10 (or 30, depending on standard) seconds.
B.7.2	M	Warm start functionality	1. Achieve "Power Down" as in B.6 2. Issue "power-up request"	"Steady State Transmission", at the same rate #2 after no more than 5 seconds

Table 5 – SCM Parameters for Tests Set B (Section 6.4.2) for Plan 998

STP #		*1*	*2*	*3*	*4*
Number of Bands		*2-band*	*2-band*	*3-band*	*4-band*
D/S payload rate Mbps		*1.207*	*9.653*	*23.168*	*15.445*
US payload rate Mbps		*1.207*	*2.172*	*4.223*	*14.721*
Loop Length (ft)[6]		*3200*	*3000*	*2000*	*1000*
Loop Length (m)[7]		*1300*	*1200*	*600*	*300*
Loop Length for notched PSD(ft)[7]		*3200*	*2400*	*1200*	*600*
Loop Length for notched PSD(m)[8]		*1300*	*700*	*300*	*150*
1D	*1D_SR*	*10*	*32*	*32*	*32*
	1D_C	*4*	*32*	*256*	*64*
	1D_CF	*40*	*66*	*66*	*66*
1U	*1U_SR*	*10*	*12*	*14*	*14*
	1U_C	*4*	*8*	*32*	*64*
	1U_CF	*132*	*132*	*134*	*134*
2D	*2D_SR*	-	-	*32*	*32*
	2D_C	-	-	*16*	*4*
	2D_CF	-	-	*204*	*204*
2U	*2U_SR*	-	-	-	*32*
	2U_C	-	-	-	*32*
	2U_CF	-	-	-	*312*

Notes
1. All tests are performed using the mandatory [0/0] frame format.
2. For the tests in Table 4, unless otherwise specified, the Interleaver is disabled.

Parameters Legend:
SR - Symbol Rate (multiples of 67.5kHz)
C - Constellation (4-256)
CF - Carrier Frequency (multiples of 33.75kHz)

STPs description:
#1 - 2-band DF_STP
#2 - 2-band ETSI A2-02OAG-R1 Profile Code
#3 - 3-band Committee T1 AM-01ON Profile Code
#4 - 4-band ETSI S3-00OAG-R1 Profile code

6 For ANSI Loop 1 (TP1). The loop lengths herein inserted are neither representative of the true capabilities of VDSL in real access network nor in standard noise environment

7 For ETSI Loop 1 (TP100). The loop lengths herein inserted are neither representative of the true capabilities of VDSL in real access network nor in standard noise environment

Table 6 – SCM Parameters for Tests Set B (Section 6.4.2) for Plan 997

STP #		*1*	*2*	*3*	*4*
Number of Bands		*2-band*	*2-band*	*3-band*	*4-band*
D/S payload rate Mbps		*1.207*	*8.688*	*14.480*	*14.480*
US payload rate Mbps		*1.207*	*2.172*	*3.258*	*14.480*
Loop Length (ft)[8]		*4500*	*4000*	*2000*	*1000*
Loop Length (m)[9]		*1350*	*1200*	*600*	*300*
Loop Length for notched PSD(ft)[9]		*4500*	*2400*	*1200*	*600*
Loop Length for notched PSD(m)[10]		*1350*	*700*	*300*	*150*
1D	*1D_SR*	*10*	*24*	*24*	*24*
	1D_C	*4*	*64*	*128*	*128*
	1D_CF	*40*	*56*	*56*	*56*
1U	*1U_SR*	*10*	*18*	*18*	*24*
	1U_C	*4*	*4*	*8*	*32*
	1U_CF	*132*	*114*	*114*	*122*
2D	*2D_SR*	-	-	*18*	*18*
	2D_C	-	-	*16*	*16*
	2D_CF	-	-	*186*	*186*
2U	*2U_SR*	-	-	-	*40*
	2U_C	-	-	-	*8*
	2U_CF	-	-	-	*282*

Notes

1. All tests are performed using the mandatory [0/0] frame format.
2. For the tests in Table 4, unless otherwise specified, the Interleaver is disabled.

