

**COMMUNICATIONS  
ALLIANCE LTD**



AUSTRALIAN STANDARD

AS/CA S043.2:2016

Requirements for Customer Equipment for  
connection to a metallic local loop interface of a  
Telecommunications Network —  
Part 2: Broadband

## **Draft Australian Standard — Requirements for Customer Equipment for connection to a metallic local loop interface of a Telecommunications Network — Part 2: Broadband**

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## FOREWORD

### General

This Standard was prepared by Communications Alliance and most recently revised by the **VDSL2 and Vectoring** Working Committee (WC58). It is one of a series of Telecommunication Standards developed under the Memorandum of Understanding between the Australian Communications Authority (ACA) and the Australian Communications Industry Forum.

Note: On 1 July 2005 the ACA became the Australian Communications and Media Authority (ACMA) and the Memorandum of Understanding continues in effect as if the reference to the ACA were a reference to the ACMA.

Communications Alliance was formed in 2006 and continues the functions previously fulfilled by ACIF.

This Standard is a revision of AS/ACIF S043.2:2015 **Requirements for Customer Equipment for connection to a metallic local loop interface of a Telecommunications Network — Part 2: Broadband**.

This Standard is the result of a consensus among representatives on the Communications Alliance Working Committee to produce it as an Australian Standard.

The requirements in this Standard are consistent with the aims of s376 of the *Telecommunications Act 1997*. Specifically these aims are:

- (a) protecting the integrity of a telecommunications network or facility;
- (b) protecting the health and safety of persons;
- (c) ensuring access to emergency services; and
- (d) ensuring interoperability with a standard telephone service.

It should be noted that some Customer Equipment (CE) may also need to comply with requirements in other Standards or other Parts of this Standard.

AS/CA S043 consists of the following parts under the general title **Requirements for Customer Equipment for connection to a metallic local loop interface of a Telecommunications Network**:

- Part 1: **General**
- Part 2: **Broadband**
- Part 3: **DC, low frequency AC and voiceband**

This Standard should be read in conjunction with AS/CA S043.1 [3].

Applicable electrical safety Standards and EMC Standards may apply under Commonwealth or State/Territory laws, or both.

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## Standards revision

Australian Standards (AS/ACIF and AS/CA Standards) developed by Communications Alliance are updated, according to the needs of the industry, by amendments or revision. Users of these Standards should make sure that they possess the latest amendments or editions. Representations concerning the need for a change to this AS/CA Standard should be addressed to:

The Project Manager  
Customer Equipment and Cable Reference Panel  
Communications Alliance  
PO Box 444  
Milsons Point NSW 1565

## Regulatory notice

Upon publication, this technical standard has effect under the *Telecommunications (Customer Equipment and Customer Cabling) Notice 2015* made by the Australian Communications and Media Authority (ACMA).

For the purposes of the ACMA Standard, defined as *Telecommunications Technical Standard (Requirements for Customer Equipment for connection to a metallic local loop interface of a Telecommunications Network – AS/CA S043) 2015*, the transition period is 6 months.

The ACMA is a Commonwealth authority with statutory powers to impose requirements concerning telecommunications Customer Equipment and Customer Cabling.

The ACMA requires Australian manufacturers and importers, or their Australian agents, of specified items of Customer Equipment and Customer Cabling to establish compliance with Standards such as this. Items are required to be labelled in accordance with the applicable labelling notices.

Details on current compliance arrangements can be obtained from the ACMA website at <http://www.acma.gov.au> or by contacting the ACMA below at:

Australian Communications and Media Authority  
PO Box 13112  
Law Courts PO  
Melbourne VIC 8010  
Australia

Telephone: +61 3 9963 6800  
Facsimile: +61 3 9963 6899  
TTY: +61 3 9963 6948  
Email: [info@acma.gov.au](mailto:info@acma.gov.au)

## Introduction

This introduction for the AS/CA S043.2 **Requirements for Customer Equipment for connection to a metallic local loop interface of a Telecommunications Network Part 2: Broadband** Standard is not an authoritative section of this draft Standard and is only provided as guidance for the user of the draft Standard to outline its objectives, the factors that have been taken into account in its development and to list the principal differences between the new and the previous edition.

The reader is directed to the clauses of this Standard for the specific requirements and to the ACMA for the applicable telecommunications labelling and compliance arrangements.

Note: Further information on the telecommunications labelling and compliance arrangements can be found in *The Telecommunications Labelling (Customer Equipment and Customer Cabling) Notice* (the TLN). The TLN can be obtained from the ACMA website at [www.acma.gov.au](http://www.acma.gov.au).

The objective of this Standard is to provide the requirements and test methods for customer equipment that is designed or intended for connection to a Telecommunications Network via a metallic local loop interface and has a broadband capability, in order to meet the regulatory arrangements for such equipment in Australia.

The objective of this revision is to update AS/CA S043.2 to add requirements for some CE to support Electrical Length Estimation.

The principal differences between this draft edition of AS/CA S043.2 and the previous edition are the addition of a requirement for VDSL2 modems to support:

- (i) Upstream Power Backoff in Equipment Class 10v, consistent with the existing requirement for Equipment Classes 10h and 10j to 10n; and
- (ii) Upstream Power Backoff Length Estimation Method (based on ITU-T Rec. G.993.2 [10]) in Equipment Classes 10h, 10j to 10n, and 10v.

Compliance with these added requirements should be by attestation by the supplier of the equipment.

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# 1 INTERPRETATIVE GUIDELINES

## 1.1 Categories of requirements

This Standard contains mandatory requirements as well as provisions that are recommendatory only. Mandatory requirements are designated by the words '**shall**' or '**shall not**'. All other provisions are voluntary.

## 1.2 Compliance statements

Compliance statements, in italics, suggest methodologies for demonstrating CE's compliance with the requirements.

## 1.3 Definitions, expressions and terms

If there is any conflict between the definitions used in this Standard and the definitions used in the Telecommunications Act 1997, the definitions in the Act take precedence.

## 1.4 Notes

Text denoted as 'Note' is for guidance in interpretation and is shown in smaller size type.

## 1.5 References

1.5.1 Applicable editions (or versions) of other documents referred to in this Standard are specified in Section 3: REFERENCES.

1.5.2 If a document refers to another document, the other document is a sub-referenced document.

1.5.3 Where the edition (or version) of the sub-referenced document is uniquely identified in the reference document, then that edition (or version) applies.

1.5.4 Where the edition (or version) of the sub-referenced document is not uniquely identified in the reference document, then the applicable edition (or version) is that which is current at the date the reference document is legislated under the applicable regulatory framework, or for a non- legislated document, the date upon which the document is published by the relevant standards organisation.

1.5.5 A number in square brackets '[ ]' refers to a document listed in Section 3: REFERENCES.

## 1.6 Units and symbols

In this Standard the International System (SI) of units and symbols is used in accordance with Australian Standard AS ISO 1000 [1].

## **1.7 Parts of Standards**

CE scoped by this Standard is to comply with the applicable technology-specific Part(s) of this Standard.

## **2 SCOPE**

- 2.1 This Standard applies to Customer Equipment (CE) that:
- (a) is designed or intended for connection to a Telecommunications Network via a metallic local loop interface; and
  - (b) has a broadband capability.
- 2.2 CE is not excluded from the scope of this Standard by reason only that it is capable of performing functions additional to those listed in this Standard.

