



## Reference Specification

for

## Very-High-Speed Digital Subscriber Line (VDSL) System

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### NOTICE

**This Reference Specification is subject to review and revision.**

**Reference Specifications and Guides are either one of the following types of documents:**

- i. Informative and interim documents on customer equipment standards which are yet to be adopted by the network operators and where standardisation is still in progress.**
- ii. Informative documents describing the network standards adopted by the Public Telecommunication Networks in Singapore.**

## PART A INTRODUCTION

### 1. SCOPE

- 1.1** This Specification outlines the requirements for transceivers to use Very-high-speed Digital Subscriber Line (VDSL) technology to provide high bit rate digital transmission on metallic, unshielded wire pairs. It is derived from the ITU-T Recommendation G.993.1 (06/2004). VDSL is an access technology that exploits the existing infrastructure of copper wires and extends the copper-wire spectrum to 12 MHz. In comparison, the spectrum for the Plain Old Telephone Services (POTS) is limited to 4 kHz while the spectrum for the ADSL/HDSL is 1 MHz. G.993.1 VDSL can be deployed from Central Offices or from fibre-fed cabinets located near the customer premises.
- 1.2** Part B of the Specification reflects a VDSL standard that is using Frequency Division Duplexing (FDD), frequency band plans (Plan 997 and 998), Upstream Power Back-Off (UPBO) method and Multi-carrier Modulation (DMT technology) in the Physical Medium Dependent (PMD) layer. As an indication to the industry that the preferred line coding for VDSL is DMT, implementation specific to the QAM technology will not be recommended for adoption (Annex I/G.993.1). ITU-T has agreed that the subsequent VDSL standard development shall be based on DMT and the VDSL2 Recommendation will specify only DMT modulation.
- 1.3** The ITU-T Recommendation G.993.1 includes world-wide frequency plans that allow asymmetric and symmetric services in the same group of wire pairs (known as a binder). This is accomplished by designating bands for the transmission of upstream and downstream signals. The G.993.1 transceivers must overcome many types of ingress interference from radio and other transmission techniques that occur in the same frequencies of typical deployment scenarios. Similarly, the G.993.1 transmission power levels have been designed to minimize potential egress interference into other transmission systems.

### 2. GENERAL REQUIREMENTS

- 2.1** The reference configuration used for the G.993.1 VDSL is shown in Figure 1. It is essentially a Fibre to Node architecture with an Optical Network Unit (ONU) sited in the Local Exchange or Central Office.