Parameters Legend:

SR - Symbol Rate (multiples of 67.5kHz)
C - Constellation (4-256)
CF - Carrier Frequency (multiples of 33.75kHz)

STPs description:

#1 - 2-band DF_STP
#2 - 2-band ETSI A2-02OAG-M Profile Code
#3 - 3-band ETSI A3-01OAG-M Profile Code
#4 - 4-band ETSI S3-00OAG-M Profile code

[8] For ANSI Loop 1 (TP1). The loop lengths herein inserted are neither representative of the true capabilities of VDSL in real access network nor in standard noise environment

[9] For ETSI Loop 1 (TP100). The loop lengths herein inserted are neither representative of the true capabilities of VDSL in real access network nor in standard noise environment

Table 7 – Link Activation Tests – MCM procedures

Test #	***M/O***	***Test Purpose***	***MCM Test Setup and Procedure***	***MCM Success Criteria***
B.1.1	M	Basic fixed data rate test	1. Connect the modems in null loop & impairment generators off 2. Configure the modems according to configuration #4 in Table 8 or Table 9 3. Start initialization	Modems reach ShowTime[10] at the specified rate
B.1.2	M	Basic fixed data rate test on non-null loop	1. Connect the modems with the loop specified in row 4 of Table 8 or Table 9 and with impairment generators turned off 2. Configure the modems according to configuration #4 in Table 8 or Table 9 3. Start initialization	Modems reach Show Time at the specified rate
B.1.3	M	Basic fixed data rate test with noise on non-null loop	1. Connect the modems with the loop specified in row 4 of Table 8 or Table 9 and apply the noise specified the appropriate column of Table 11 2. Configure the modems according to configuration #4 in Table 8 or Table 9 3. Start initialization	Modems reach Show Time at the specified rate
B.1.4	M	Basic Fixed Rate test with FEC	1. See B.1.3 2. Successively apply each of the FEC settings in Table 10	Modems reach Show Time at the specified rate
B.2.1[11]	M2	Basic Rate adaptation test (2 band plan)	1. Connect the modems with the loop specified in row 2 of Table 8 or Table 9 and apply the noise specified the appropriate column of Table 11 2. Used spectrum is limited to 5.2 MHz or 5.1 MHz accordingly to the spectral plan (998 and 997 respectively) 3. Start initialization – the modems negotiate the achievable rate	Modems reach Show Time with a data rate = the rate specified in Row 2 of Table 8 or Table 9
B.2.2[10]	M3	Basic Rate adaptation test (3 band plan)	1. Connect the modems with the loop specified in row 1 of Table 8 or Table 9 and apply the noise specified the appropriate column of Table 11 2. Used spectrum is limited to 8.5 MHz or 7.05 MHz accordingly to the spectral plan (998 and 997 respectively) 3. Start initialization – the modems negotiate the achievable rate	Modems reach Show Time with a data rate = the rate specified in Row 1 of Table 8 or Table 9
B.2.3[10]	M4	Basic Rate adaptation test (4 band plan)	1. Connect the modems with the loop specified in row 3 of Table 8 or Table 9 and apply the noise specified the appropriate column of Table 11. 2. Used spectrum is limited to 12 MHz 3. Start initialization – the modems negotiate the achievable rate	Modems reach Show Time with a data rate = the rate specified in row 3 Table 8 or Table 9.
B.4	M	Failure test	1. Terminate the loop with an open circuit 2. Modems attempt to initialize at highest data rate in Table 8 or Table 9	Modems return to power down

[10] "reach ShowTime" means that both modems conclude the initialization correctly. No data transfer is required yet at this point.

[11] This test shall be performed without notched PSDs using the "Without Notching" columns defined in tables 8 and 9. For modems that are capable of supporting notched PSDs this test shall be performed also using the "With notching" columns defined in tables 8 and 9.