### 3 REFERENCES

	Publication	Title
<b>Australian Standards</b>		
[1]	AS ISO 1000—1998	The International System of Units (SI) and its application
<b>AS/CA Standards</b>		
[2]	AS/CA S041:2014	Requirements for DSL Customer Equipment for connection to the Public Switched Telephone Network
	AS/CA S043	Requirements for Customer Equipment for connection to a metallic local loop interface of a Telecommunications Network
[3]	AS/CA S043.1:2015	Part 1: General
[4]	AS/CA S043.3:2015	Part 3: DC, low frequency AC and voiceband
<b>International Telecommunications Union</b>		
[5]	G.991.1 (10/1998)	High bit rate Digital Subscriber Line (HDSL) transceivers  <a href="http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=7073">http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=7073</a>
[6]	G.991.2 (12/2003)	Single-pair high-speed digital subscriber line (SHDSL) transceivers  <a href="http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=4718">http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=4718</a>
[7]	G.992.1 (07/1999)	Asymmetrical Digital Subscriber Line (ADSL) Transceivers  <a href="http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=4719">http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=4719</a>
[8]	G.992.3 (04/2009)	Asymmetric Digital Subscriber Line Transceivers-2 (ADSL2)  <a href="http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=9652">http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=9652</a>
[9]	G.992.5 (01/2009)	Asymmetrical Digital Subscriber Line (ADSL) Transceivers - Extended bandwidth ADSL2 (ADSL2+)  <a href="http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=9653">http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=9653</a>

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[10]	G.993.2 (12/2011)	Very high speed Digital Subscriber Line transceivers 2 (VDSL2)  <a href="http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=11415">http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=11415</a>
[11]	G.993.5 (04/2010)	Self-FEXT cancellation (vectoring) for use with VDSL2 transceivers  <a href="http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=10414">http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=10414</a>
[12]	O.151 (10/1992)	Error performance measuring equipment operating at the primary rate and above  <a href="http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=1679">http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=1679</a>
[13]	O.152 (10/1992)	Error performance measuring equipment for bit rates of 64 kbit/s and N x 64 kbit/s  <a href="http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=1681">http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=1681</a>
[14]	O.153 (10/1992)	Basic parameters for the measurement of error performance at bit rates below the primary rate  <a href="http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=1683">http://www.itu.int/ITU-T/recommendations/rec.aspx?rec=1683</a>
<hr/> <b>European Telecommunications Standards Institute</b>		
[15]	TS 102 080 V1.3.1 (1998-11)	Transmission and Multiplexing (TM); Integrated Services Digital Network (ISDN) basic rate access; Digital transmission system on metallic local lines

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## 4 ABBREVIATIONS AND DEFINITIONS

For the purposes of this Standard, the following abbreviations and definitions and those of Part 1 apply:

### 4.1 Abbreviations

AC	Alternating Current
ACA	Australian Communications Authority
ACMA	Australian Communications and Media Authority
ACIF	Australian Communications Industry Forum
ADSL	Asymmetric Digital Subscriber Line
ADSL2	Asymmetric Digital Subscriber Line version 2
ADSL2+	Extended bandwidth ADSL2
AELE	Alternative Electrical Length Estimation
AS	Australian Standard
BR	Basic Rate
CE	Customer Equipment
CO-MIB	Central Office Management Information Base
DC	Direct Current
DSL	Digital Subscriber Line
EC	Echo Cancelling
ELE	Electrical Length Estimation
ELE-M0	Electrical Length Estimation Mode 0
ELE-M1	Electrical Length Estimation Mode 1
ESHDSL	Single-Pair High-Speed Digital Subscriber Line Extended rate
ETSI	European Telecommunications Standards Institute
FD	Frequency Division
FFS	For Further Study
HDSL	High bit rate Digital Subscriber Line
ISDN	Integrated Services Digital Network
PR	Payload Rate
PSD	Power Spectral Density
PSTN	Public Switched Telephone Network
RBW	Resolution BandWidth
ReADSL2	Reach extended ADSL2
SDSL	Symmetric Digital Subscriber Line
SHDSL	Single-Pair High Speed Digital Subscriber Line
TCPAM	Trellis Coded Pulse Amplitude Modulation
VDSL2	Very high speed Digital Subscriber Line

## **4.2 Definitions**

### **4.2.1 Broadband capability**

A means of transmission of signals that uses frequencies above 20 kHz.

### **4.2.2 Equipment Class**

A classification of CE used in this Standard to identify applicable requirements for CE designed or intended for connection to a metallic local loop interface.

Note: Table 1 lists the Equipment Classes and test criteria used in this Standard. Each Equipment Class has a related Appendix which lists the requirements for the class. The Equipment Class and test criteria do not relate to the class types of any other regime or country.

### **4.2.3 Power Spectral Density (PSD)**

The power level and frequency content of a transmitted signal.

### **4.2.4 Public Switched Telephone (PSTN)**

That part of the Telecommunications Network which enables any customer to establish a connection for voice frequency communication with any other customer either automatically or with operator assistance.

Note: The PSTN has a nominal transmission bandwidth of 3 kHz.

### **4.2.5 Referenced Documents**

Those documents set out in the column titled 'Group B' in the tables in the Appendices.

### **4.2.6 Vectoring**

The coordinated transmission and/or coordinated reception of signals of multiple DSL transceivers using techniques to mitigate the adverse effects of crosstalk to improve performance.

## 5 REQUIREMENTS

### 5.1 General

#### 5.1.1 Applicable requirements

CE **shall** comply with the requirements of an Equipment Class as specified in Clauses 5.2 to 5.6. The Appendix detailing the test criteria and Referenced Documents for each Equipment Class is specified in Table 1.

#### 5.1.2 Multiple Equipment Classes

Where more than one Equipment Class applies to the CE, the CE **shall** comply with each Equipment Class requirement.

#### 5.1.3 Group A and Group B requirements

CE **shall** comply with all the requirements of either:

- (a) Group A which specifies the parameter values and testing requirements; or
- (b) Group B which specifies either the test criteria or the requirements in the Referenced Documents

for the applicable Equipment Class.

Where the CE does not support all line code options in an Equipment Class (e.g. where there are multiple types of coding), the CE **shall** comply with each requirement that has been implemented of the applicable Equipment Class.

Note 1: It is expected that most equipment which complies with international standards will comply under the relevant Group B requirements in this Standard. Group A requirements, which correspond to tighter (i.e. lower) PSD masks than the Group B requirements, are available as an alternative path for compliance of systems which cannot comply with the line code aspect of the Group B requirements.

Note 2: For Equipment Class 10v, there is no option to comply with Group A requirements, because the line code and vectoring operation need to be consistent across all Class 10v services in the cables.

#### 5.1.4 Non-compliant line code

CE that does not comply with a line code specified in Group B for the applicable Equipment Class, except Equipment Class 10v, **shall** use the Group A requirements.

### 5.2 Total average power

The total average power transmitted by CE **shall not** exceed the total average power limit over the specified frequency range, measured when the CE is transmitting maximum power, excluding any transient startup or initialisation phases.

### 5.3 Total average power in Voiceband

For each equipment class, the total average transmitted power in the voiceband **shall** be less than or equal to -10dBm measured in 0 to 4 kHz, with 600  $\Omega$  measuring impedance.

Note: This requirement is intended to limit pair to pair crosstalk into voice services to acceptable levels. For systems such as ADSL that coexist with voice services on the same line, tighter requirements exist. Refer to AS/CA S041 [2].

*Compliance with Clause 5.2 should be demonstrated using the methodology specified in Clause 6.4.1.*

### 5.4 Power Spectral Density (PSD)

The PSD transmitted by CE **shall not** exceed the PSD mask, at any frequency, measured when the CE is transmitting maximum power, excluding any transient startup or initialisation phases.

*Compliance with Clause 5.3 should be demonstrated using the methodology specified in Clause 6.4.2.*

### 5.5 Line code

Where Group B requirements are used, the CE **shall** comply with the requirements for line code.

*Compliance with Clause 5.4 should be by attestation by the supplier of the equipment.*

### 5.6 Longitudinal balance

The longitudinal balance of the CE **shall** be greater than or equal to the longitudinal balance limit over the specified frequency range, when the longitudinal termination is 1/4 of the termination impedance for the Equipment Class.