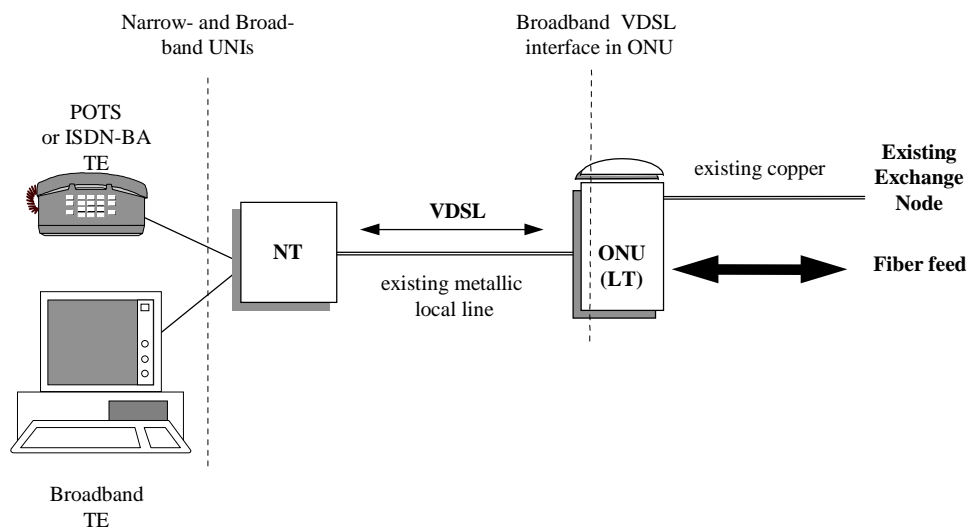


FIGURE 1 (Figure 5-1/ITU-T REC. G.993.1):  
General Reference Model

- 2.2** Application of VDSL technology is found in the transport of various protocols, and different application requirements have been developed for the Transport Protocol Specific – Transmission Convergence Layer (TPS-TC). This Specification defines the functional requirements for the transport of ATM and PTM.
- 2.3** The VDSL service should non-invasively coexist with the narrow-band services on the same pair. Failure of power to the broadband NT or failure of the VDSL service shall not affect any existing narrow-band services. This implies that the splitter filter is of a passive nature not requiring external power in order to provide frequency separation of the VDSL and existing narrow-band signals.
- 2.4** POTS, if present, shall continue to be powered from the existing exchange node and a DC path is required from the local exchange to the customer telephone. Similarly a DC path is required for ISDN-BA in order to provide remote power feeding to the ISDN-BA NT (and that emergency power can be provided by the local exchange for one ISDN terminal in the event of loss of power at the subscriber premises).
- 2.5** POTS and ISDN-BA cannot exist simultaneously on the same pair at present. Network Operators may provide one or the other but not both over a single wire-pair. Network Operators may choose to provide VDSL on access lines without any narrow-band services.
- 2.6** The broadband NT is not required to be powered remotely. Repeater operation is not a requirement for the G.993.1 VDSL.

**3. SAFETY REQUIREMENTS**

The VDSL equipment shall be tested for compliance with the International Electrotechnical Commission IEC 60950 safety standard<sup>1</sup>. The requirements in IEC 60950 that are applicable to the equipment (e.g. class of equipment, type of TNV circuit and types of components) shall be identified and complied with.

**4. REFERENCES**

ITU-T Rec. G.993.1 (06/2004)	Very-high-speed Digital Subscriber Line Foundation
ETSI TS 101 270-1 v1.3.1 (2003-07)	Very-high-speed Digital Subscriber Line (VDSL); Part 1: Functional Requirements
ETSI TS 101 270-2 v1.2.1 (2003-07)	Very-high-speed Digital Subscriber Line (VDSL); Part 2: Transceiver Specification
ATMF <i>UTOPIA Level 2</i> , Version 1.0, June 1995	ATM Forum Specification af-phy-0039.000
ANSI T1.424	VDSL Metallic interface
IEC CISPR 22: 1997	Information Technology Equipment – Radio Disturbance Characteristics – Limits and Methods of Measurement
IEC 60950	International Electrotechnical Commission - Safety of Information Technology Equipment

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<sup>1</sup> The safety standard includes, among others, protection of telecommunications network service personnel and users of other equipment connected to the network from hazards in the VDSL equipment.

**ABBREVIATIONS**

ADSL	Asynchronous Digital Subscriber Line
ATM	Asynchronous Transfer Mode
DMT	Discrete Multi-Tone
DS	Downstream
DSL	Digital Subscriber Line
EIO	External Interface Adapter
eoc	Embedded Operations Channel (between the VTU-O and VTU-R)
FDD	Frequency Division Duplexing
FEC	Forward Error Correction
HDSL	High-speed Digital Subscriber Line
HEC	Header Error Control
ISDN	Integrated Services Digital Network
LCD	Loss of Cell Delineation
LT	Line Termination
MIB	Management Information Base
MSB	Most Significant Bit
NT	Network Termination
NTR	Network Timing Reference
OAM	Operations, Administration and Maintenance
OC	Overhead Channel
ONU	Optical Network Unit
PHY	Physical Layer
PMD	Physical Media Dependent
PMS	Physical Media Specific
PMS-TC	Physical Media Specific-Transmission Convergence
PSD	Power Spectral Density
PTM	Packet Transfer Mode
QAM	Quadrature Amplitude Modulation
QoS	Quality of service
RF	Radio Frequency
TC	Transmission Convergence
TCM	Time Compression Multiplex
TPS	Transmission Protocol Specific
TPS-TC	Transmission Protocol Specific-Transmission Convergence
TX	Transmitter
UPBO	Upstream Power Back-off
US	Upstream
VDSL	Very high-speed Digital Subscriber Line
VTU	VDSL Transceiver Unit
VTU-O	VTU at the ONU
VTU-R	VTU at the Remote site
VTU-x	Any one of VTU-O or VTU-R
xDSL	Generic term covering the family of all DSL technologies, e.g. DSL, HDSL, ADSL, VDSL