Test #	M/O	Test Purpose	MCM Test Setup and Procedure	MCM Success Criteria
			3. When failing to achieve the requested rate, modems return to power down	
B.5.1	M	Stability test	1. Connect modems as in B.1.3. 2. Maintain connection for 10 minutes. 3. Estimate BER using the Frame Error count.	Remain converged for 10 minutes, with data pump BER<10^{-7}.
B.5.2	M	Recovery from noise-impairment test	1. Achieve "Steady State Transmission" as in B.1.3. 2. Increase noise at VTU-C to an excessive level in purpose to cause a loss of link. 3. Remove the excessive level of noise.	"Steady State Transmission" re-established after 5.5,10.5 or 35.5 seconds, depending on standard and on duration of interference (Warm Start or Cold Start)
B.5.3	M	Recovery from disconnection	1. Achieve "Steady State Transmission" as in B.1.3. 2. Physically disconnect the line connection between the VTU-C and VTU-R. 3. Re-connect.	"Steady State Transmission" re-established after 5.5,10.5 or 35.5 seconds, depending on standard and on duration of disconnection (Warm Start or Cold Start)
B.6	M	Deactivation test	1. Connect modems as in B.1.3. 2. Issue "Power Down" command.	Modems exit ShowTime and go to Power Down
B.7	M	Startup duration test	Duration of initialization shall be in conformance with relevant standards.	

Table 8 – Service settings for MCM Fixed rate tests for Plan 998

	Downstream Payload Rate (kbps)	*Upstream Payload Rate (kbps)*	*Loop Length[12] (ft)*	*Loop Length[13] (m)*	*Loop Length for notched PSD[11] (ft)*	*Loop Length for notched PSD[12] (m)*	*Class of Operation*
1	23 168	4 096	2000	600	1000	300	ETSI-A4
2	8 576	2 048	4000	1200	2000	600	ETSI-A2
3	14 464	14 464	1000	300	500	150	ETSI-S3
4	1 500	1 500	4000	1200	3000	1200	Low rate

[12] For ANSI Loop 1 (TP2). The loop lengths herein inserted are neither representative of the true capabilities of VDSL in real access network nor in standard noise environment

[13] For ETSI Loop 1 (TP100). The loop lengths herein inserted are neither representative of the true capabilities of VDSL in real access network nor in standard noise environment

Table 9 – Service settings for MCM Fixed rate tests for Plan 997

	Downstream Payload Rate (kbps)	*Upstream Payload Rate (kbps)*	*Loop Length[14] (ft)*	*Loop Length[15] (m)*	*Loop Length for notched PSD[13] (ft)*	*Loop Length for notched PSD[14] (m)*	*Class of Operation*
1	14 464	3 072	2000	600	1000	300	ETSI-A3
2	8 576	2 048	3000	900	1500	450	ETSI-A2
3	14 464	14 464	1000	300	500	150	ETSI-S3
4	1 500	1 500	4000	1200	3000	1200	Low rate

Table 10 – FEC settings for MCM interoperability tests

	FEC	*Interleaver*
1	-	-
2	*(N,K)=(240,224)*	-
3	*(N,K)=(240,224)*	*(I,M)=(30,2)*

Table 11 – ETSI and Committee T1 parameters

Parameter	*ETSI FTTCab*	*ETSI FTTEx*	*Committee T1 FTTCab*	*Committee T1 FTTEx*
Noise Scenario	U8.cab+D8.cab plus 20 self-Xtalk[16]	U5.ex+D5.ex plus 20 self-Xtalk[16]	Noise models A plus 20 self-Xtalk and –140dBm/ Hz background noise	Noise models F plus 20 self-Xtalk and –140dBm/ Hz background noise
PSD Mask	Pcab.P.M1 or Pcab.P.M2[17]	Pex.P1.M1, Pex.P2.M1, Pex.P1.M2 or Pex.P2.M2[18]	FTTCab Mask 1	FTTEx Mask 1

[14] For ANSI Loop 1 (TP2). The loop lengths herein inserted are neither representative of the true capabilities of VDSL in real access network nor in standard noise environment

[15] For ETSI Loop 1 (TP100). The loop lengths herein inserted are neither representative of the true capabilities of VDSL in real access network nor in standard noise environment

[16] The 20 VDSL disturbers composing the self crosstalk noise shall be equal to the VDSL nominal PSD as defined in the relevant standard

[17] One or more of the specified masks may be used.

[18] One or more of the specified masks may be used.