Longitudinal balance is defined as:

$$\text{Longitudinal balance(dB)} = 20 \times \log_{10} \left( \frac{V_l}{V_m} \right)$$

where:  $V_l$  is the longitudinal or common mode voltage

$V_m$  is the metallic or differential voltage

*Compliance with Clause 5.5 should be demonstrated using the methodology specified in Clause 6.4.3.*

### 5.7 Longitudinal output voltage

The longitudinal output voltage **shall not** exceed the longitudinal output voltage limit over the specified frequency range, when measured across a load (consisting of 100  $\Omega$  in series with 0.15  $\mu\text{F}$ )

when CE is transmitting maximum power. Any transient startup or initialisation phases should be excluded.

*Compliance with Clause 5.6 should be demonstrated using the methodology specified in Clause 6.4.4.*

## **5.8 Customer Equipment for connection to the PSTN**

AS/CA S041 [2] contains separate requirements for CE that is designed or intended for connection to a DSL service that shares the metallic local loop with an analogue PSTN Ring-In / Loop-Out two-wire service.

**Table 1**  
**Equipment classes and test criteria**

<b>Equipment Class</b> (Note 1)	<b>Appendix specifying the test criteria and Referenced Documents</b>	<b>Typical technology (informative)</b> (Notes 2, 3, 5, 6)
1a	Not used in this Standard	–
1b	Not used in this Standard	–
2a	Not used in this Standard	–
3a	Not used in this Standard See also AS/CA S043.3 [4] (Note 4)	Low Band (DC to 3.4 kHz)
3b	Not used in this Standard See also AS/CA S043.3 [4] (Note 4)	Low Band (DC to 20 kHz)
4a	Appendix A	ISDN BR 2B1Q
5a	Appendix B	–
5b	Appendix C	–
6a, 6d, 6e, 6f	Appendix D	ADSL FD, ADSL EC or ADSL2 EC
6b	Not used in this Standard	ADSL Lite
6c	Appendix E	ADSL over ISDN or ADSL2 over ISDN
6g	Appendix F	Reach Extended ADSL2 non-overlapped spectrum with mask 1
6h	Appendix G	ADSL2 non-overlapped spectrum or ADSL2+ non-overlapped spectrum
6i	Appendix H	All Digital Mode ADSL2 non-overlapped spectrum or All Digital Mode ADSL2+ non overlapped spectrum
6j	Appendix I	ADSL2 or ADSL2+ with extended upstream bandwidth (Annex M) Mask EU-40
6k	Appendix I	ADSL2 or ADSL2+ with extended upstream bandwidth (Annex M) Mask EU-52
6l	Appendix I	ADSL2 or ADSL2+ with extended upstream bandwidth (Annex M) Mask EU-56

<b>Equipment Class</b> (Note 1)	<b>Appendix specifying the test criteria and Referenced Documents</b>	<b>Typical technology (informative)</b> (Notes 2, 3, 5, 6)
6m	Appendix I	ADSL2 or ADSL2+ with extended upstream bandwidth (Annex M) Mask EU-60
6n	Appendix I	ADSL2 or ADSL2+ with extended upstream bandwidth (Annex M) Mask EU-64
7a to 7j	Not used in this Standard	SDSL
8a	Not used in this Standard	HDSL 2B1Q (768 kbit/s)
8b	Appendix J	HDSL 2B1Q (1168 kbit/s)
8c, 8d	Not used in this Standard	HDSL 2B1Q (2320 kbit/s)
9a	Appendix K	SHDSL (up to 576 kbit/s)
9b, 9c	Appendix K	SHDSL (up to 776 kbit/s)
9d	Appendix K	SHDSL (up to 1160 kbit/s)
9e	Appendix K	SHDSL (up to 1544 kbit/s)
9h	Appendix K	SHDSL (up to 1800 kbit/s)
9f	Appendix K	SHDSL (up to 2056 kbit/s)
9g	Appendix K	SHDSL (up to 2312 kbit/s)
9i	Appendix L	ESHDSL (up to 2624(C-16) or 3496(C-32) kbit/s)
9j	Appendix L	ESHDSL (up to 2880(C-16) or 3840(C-32) kbit/s)
9k	Appendix L	ESHDSL (up to 3072(C-16) or 4096(C-32) kbit/s)
9l	Appendix L	ESHDSL (up to 3264(C-16) or 4352(C-32) kbit/s)
9m	Appendix L	ESHDSL (up to 3456(C-16) or 4608(C-32) kbit/s)
9n	Appendix L	ESHDSL (up to 3648(C-16) or 4864(C-32) kbit/s)
9o	Appendix L	ESHDSL (up to 3840(C-16) or 5120(C-32) kbit/s)
9p	Appendix L	ESHDSL (up to 5376(C-32) kbit/s)
9q	Appendix L	ESHDSL (up to 5696(C-32) kbit/s)
9r	Appendix L	ESHDSL (up to 6096(C-32) or 7624(C-64) or 9152(C-128) kbit/s)
9s	Appendix L	ESHDSL (up to 8104(C-32) or 10136(C-64) or 12160(C-128) kbit/s)

<b>Equipment Class</b> (Note 1)	<b>Appendix specifying the test criteria and Referenced Documents</b>	<b>Typical technology (informative)</b> (Notes 2, 3, 5, 6)
9t	Appendix L	ESHDSL (up to 10192(C-32) or 12744(C 64) or 15296(C-128) kbit/s)
10a to 10g	Not used in this Standard	-
10h	Appendix M	VDSL2 non-overlapped spectrum
10i	Not used in this Standard	-
10j	Appendix N	VDSL2 with extended upstream ADSL2 bandwidth (Annex M) Mask EU-40 below 1104 kHz
10k	Appendix N	VDSL2 with extended upstream ADSL2 bandwidth (Annex M) Mask EU-52 below 1104 kHz
10l	Appendix N	VDSL2 with extended upstream ADSL2 bandwidth (Annex M) Mask EU-56 below 1104 kHz
10m	Appendix N	VDSL2 with extended upstream ADSL2 bandwidth (Annex M) Mask EU-60 below 1104 kHz
10n	Appendix N	VDSL2 with extended upstream ADSL2 bandwidth (Annex M) Mask EU-64 below 1104 kHz
10v	Appendix O	Vectored VDSL2 for FTTN deployment

Note 1: Some CE may have more than one Equipment Class.

Note 2: The individual technologies listed in this column are examples only.

Note 3: The bit rate upper limits under the column titled 'Typical technology' represent line rates (total payload plus overhead bits carried), except for SHDSL and ESHDSL where they represent payload rates only, without the 8 kbps line overhead. For Classes 9a to 9h the SHDSL system maximum payload rates shown are based on 3 bits per symbol (C-16 line-code) as per the default in G.991.2 [6]. For these Classes systems that operate at the same symbol rates using the alternative option of 4 bits per symbol (C-32) have maximum payload rates corresponding to the 32-TCPAM column of Table K2. Classes 9i to 9o are for ESHDSL systems for which G.991.2 [6] specifies two line-code options (C-16 or C-32). Maximum payload rates are shown for both options for these Classes. Classes 9p and 9q show maximum payload rates for the C-32 line-code only, because G.991.2 [6] specifies no C-16 alternatives for these cases.

Note 4: Subject to other Standards or Parts of this Standard.

Note 5: SHDSL and ESHDSL system Equipment Class is determined by the Symbol Rate – which may correspond to different system bit-rates depending on whether 16-TCPAM (3 bits per symbol) or 32-TCPAM (4 bits/symbol) coding is being used, as defined in G.991.2 Annex K [6]. Example payload bitrates are denoted with a suffix (C-16) for 16-TCPAM (3 bits/symbol) values, and (C-32) for 32-TCPAM (4 bits/symbol) values. Refer to Appendix K for details on SHDSL and Appendix L for details on ESHDSL.