**Note:**

The following notations are used in the Specification:

- CR Conformance requirement defines features and functions which must be supported at minimum.
- M Mandatory requirements
- O Optional requirements (If the function is implemented, it is "M" to comply with requirements specified under the clause.)
- NA Not Applicable
- GID General Information and Definitions

**PART B VERY-HIGH-SPEED DIGITAL SUBSCRIBER LINE**

(Based on ITU-T Rec. G.993.1, 06/2004)

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<b>SCOPE AND APPLICATIONS</b>	<b>1</b>		GID
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<b>ABBREVIATIONS</b>	<b>4</b>		GID
<b>REFERENCE MODELS</b>	<b>5</b>		GID
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<b>Functional Reference Model</b>	<b>5.2</b>		GID
<b>Protocol Reference Model</b>	<b>5.3</b>		GID
<b>TRANSMISSION MEDIUM INTERFACE CHARACTERISTICS</b>	<b>6</b>		GID
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Stop Bands	6.2.2		M
PSD reduction function in the frequency region below 1.104MHz	6.2.3		M
Egress Control	6.2.4		M
<b>Upstream Power Back Off (UPBO)</b>	<b>6.3</b>	Heading	–
Power Back-off Mechanism	6.3.1		M
Power Back-off Mask	6.3.2		M
<b>Termination impedance</b>	<b>6.4</b>	Value of $R_V$ is regionally specific. For some regions the value of $R_V$ is presented in G.993.1/Annexes D, E, and F.	M
<b>Return loss</b>	<b>6.5</b>	In-band return loss $\geq 12$ dB Out-of-band return loss $\geq 3$ dB	M
<b>Output signal balance</b>	<b>6.6</b>	OSB of the VDSL transceiver shall be $\geq 35$ dB in the entire VDSL band.	M
<b>TPS-TC SUBLAYER GENERAL FUNCTIONAL CHARACTERISTICS</b>	<b>7</b>	The physical layer shall be able to transport at least one of ATM or PTM signals. See G.993.1/Annexes G and H for the specifics of these TPS-TC Applications.	M
<b><math>\alpha/\beta</math> Interface Specification</b>	<b>7.1</b>		M
<b>OC TPS-TC Application Interface (<math>\gamma_O, \gamma_R</math>) Description</b>	<b>7.2</b>		M
<b>PMS-TC SUBLAYER</b>	<b>8</b>		GID
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<b>Scrambler</b>	<b>8.2</b>		M
<b>Forward error correction</b>	<b>8.3</b>		M
<b>Interleaving</b>	<b>8.4</b>		M
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Title	ITU-T Rec. G.993.1	Comments	CR
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Tone Spacing	9.2.1.1		M
Data sub-carriers	9.2.1.2		O
Modulation by the inverse Fourier transform (IDFT)	9.2.1.3		M
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Synchronization	9.2.3	Heading	–
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Loop timing	9.2.3.2		M
Timing advance	9.2.3.3		M
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Power back-off in the upstream direction	9.2.4		M
Constellation encoder	9.2.5		M
Gain scaling	9.2.6		M
Tone ordering	9.2.7		M
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<b>OAM function model</b>	<b>10.1</b>		M
<b>OAM communication channels</b>	<b>10.2</b>		M
Indicator bits	10.2.1		M
VDSL embedded operations channel (eoc)	10.2.2		M
VDSL overhead control (VOC) channel	10.2.3		M
Partitioning of OAM data	10.2.4		M
<b>Embedded operation channel (eoc) functions and description</b>	<b>10.3</b>		M
EOC Functional Model	10.3.1		M
VME Functionality	10.3.1.1		M
EOC protocol and messages	10.3.2		M
<b>Fault and Performance Monitoring</b>	<b>10.4</b>		M
<b>OAM parameters and primitives</b>	<b>10.5</b>	Heading	–
Line-related primitives	10.5.1		M
Path-related primitives	10.5.2		M
Power-related primitives	10.5.3		M
A minimum set of far-end indicators	10.5.4		M
Performance parameters	10.5.5		M
Testing parameters	10.5.6		M
<b>VDSL Overhead channel (VOC)</b>	<b>10.6</b>		M
VOC bandwidth	10.6.1		M
VOC protocol	10.6.2		M
High-level on-line adaptation	10.6.3		M