6.4.3 Connectivity Tests (Tests Set C)

The purpose of the connectivity tests is to verify interoperability between systems at the ATM or Ethernet layers. These tests are intended for those systems that have either ATM, Utopia or Ethernet interfaces available in the relevant equipment (VTU-C and/or VTPD). The tests are divided into two system types, depending on the interface availability at the VTPD. The different system types are:

System Type A – The VTU-R has an ATM or Utopia interface available
System Type B – The VTPD has an Ethernet interface available

In order to be able to perform all[19] Type A tests, the VTU-C should have either an ATM interface (e.g. STM-1) available or an Utopia interface available. An ATM interface should be available at the VTU-C in order to be able to perform all Type B tests. The tests assume modems are at "Steady State Transmission" or "Showtime", and margin is better than 0dB.

Table 12 –Connectivity Tests

Test #	***System Type***	***Test Purpose***	***Test Setup and Procedure***	***Success Criteria***
C.1.1	A	One ATM cell from VTU-C to VTU-R	1. Connect the ATM tester to both the VTU-C and VTU-R via ATM or Utopia interface 2. Configure the ATM tester to transmit one ATM cell with the content of 'AA', VPI=1 and VCI=33 3. Send this cell from VTU-C 4. Check the received content at the VTU-R	One cell successfully received at VTU-R; content identical to transmitted cell; no HEC errors
C.1.2	A	One ATM cell from VTU-R to VTU-C	1. Connect the ATM tester to both the VTU-C and VTU-R via ATM or Utopia interface 2. Configure the ATM tester to transmit one ATM cell with the content of 'AA', VPI=1 and VCI=33. 3. Send this cell from VTU-R 4. Check the received content at the VTU-C	One cell successfully received at VTU-C; content identical to transmitted cell; no HEC errors
C.1.3	B	One Ethernet frame (encapsulated in an AAL 5 PDU) from VTU-C to VTU-R	1. Connect the Ethernet over ATM tester to both the VTU-C and VTU-R, using respectively an ATM interface (e.g. STM-1) and a 10/100 Base-T interface. 2. Configure the ATM Generator connected to the VTU-C to transmit one AAL5 PDU containing an Ethernet frame of length 64 bytes with LLC/SNAP encapsulation without FCS,	One frame successfully received at VTU-R; content of the frame identical to the encapsulated frame transmitted at VTU-C side

[19] Test C.2.2 may be performed w/o an ATM or Utopia interface available at the VTU-C

Test #	*System Type*	*Test Purpose*	*Test Setup and Procedure*	*Success Criteria*
			and send the PDU over the PVC (VPI=1 and VCI=33). 3. Send the test PDU to the VTU-C 4. Check the received frame at the VTU-R 5. Repeat the above with frame length of 1518 bytes.	
C.1.4	B	One Ethernet frame from VTU-R to VTU-C	1. Connect the Ethernet over ATM tester to both the VTU-C and VTU-R, using respectively an ATM interface (e.g. STM-1) and a 10/100 Base-T interface. 2. Configure the Ethernet Generator connected to the VTU-R to transmit one Ethernet frame of length 64 bytes. 3. In order to make sure the traffic generated in upstream by the modem is forwarded over the PVC with VPI = 1 and VCI = 33, send some downstream traffic over the same PVC to update the aging table of the learning bridge included in the VTPD. 4. Send the test Ethernet frame to the VTU-R 5. Check the received content at the VTU-C analysing the AAL5 PDU received 6. Repeat the above with frame length of 1518 bytes.	One frame successfully received at VTU-C; the frame should be contained in an AAL5 PDU and encapsulated LLC/SNAP without FCS.
C.2.1	A and B	ATM Loop-back at VTU-R	1. Set up the modems to a payload rate greater than 1.2Mbps on both D/S and U/S 2. Connect the ATM tester to the VTU-C via the ATM or Utopia interface 3. Configure the ATM tester to work bi-directional with VPI=1 and VCI=33, using a PRBS sequence (e.g. PRBS9 = $X^9 + X^5 + 1$) to fill the transmitted cells, working at flat (CBR) rate of 0.6Mbps. 4. Configure the VTU-R to loop back this VPI/VCI on the ATM-TC layer (*i.e.*, loop back occurs after cell delineation and de-scrambling). 5. Measure the Cell loss ratio on the ATM tester over a period of more than five minutes.	No Cell loss
C.2.2	A	ATM Loop-back at VTU-C	1. Set up the modems to a payload rate greater than 1.2Mbps on both D/S and U/S 2. Connect the ATM tester to the VTU-R via the ATM or Utopia interface 3. Configure the ATM tester to work bi-directional with VPI=1 and VCI=33,	No Cell loss