Note 6: The Equipment Classes (with corresponding 'Typical technology') listed below were in earlier version(s) of this Standard but have been removed as options for deployment of a new service in the future because:

- (i) doing so will improve the overall performance of services on an access network by reducing the risk of interference between services; and
- (ii) the number of existing services for the Equipment Classes listed below are zero in most examples or few enough to be managed on a case-by-case basis:
  - (a) 1a and 1b (E1 HDB3) – redeployment of existing E1 services and pair rearrangement might still occur.
  - (b) 2a (listed in the original planning of Equipment Classes but never used in publication).
  - (c) 6b (ADSL Lite).
  - (d) 7a to 7j (SDSL at various data rates).
  - (e) 8a, 8c and 8d (HDSL at 784 kbps and 2320 kbps).

## **6 TESTING**

### **6.1 General**

#### 6.1.1 Compliance verification

Compliance with all requirements applicable to the CE as specified in Clause 5 is to be verified. This verification may be through direct measurement, modelling and analysis, or inspection.

#### 6.1.2 Compliance demonstration methods

Methods for demonstrating compliance of CE with requirement Clauses specified in this Standard are described in Clauses 6.2 to 6.4. Other methods may be used if the risk of passing non-compliant CE is not increased because of increased measurement uncertainty.

### **6.2 Standard test conditions**

#### 6.2.1 Conditions

Unless this Standard provides otherwise, testing for compliance with this Standard should be conducted at the nominal supply voltage of the equipment and within the following ranges of atmospheric conditions:

- (a) an ambient temperature in the range of 15°C to 25°C inclusive.
- (b) a relative humidity in the range of 30% to 75% inclusive.
- (c) an air pressure in the range of 86 kPa to 106 kPa inclusive.

#### 6.2.2 Record keeping

The prevailing conditions should be recorded for each test including measurement uncertainty. The environmental conditions at the time of test should be recorded.

### **6.3 Test configurations**

#### 6.3.1 General

Test configurations used should be outlined for each individual test. Test circuits other than those indicated in this Standard may be used but details of the circuits should accompany test reports.

Note: CE under test should be placed in and maintain a normal operational state.

### 6.3.2 Termination impedance

The termination impedance for tests should be as specified for the Equipment Class. The accuracy of the terminating impedance should be taken into account when assessing the measurement uncertainty.

### 6.3.3 DC line current

Where CE sources or sinks DC power feed or wetting current, the test conditions should be that which are normally present in use. The test circuits should provide the required current sources and sinks. The AC impedance of the source/sink should be taken into account in the estimation of measurement uncertainty. The balance of the source/sink should also be sufficient to allow the measurement of longitudinal balance.

## 6.4 Measurements

### 6.4.1 Total average power

Total average power should be measured using the test circuit in Figure 1.

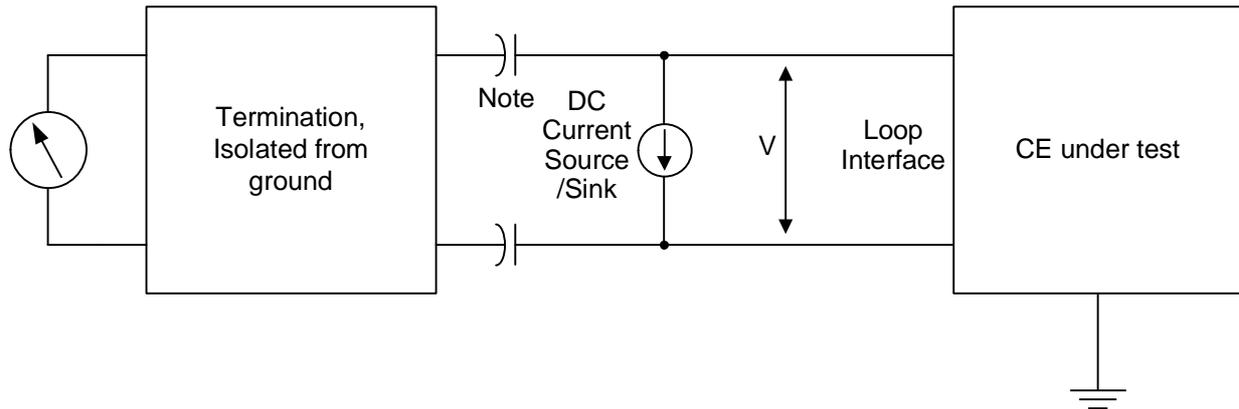
The DC source/sink and blocking components are not required where the power feed or wetting current is not supported.

The total average power should be measured with the CE under test terminated in the termination impedance for the Equipment Class.

The total average power should be measured over the averaging time for the Equipment Class.

The measurement equipment should not be synchronous with the CE.

The data input to the CE under test should be a pseudo-random sequence, and the CE should provide all processes used in normal operation (e.g. scrambling, coding). Pseudo-random sequences should be those specified in O.151 [12], O.152 [13] or O.153 [14] for the appropriate data rate.



Note: The measurement uncertainty needs to take into account the accuracy of the differential termination, including the effect of the blocking capacitors and other equipment.

**Figure 1**  
**Average power and PSD test configuration**

#### 6.4.2 Power Spectral Density

The PSD should be measured using the configuration in Figure 1. The data input to the CE under test should be a pseudo-random sequence, and the CE should provide all processes used in normal operation (e.g. scrambling and coding). Pseudo-random sequences should be those specified in the O.151 [12], O.152 [13] or O.153 [14] for the appropriate data rate.

Where resolution bandwidths and frequency ranges are specified for the Equipment Class, the specified resolution bandwidth and frequency ranges should be used in measuring the PSD. Where resolution bandwidth and frequency ranges are not specified a resolution bandwidth less than or equal to 100 Hz **shall** be used in measuring the PSD.

Measurements should be made at discrete frequencies, with a spacing equal to the resolution bandwidth, covering the range specified for the Equipment Class.

The measurement at each frequency should be averaged over a time which takes into account the settling time for the resolution bandwidth. For a measurement bandwidth of 10 kHz at least 2 seconds is required.

To obtain the dynamic range required in the measurement of some Equipment Classes, it may be necessary to use passive filters before the spectrum analyser or selective level meter when measuring the out of band spectrum. If filters are used it is necessary to assure the nominal termination impedance is maintained across the whole signal band.

### 6.4.3 Longitudinal balance

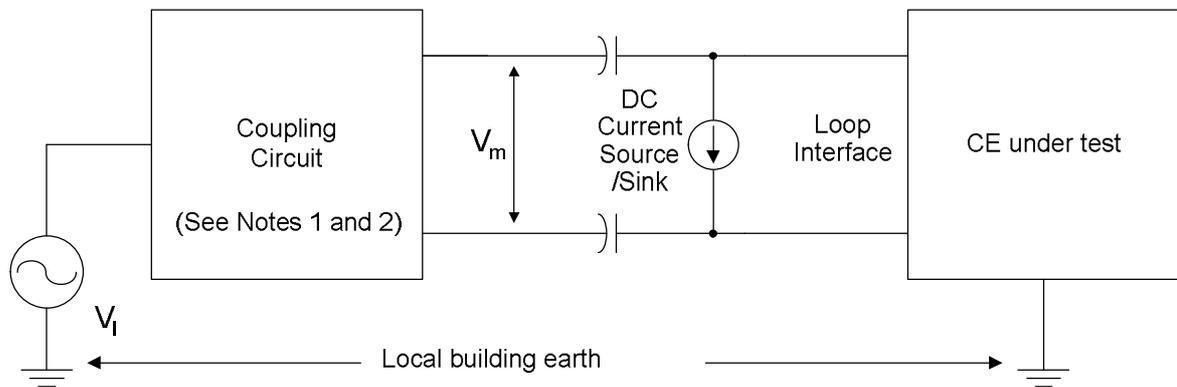
Longitudinal balance is measured using the test circuit in Figure 2.

The transmitter of the CE under test should be placed in a quiet mode and the termination of the line by the CE under test should be maintained.

The DC source/sink and blocking components are not required where the power feed or wetting current is not supported.

The CE under test should be earthed as under normal operating conditions.