Title	ITU-T Rec. G.993.1	Comments	CR
<b>PERFORMANCE REQUIREMENTS</b>	<b>11</b>	Heading	–
<b>Error Performance Requirements</b>	<b>11.1</b>	Operate with a noise margin of at least +6 dB and a long-term bit error rate of $< 1$ in $10^{-7}$	M
<b>Latency Requirements</b>	<b>11.2</b>	1 ms	M
<b>Impulse Noise Immunity Requirements</b>	<b>11.3</b>		M
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<b>Service splitters</b>	<b>13.1</b>	The basic electrical requirements are listed in Table 11-1/G.993.1. The values of the parameters as well as other specific requirements are regionally specific and described in the regional specific Annexes (e.g. Annexes D, E and F).	M
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<b>Impairment generators</b>	<b>14.2</b>		M
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NEXT noise generator [G1]	14.2.1.2		M
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Frequency domain profiles of generators [G1] and [G2]	14.2.1.4		M
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Additive white Gaussian noise generator [G4]	14.2.3		M
Radio noise generator [G5]	14.2.4		M
Amateur radio noise generator [G6]	14.2.5		M
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<b>Transmission performance test</b>	<b>14.3</b>		M
Test setup	14.3.1		M
Measuring noise margin	14.3.2		M
Noise generator sets for different test scenarios	14.3.3		M

Title	ITU-T Rec. G.993.1	Comments	CR
<b>Bandplan A</b>	<b>Annex A</b>		O
<b>Bandplan B</b>	<b>Annex B</b>		O
<b>Bandplan C</b>	<b>Annex C</b>		NA
<b>Requirements for Region A (North America)</b>	<b>Annex D</b>		O
<b>Requirements for Region B (Europe)</b>	<b>Annex E</b>		O
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<b>Bandplan and PSD Masks</b>	<b>F.1</b>	Heading	-
<b>Bandplan</b>	<b>F.1.1</b>	Refers to Bandplan A specified in G.993.1/Annex A	O
<b>Transmit signal PSD Masks</b>	<b>F.1.2</b>	Heading	-
VDSL system operating in the frequency region above POTS band	F.1.2.1		O
VDSL system operating in the frequency region above TCM-ISDN DSL band	F.1.2.2		O
VDSL system with PSD reduction function in the frequency region below 1.104 MHz	F.1.2.3		O
Transmit notches	F.1.2.4		M
Upstream power back off (UPBO) PSD masks	F.1.2.5		M
<b>Service Splitter</b>	<b>F.2</b>	Heading	-
<b>Introduction</b>	<b>F.2.1</b>	Requirements for a POTS splitter appropriate to Japan are specified in the G.993.1 § F.2.2.	O
<b>POTS splitter</b>	<b>F.2.2</b>		O
<b>ISDN splitter</b>	<b>F.2.3</b>		O
<b>TEST LOOPS AND CROSSTALK DISTURBERS</b>	<b>F.3</b>		GID
<b>ATM-TC</b>	<b>Annex G</b>		O
<b>PTM-TC</b>	<b>Annex H</b>		O
<b>Specific implementation in systems using QAM modulation</b>	<b>Annex I</b>		NA
<b>UTOPIA Implementation of the ATM-TC Interface</b>	<b>Appendix I</b>		O
<b>Bibliography</b>	<b>Appendix II</b>		GID