Test #	***System Type***	***Test Purpose***	***Test Setup and Procedure***	***Success Criteria***
			using a PRBS sequence (e.g. PRBS9 = $X^9 + X^5 + 1$) to fill the transmitted cells, working at flat (CBR) rate of 0.6Mbps. 4. Configure the VTU-C to loop back this VPI/VCI on the ATM-TC layer (*i.e.*, loop back occurs after cell delineation and de-scrambling). 5. Measure the cell loss ratio on the ATM tester over a period of more than five minutes.	
C.3.1	A	Bi-directiona l ATM transmission	1. Set up the modem to a VDSL service with payload rates greater than 1.2Mbps for D/S and greater than 1.2Mbps for U/S. 2. Connect the ATM tester to both the VTU-C and VTU-R ATM interface 3. Configure the ATM tester to work bi-directional with VPI=1 and VCI=33, using a PRBS sequence (e.g. PRBS9 = $X^9 + X^5 + 1$) to fill the transmitted cells, working at flat (CBR) rate of 0.6Mbps on D/S and 0.6Mbps on U/S. 4. Measure the Cell loss ratio on the ATM tester on both ends over a period of more than five minutes.	No Cell loss
C.3.2	B	Bi-directiona l Ethernet transmission	1. Set up the modems to a VDSL service with payload rates greater than 1.2Mbps for D/S and greater than 1.2Mbps for U/S. 2. Connect the Ethernet over ATM tester to both the VTU-C and VTU-R, using respectively an ATM interface (e.g. STM-1) and a 10/100 Base T interface 3. Configure the tester to work bi-directional at a physical rate of around 0.6Mbps on D/S and 0.6Mbps on U/S (Ethernet overhead excluded). 4. Measure the performance of the Ethernet transmission on both ends over a period of more than five minutes.	No Frame loss and no AAL5 PDU loss

6.4.4 Operation Channel Connectivity (Tests Set D)

The purpose of the OC connectivity tests is to verify that the VTU-C and the VTU-R can communicate via the Operation Channel. The tests assume modems are at "Steady State Transmission" or "Showtime", and margin is better than 0dB.

Table 13 – Operation Channel Connectivity Tests

Test #	***M/O***	***Test Purpose***	***Test Setup and Procedure***	***Success Criteria***
D.1	M	VTU-C read Line Attenuation and SNR or SNR margin from VTU-R	1. Issue "Return to Normal" (RTN[20]) commands from VTU-C to put VTU-R state machine in a known state. 2. Issue EOC Read command from VTU-C to verify VTU-R Line Attenuation. 3. Issue EOC Read command from VTU-C to verify VTU-R SNR or SNR margin.	VTU-R responds by either UTC or valid Line Attenuation and SNR or SNR margin
D.2	M	VTU-C read Vendor ID of VTU-R	1. Issue "Return to Normal" (RTN) commands from VTU-C to put VTU-R state machine in a known state. 2. Issue EOC Read command from VTU-C to verify VTU-R vendor ID. 3. VTU-R should respond by changing state and reply with a valid byte 4. Issue NEXT command from VTU-C 5. VTU-R should acknowledge request and forward next byte in the multi-byte message, and issue EOD after last byte of message is sent	Correct vendor ID received at VTU-C
D.3.1	M	Clear EOC from VTU-C to VTU-R	1. Send Clear EOC octet with data "AA" from VTU-C. .	VTU-R should acknowledge receipt of octets
D.3.2	M	Clear EOC from VTU-R to VTU-C	1. Send Clear EOC octet with data "AA" from VTU-R.	VTU-C should acknowledge receipt of octets

[20] For a description of the EOC commands, refer to section 7.6 in [2] and section 10.6 in [3]