The residual balance of the test circuit should be at least 20 dB over the limit when a resistor of the termination impedance for the Equipment Class is substituted for the CE under test.



Note 1: The impedance of the metallic or differential termination of the coupling circuit is equal to the termination impedance for the Equipment Class.

Note 2: The longitudinal or common mode termination of the coupling circuit is equal to 1/4 of the termination impedance for the Equipment Class.

**Figure 2**  
**Longitudinal balance measurement**

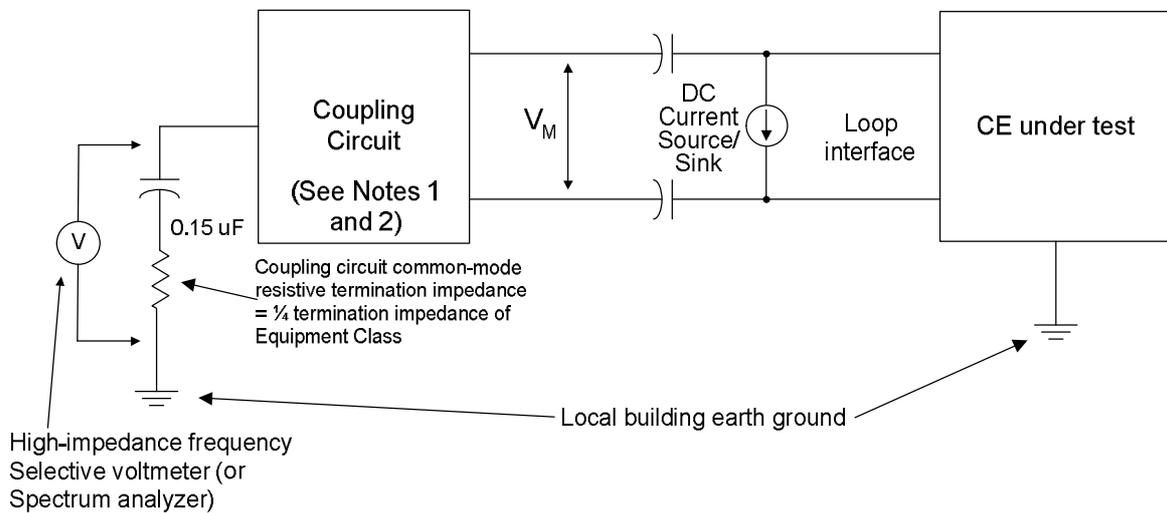
#### 6.4.4 Longitudinal output voltage

The longitudinal output voltage should be measured using the circuit in Figure 3.

The DC source/sink and blocking components are not required where the power feed or wetting current is not supported.

The measurement equipment should not be synchronous with the system.

The data input to the system under test should be a pseudo-random sequence, and the system should provide all processes used in normal operation (e.g. scrambling, coding). Pseudo-random sequences should be those specified in the O.151 [12], O.152 [13] or O.153 [14] for the appropriate data rate.



Note 1: The impedance of the metallic or differential termination of the coupling circuit is equal to the termination impedance for the Equipment Class.

Note 2: The longitudinal or common mode impedance of the coupling circuit is equal to 1/4 of the termination impedance for the Equipment Class.

**Figure 3**  
**Longitudinal output voltage measurement**

## APPENDIX

### A Equipment Class 4a

Table A1 provides the Group A and Group B test criteria and Referenced Documents for Equipment Class 4a. A typical technology is ISDN BR 2B1Q.

The test termination impedance for Equipment Class 4a is 135  $\Omega$ .

**Table A1**  
**Test criteria and Referenced Documents for**  
**Equipment Class 4a**

Parameter		Group A	Group B
Total average power	Level	14 dBm	TS 102 080 Clause A.12.3 [16]
	Frequency range	0 Hz to 136 kHz	TS 102 080 Clause A.12.3 [16]
	Averaging time	$\geq 10$ s	$\geq 10$ s
PSD mask	–	Table A2	TS 102 080 Clause A.12.4, A12.4.1 [16] to 12040 kHz
Line code	–	Not applicable	TS 102 080 Clause A.1 [16]
Longitudinal balance	Level	45 dB from 5 kHz to 60 kHz, with a slope of 20 dB/decade below 5 kHz and –20 dB/decade above 60 kHz	TS 102 080 Clause A.13.3 [16]
	Frequency range	500 Hz to 190 kHz	TS 102 080 Clause A.13.3 [16]
Longitudinal output voltage	Level	–50 dBV in any 4 kHz band	–50 dBV in any 4 kHz band
	Frequency range	As per longitudinal balance	As per longitudinal balance

**Table A2**  
**PSD mask for Equipment Class 4a (Group A)**

Frequency Range, $f$ (kHz)	PSD (dBm/Hz)
$0 < f \leq 25$	-32.5
$25 < f \leq 76$	$-32.5 - 10.35 \times \log_{10}\left(\frac{f}{25}\right)$
$76 < f \leq 79$	$-37.5 - 0.5 \times \left(\frac{f-76}{3}\right)$
$79 < f \leq 85$	$-38 - 19.6 \times \log_{10}\left(\frac{f-69}{10}\right)$
$85 < f \leq 100$	$-42 - 4 \times \frac{f-85}{15}$
$100 < f \leq 115$	$-46 - 7 \times \frac{f-100}{15}$
$115 < f \leq 120$	-53
$120 < f \leq 225$	$-53 - 55 \times \log_{10}\left(\frac{f}{120}\right)$
$225 < f \leq 635$	$-68 - 70 \times \log_{10}\left(\frac{f}{225}\right)$
$635 < f \leq 30175$	$-143 - 10 \times \log_{10}\left(\frac{(10^3 \times f)^{1.5}}{1.134 \times 10^{13}}\right)$

## APPENDIX

### B Equipment Class 5a

Table B1 provides the Group A and Group B test criteria for Equipment Class 5a.

The test termination impedance for Equipment Class 5a is 135  $\Omega$ .

**Table B1**  
**Test criteria for Equipment Class 5a**

Parameter		Group A	Group B
Total average power	Level	14 dBm	14 dBm
	Frequency range	0 Hz to 1100 kHz	0 Hz to 1100 kHz
	Averaging time	$\geq 10$ s	$\geq 10$ s
PSD mask	–	Table B2	Table B3
Line code	–	Not applicable	Trellis Coded Pulse Amplitude Modulation
Longitudinal balance	Level	40 dB from 20 kHz to 95 kHz, with a slope of 20 dB/decade below 20 kHz and –20 dB/decade above 95 kHz	40 dB from 20 kHz to $f_{\text{sym}}/2$ kHz, with a slope of 20 dB/decade below 20 kHz and –20 dB/decade above $f_{\text{sym}}/2$ kHz
	Frequency Range	20 kHz to 2000 kHz	20 kHz to 2000 kHz
Longitudinal output voltage	Level	–50 dBV in any 4 kHz band	–50 dBV in any 4 kHz band
	Frequency Range	20 kHz to 450 kHz	20 kHz to 450 kHz

Note:  $f_{\text{sym}}$  is the symbol rate or baud rate on the line.

**Table B2**  
**PSD mask and testing requirements for Equipment Class 5a (Group A)**

Frequency in kHz	PSDMASK (f) in dBm/Hz	Testing Requirements
$f < f_{int}$	$10 \times \log_{10} \left[ \frac{K}{135} \times \frac{1}{f_{sym}} \times \frac{\left[ \sin \left( \frac{\pi f}{N f_{sym}} \right) \right]^2}{\left( \frac{\pi f}{N f_{sym}} \right)^2} \times \frac{1}{1 + \left( \frac{f}{f_{3dB}} \right)^{2 \times \text{Order}}} \right]$	PSD
$f_{int} \leq f \leq 1500$	$10 \times \log_{10} \left[ 1.7971 \times 10^{-6} \times f^{-1.5} \right]$	PSD
$1500 < f \leq 11040$	-110	-90 dBm/Hz peak; and Maximum power in the [f, f + 1 MHz] window of -50 dBm
$11040 < f \leq 30175$	-110	-90 dBm/Hz peak

where:

PSDMASK(f) is in dBm/Hz, f is in kHz.  $f_{sym}$  (kbaud) = 66.6 to 194.7,  $K = 7.86$ ,  $\text{Order} = 3$ ,  $N = 1$ ,  $f_{3dB}$  (kHz) =  $1.0 \times f_{sym}/2$

$f_{int}$  is the frequency where the two equations governing PSDMASK(f) intersect, in kHz.

For each data rate at which the equipment can operate, it **shall not** exceed the PSDMASK generated by choosing a value of  $f_{sym}$  which need not be related to the actual CE parameters but may be any value between 66.6 kbaud and 194.7 kbaud. Because the Group A requirement permits such wide freedom to choose any  $f_{sym}$  value in the prescribed range, a party submitting equipment for test under Group A should provide to the test laboratory a detailed list of operating modes and corresponding  $f_{sym}$  values to use in generating the compliance masks.

The PSD **shall** be measured with a 10 kHz resolution bandwidth. Large PSD variations over narrow frequency intervals (for example near the junction of the main lobe with the noise floor) might require a smaller resolution bandwidth (RBW) to be used. An appropriate way would be to choose RBW such that there is no more than 1 dB change in the signal PSD across the RBW.

The power in the 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.

**Table B3**  
**PSD mask for Equipment Class 5a (Group B)**

$\text{PSDMASK}(f) = 10 \times \log_{10} \left\{ \begin{array}{l} \frac{K}{135} \times \frac{1}{f_{\text{sym}}} \times \frac{\left[ \sin\left(\frac{\pi f}{N f_{\text{sym}}}\right) \right]^2}{\left(\frac{\pi f}{N f_{\text{sym}}}\right)^2} \times \frac{1}{1 + \left(\frac{f}{f_{3\text{dB}}}\right)^{2 \times \text{Order}}} \times 10^{\frac{\text{MaskOffsetdB}(f)}{10}}, \quad f < f_{\text{int}} \\ 1.797 \times 10^{-6} \times f^{-1.5}, \quad f_{\text{int}} \leq f \leq 1500 \text{ kHz} \end{array} \right.$				
PSDMASK (f) = -90 peak (Max power in the [f, f + 1 MHz] window of -50 dBm),      1500 kHz < f ≤ 11040 kHz				
PSDMASK (f) = -90 peak,      11040 kHz < f ≤ 12040 kHz				
where:				
$\text{MaskOffsetdB}(f) = \begin{cases} 1 + 0.4 \times \frac{f_{3\text{dB}} - f}{f_{3\text{dB}}}, & f < f_{3\text{dB}} \\ 1, & f \geq f_{3\text{dB}} \end{cases}$				
PSDMASK(f) is in dBm/Hz, f is in kHz.				
f <sub>int</sub> is the frequency where the two equations governing PSDMASK(f) intersect, in kHz.				
f <sub>sym</sub> = (payload kbit rate + overhead kbit rate)/(number of bits per symbol)				
The PSD <b>shall</b> be measured with a 10 kHz resolution bandwidth. Large PSD variations over narrow frequency intervals (for example near the junction of the main lobe with the noise floor) might require a smaller resolution bandwidth (RBW) to be used. An appropriate way would be to choose RBW such that there is no more than 1 dB change in the signal PSD across the RBW.				
The power in the 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.				
f <sub>sym</sub> (kbaud)	K	Order	N	f <sub>3dB</sub> (kHz)
66.6 to 194.7	7.86	3	1	1.0 × f <sub>sym</sub> /2

## APPENDIX

### C Equipment Class 5b

Table C1 provides the Group A and Group B test criteria for Equipment Class 5b.

The test termination impedance for Equipment Class 5b is 135  $\Omega$ .

**Table C1**  
**Test criteria for Equipment Class 5b**

Parameter		Group A	Group B
Total average power	Level	14 dBm	14 dBm
	Frequency range	0 Hz to 1100 kHz	0 Hz to 1100 kHz
	Averaging time	$\geq 10$ s	$\geq 10$ s
PSD mask	–	Table C2	Table C3
Line code	–	Not applicable	Trellis Coded Pulse Amplitude Modulation
Longitudinal balance	Level	40 dB from 20 kHz to 131 kHz, with a slope of 20 dB/decade below 20 kHz and –20 dB/decade above 131 kHz	40 dB from 20 kHz to $f_{\text{sym}}/2$ kHz, with a slope of 20 dB/decade below 20 kHz and –20 dB/decade above $f_{\text{sym}}/2$ kHz
	Frequency Range	20 kHz to 2000 kHz	20 kHz to 2000 kHz
Longitudinal output voltage	Level	–50 dBV in any 4 kHz band	–50 dBV in any 4 kHz band
	Frequency Range	20 kHz to 450 kHz	20 kHz to 450 kHz

Note:  $f_{\text{sym}}$  is the symbol rate or baud rate on the line.

**Table C2**  
**PSD mask and testing requirements for Equipment Class 5b (Group A)**

Frequency in kHz	PSDMASK (f) in dBm/Hz	Testing Requirements
$f < f_{\text{int}}$	$10 \times \log_{10} \left[ \frac{K}{135} \times \frac{1}{f_{\text{sym}}} \times \frac{\left[ \sin \left( \frac{\pi f}{N f_{\text{sym}}} \right) \right]^2}{\left( \frac{\pi f}{N f_{\text{sym}}} \right)^2} \times \frac{1}{1 + \left( \frac{f}{f_{3\text{dB}}} \right)^{2 \times \text{Order}}} \right]$	PSD
$f_{\text{int}} \leq f \leq 1500$	$10 \times \log_{10} [1.7971 \times 10^{-6} \times f^{-1.5}]$	PSD
$1500 < f \leq 11040$	-110	-90 dBm/Hz peak; and Maximum power in the [f, f + 1 MHz] window of -50 dBm
$11040 < f \leq 30175$	-110	-90 dBm/Hz peak

where:

PSDMASK(f) is in dBm/Hz, f is in kHz.  $f_{\text{sym}}$  (kbaud) = 66.6 to 261.4,  $K = 3.5.1$ ,  $\text{Order} = 3$ ,  $N = 1$ ,  $f_{3\text{dB}}$  (kHz) =  $1.0 \times f_{\text{sym}}/2$

$f_{\text{int}}$  is the frequency where the two equations governing PSDMASK(f) intersect, in kHz.

For each data rate at which the equipment can operate, it **shall not** exceed the PSDMASK generated by choosing a value of  $f_{\text{sym}}$  which need not be related to the actual CE parameters but may be any value between 66.6 kbaud and 261.4 kbaud. Because the Group A requirement permits such wide freedom to choose any  $f_{\text{sym}}$  value in the prescribed range, a party submitting equipment for test under Group A should provide to the test laboratory a detailed list of operating modes and corresponding  $f_{\text{sym}}$  values to use in generating the compliance masks.

The PSD **shall** be measured with a 10 kHz resolution bandwidth. Large PSD variations over narrow frequency intervals (for example near the junction of the main lobe with the noise floor) might require a smaller resolution bandwidth (RBW) to be used. An appropriate way would be to choose RBW such that there is no more than 1 dB change in the signal PSD across the RBW.

The power in the 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.

**Table C3**

**PSD mask for Equipment Class 5b (Group B)**

$$\text{PSDMASK}(f) = 10 \times \log_{10} \left\{ \begin{array}{l} \frac{K}{135} \times \frac{1}{f_{\text{sym}}} \times \frac{\left[ \sin\left(\frac{\pi f}{N f_{\text{sym}}}\right) \right]^2}{\left(\frac{\pi f}{N f_{\text{sym}}}\right)^2} \times \frac{1}{1 + \left(\frac{f}{f_{3\text{dB}}}\right)^{2 \times \text{Order}}} \times 10^{\frac{\text{MaskOffsetdB}(f)}{10}}, \quad f < f_{\text{int}} \\ 1.797 \times 10^{-6} \times f^{-1.5}, \quad f_{\text{int}} \leq f \leq 1500 \text{ kHz} \end{array} \right.$$

PSDMASK (f) = -90 peak (Max power in the [f, f + 1 MHz] window of -50 dBm ),  
1500 kHz < f ≤ 11040 kHz

PSDMASK (f) = -90 peak, 11040 kHz < f ≤ 12040 kHz

where:

$$\text{MaskOffsetdB}(f) = \begin{cases} 1 + 0.4 \times \frac{f_{3\text{dB}} - f}{f_{3\text{dB}}}, & f < f_{3\text{dB}} \\ 1, & f \geq f_{3\text{dB}} \end{cases}$$

PSDMASK(f) is in dBm/Hz, f is in kHz.

f<sub>int</sub> is the frequency where the two equations governing PSDMASK(f) intersect, in Hz.

f<sub>sym</sub> = (payload kbit rate + overhead kbit rate)/(number of bits per symbol)

The PSD **shall** be measured with a 10 kHz resolution bandwidth. Large PSD variations over narrow frequency intervals (for example near the junction of the main lobe with the noise floor) might require a smaller resolution bandwidth (RBW) to be used. An appropriate way would be to choose RBW such that there is no more than 1 dB change in the signal PSD across the RBW.

The power in the 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.

f <sub>sym</sub> (kbaud)	K	Order	N	f <sub>3dB</sub> (kHz)
66.6 to 261.4	3.51	3	1	1.0 × f <sub>sym</sub> /2

## APPENDIX

### D Equipment Classes 6a, 6d, 6e and 6f

Table D1 provides the Group A and Group B test criteria and Referenced Documents for Equipment Classes 6a, 6d, 6e and 6f. Typical technologies are ADSL2 (excluding the option of using the voice channel), ADSL FD and ADSL EC.

The test termination impedance for Equipment Classes 6a, 6d, 6e and 6f is 100 Ω.

**Table D1**  
**Test criteria and Referenced Documents for**  
**Equipment Classes 6a, 6d, 6e and 6f**

Parameter		Group A	Group B
Total Average Power	Level	12.5 dBm	G.992.1 Clause A.2.4.3.3 [7]
	Frequency range	25.875 kHz to 138 kHz	G.992.1 Clause A.2.4.3.3 [7]
	Averaging time	≥ 10 s	≥ 10 s
PSD Mask	–	Table D2	G.992.1 Clause A.2.4 [7]. The maximum power in the 0 to 4 kHz band is to be –65 dBm in place of the –75 dBm (+15 dBm) in G.992.1 [7] (See Note)
Line Code	–	Not applicable	G.992.1 Clauses 8.7, 8.10, 8.11 and either Clause 8.8 or 8.9 [7]
Longitudinal Balance	Level	40 dB	G.992.1 Clause A 4.3.1 [7]
	Frequency Range	30 kHz to 1104 kHz	G.992.1 Clause A 4.3.1 [7]
Longitudinal Output Voltage	Level	–50 dBV in any 4 kHz band	–50 dBV in any 4 kHz band
	Frequency Range	As per longitudinal balance	As per longitudinal balance

Note: The limit for the maximum power in the 0 to 4 kHz band assumes that the high pass filter is included in CE. If an external splitter or filter is required to meet this requirement, the specification and installation of such a filter is to be detailed in the CE manual.

**Table D2**  
**PSD mask and testing requirements for**  
**Equipment Classes 6a, 6d, 6e and 6f**

Frequency band f (kHz)	PSD (dBm/Hz) (See Note 2)	Testing Requirements
$0 < f \leq 4$	-97.5	PSD and Wideband power -65 dBm (See Note 1)
$4 < f \leq 25.875$	$-96 + 21.533 \times \log_2(f/4)$	PSD
$25.875 < f \leq 138$	-38	PSD
$138 < f \leq 307$	$-38 + 48.112 \times \log_2(f/138)$	PSD
$307 < f \leq 1221$	-93.5	PSD
$1221 < f \leq 1630$	$-93.5 - 39.587 \times \log_2(f/1221)$	-93.5 dBm/Hz peak and in the [f, f + 1 MHz] window: $-90 - 48 \times \log_2\left(\frac{f}{1221}\right) + 60$ dBm (See Note 3)
$1630 < f \leq 11040$	-110	-93.5 dBm/Hz peak and in the [f, f + 1 MHz] window: -50 dBm (See Note 3)
$11040 < f < 30175$	-110	-93.5 dBm/Hz peak

Note 1: The 0 to 4 kHz band total power measurement is in 600 Ω. The limit for the maximum power in the 0 to 4 kHz band assumes that the high pass filter is included in CE. If an external splitter or filter is required to meet this requirement, the specification and installation of such a filter is to be detailed in the CE manual.

Note 2: Above 25.875 kHz, the peak PSD is measured with a 10 kHz resolution bandwidth.

Note 3: The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.

## APPENDIX

### E Equipment Class 6c

Table E1 provides the Group A and Group B test criteria and Referenced Documents for Equipment Class 6c. A typical technology is ADSL over ISDN.

The test termination impedance for Equipment Class 6c is 100 Ω.

**Table E1**  
**Test criteria and Referenced Documents for**  
**Equipment Class 6c**

Parameter		Group A	Group B
Total average power	Level	13.3 dBm	G.992.1 Clause B.2.2.3.2 [7]
	Frequency range	138 kHz to 276 kHz	G.992.1 Clause B.2.2.3.2 [7]
	Averaging time	≥ 10 s	≥ 10 s
PSD mask	–	Table E2	G.992.1 Clause B2.2 [7]
Line code	–	Not applicable	G.992.1 Clauses 8.7, 8.10, 8.11 and either Clause 8.8 or 8.9 [7]
Longitudinal balance	Level	40 dB	G.992.1 Clause A 4.3.1 [7]
	Frequency range	30 kHz to 1104 kHz	G.992.1 Clause A 4.3.1 [7]
Longitudinal output voltage	Level	–50 dBV in any 4 kHz band	–50 dBV in any 4 kHz band
	Frequency range	As per longitudinal balance	As per longitudinal balance

**Table E2**

**PSD mask and testing requirements for Equipment Class 6c (Group A)**

Frequency band f (kHz)	PSD (dBm/Hz) (See Note 1)	Testing Requirements
$0 < f \leq 50$	-90	PSD
$50 < f \leq 80$	$-90 + 12 \times \log_2\left(\frac{f}{50}\right)$	PSD
$80 < f \leq 138$	$-81.863 + 55.763 \times \log_2(f/80)$	PSD
$138 < f \leq 276$	-38	PSD
$276 < f \leq 615$	$-38 - 48.014 \times \log_2(f/276)$	PSD
$615 < f \leq 1221$	-93.5	PSD
$1221 < f \leq 1630$	$-93.5 - 39.587 \times \log_2(f/1221)$	-93.5 dBm/Hz peak and in the [f, f + 1 MHz] window: $-90 - 48 \times \log_2\left(\frac{f}{1221}\right) + 60$ dBm (See Note 2)
$1630 < f \leq 11040$	-110	-93.5 dBm/Hz peak and in the [f, f + 1 MHz] window: -50 dBm (See Note 2)
$11040 < f \leq 30175$	-110	-93.5 dBm/Hz peak

Note 1: Above 25.875 kHz, the peak PSD is measured with a 10 kHz resolution bandwidth.

Note 2: The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.

## APPENDIX

### F Equipment Class 6g

Table F1 provides the Group A and Group B test criteria and Referenced Documents for Equipment Class 6g. A typical technology is Reach Extended ADSL2 non-overlapped spectrum with mask 1 (Re-ADSL2).

The test termination impedance for Equipment Class 6g is 100  $\Omega$ .

**Table F1**  
**Test criteria and Reference Documents for**  
**Equipment Class 6g**

Parameter	Sub-parameter	Group A (Value)	Group B
Total average power	Level	12.5 dBm	G.992.3 Clause L.2.2.2 [8]
	Frequency range	25.875 kHz to 103.5 kHz	G.992.3 Clause L.2.2 [8]
	Averaging time	$\geq 10$ s	$\geq 10$ s
PSD mask		Table F2	G.992.3 mask 1 Clause L.2.2.[8]
Line code		Not applicable	G.992.3 Clause 8.8 [8].
Longitudinal balance	Level	40 dB	G.992.3 Clause A 4.3.3.1 [8]
	Frequency range	30 kHz to 1104 kHz	G.992.3 Clause A 4.3.3.1 [8]
Longitudinal output voltage	Level	-50 dBV in any 4 kHz band	-50 dBV in any 4 kHz band
	Frequency range	As per longitudinal balance	As per longitudinal balance

**Table F2**  
**PSD mask and testing requirements for**  
**Equipment Class 6g (Group A)**

Frequency band <i>f</i> (kHz)	PSD (dBm/Hz) (See Note 2)	Testing requirements
$0 < f \leq 4.0$	-101.5	PSD. Also wideband power < -65 dBm (See Note 1)
$4 < f \leq 25.875$	$-96 + 22.127 \times \log_2\left(\frac{f}{4}\right)$	PSD
$25.875 < f \leq 103.5$	-36.4	PSD
$103.5 < f \leq 400.9$	$\text{Max}\left\{ \begin{array}{l} -36.4 - 72 \times \log_2\left(\frac{f}{103.5}\right) \\ 10 \times \log_{10}\left[0.05683 \times (1000 f)^{-1.5}\right] - 3.5 \end{array} \right\}$	PSD
$400.9 < f \leq 1411$	-100	PSD
$1411 < f \leq 1630$	$-100 - 48.041 \times \log_2\left(\frac{f}{1411}\right)$	-100 dBm/Hz peak and in the [f, f + 1 MHz] window: $-40 - 48 \times \log_2\left(\frac{f}{1411}\right)$ dBm (See Note 2)
$1630 < f \leq 5275$	$-110 - 1.1804 \times \log_2\left(\frac{f}{1630}\right)$	-100 dBm/Hz peak and in the [f, f + 1 MHz] window: $-50 - 1.18 \times \log_2\left(\frac{f}{1630}\right)$ dBm (See Note 2)
$5275 < f \leq 30175$	-112	-100 dBm/Hz peak and in the [f, f + 1 MHz] window: -52 dBm (See Note 2)

Note 1: The 0 to 4 kHz band total power measurement is in 600 Ω. The limit for the maximum power in the 0 to 4 kHz band assumes that the high pass filter is included in CE. If an external splitter or filter is required to meet this requirement, the specification and installation of such a filter is to be detailed in the CE manual.

Note 2: The power in a 1MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.

## APPENDIX

### G Equipment Class 6h

Table G1 provides the Group A and Group B test criteria and Referenced Documents for Equipment Class 6h network systems. A typical technology is ADSL2 non-overlapped spectrum or ADSL2+ non-overlapped spectrum.

The termination impedance for Equipment Class 6h is 100 Ω.

**Table G1**

**Test criteria and Reference Documents for Equipment Class 6h**

Parameter	Sub-parameter	Group A (Value)	Group B
Total average power	Level	12.5 dBm	G.992.5 Clause A.2.2.2 [9]
	Frequency range	25.875 to 138 kHz	G.992.5 Clause A.2.2 [9]
	Averaging time	≥ 10 s	≥ 10 s
PSD mask		Table G2	G.992.5 Clause. A.2.2 [9] Maximum power in the 0 to 4 kHz band is relaxed to -65 dBm <sub>600Ω</sub>
Line code		Not applicable	G.992.5 Clauses 7 & 8 [9]
Longitudinal balance	Level	40 dB	G.992.5 Clause A 4 [9] and G.992.3 Clause A 4.3.3.1 [8]
	Frequency range	30 kHz to 2208 kHz	G.992.5 Clause A 4 [9]
Longitudinal output voltage	Level	-50 dBV in any 4 kHz band	-50 dBV in any 4 kHz band
	Frequency range	As per longitudinal balance	As per longitudinal balance

**Table G2**

**PSD mask and testing requirements for Equipment Class 6h**

Frequency band $f$ (kHz)	PSD (dBm/Hz in Narrow Resolution Bandwidth)	Testing requirements
$0 < f \leq 4$	-101	PSD
$4 < f \leq 25.875$	$-96 + 21.533 \times \log_2(f/4)$	PSD
$25.875 < f \leq 138$	-38	PSD
$138 < f \leq 229.6$	$-38 - 74.749 \times \log_2(f/138)$	PSD
$229.6 < f \leq 686$	$-92.9 - 4.4963 \times \log_2(f/229.6)$	PSD
$686 < f \leq 1411$	-100	PSD
$1411 < f \leq 1630$	$-100 - 48.041 \times \log_2(f/1411)$	-100 dBm/Hz peak and in the $[f, f + 1 \text{ MHz}]$ window: - 40 - 48 $\times \log_2(f/1411)$ dBm
$1630 < f \leq 5275$	$-110 - 1.1804 \times \log_2(f/1630)$	-100 dBm/Hz peak and in the $[f, f + 1 \text{ MHz}]$ window: - 50 - 1.18 $\times \log_2(f/1630)$ dBm
$5275 < f \leq 30175$	-112	-100 dBm/Hz peak and in the $[f, f + 1 \text{ MHz}]$ window: -52 dBm
<p>where:</p> <p>Below 25.875 kHz the peak PSD <b>shall</b> be measured with a 100 Hz resolution bandwidth.</p> <p>Above 25.875 kHz the peak PSD <b>shall</b> be measured with a 10 kHz resolution bandwidth.</p>		

## APPENDIX

### H Equipment Class 6i

Table H1 provides the Group A and Group B test criteria and Referenced Documents for Equipment Class 6i. A typical technology is All Digital Mode ADSL2+ non overlapped spectrum.

The termination impedance for Equipment Class 6i is 100  $\Omega$ .

**Table H1**

**Test criteria and Reference Documents for Equipment Class 6i**

Parameter	Sub-parameter	Group A (Value)	Group B
Total average power	Level	13.3 dBm	G.992.5 Clause I.2.2.2 [9]
	Frequency range	3 kHz to 138 kHz	G.992.5 Clause I.2.2 [9]
	Averaging time	$\geq 10$ s	$\geq 10$ s
PSD mask		Table H2	G.992.5 Clauses I.2.2 [9]
Line code		Not applicable	G.992.5 Clause 8.8 and 8.9 [9]
Longitudinal balance	Level	40 dB	G.992.3 Clause A 4.3.3.1 [8]
	Frequency range	30 kHz to 2208 kHz	G.992.5 Clause A I.4 [9]
Longitudinal output voltage	Level	-50 dBV in any 4 kHz band	-50 dBV in any 4 kHz band
	Frequency range	As per longitudinal balance	As per longitudinal balance

**Table H2**

**PSD mask and testing requirements for Equipment Class 6i (Group A)**

Frequency band f (kHz)	PSD (dBm/Hz in Narrow Resolution Bandwidth) (See Note 1)	Testing requirements
$0 < f \leq 1.5$	-50	PSD
$1.5 < f \leq 3$	$-50 + 12 \times \log_2\left(\frac{f}{1.5}\right)$	PSD
$3 < f \leq 138$	-38	PSD
$138 < f \leq 229.6$	$-38 - 74.749 \times \log_2\left(\frac{f}{138}\right)$	PSD
$229.6 < f \leq 686$	$-92.9 - 4.4963 \times \log_2\left(\frac{f}{229.6}\right)$	PSD
$686 < f \leq 1411$	-100	PSD
$1411 < f \leq 1630$	$-100 - 48.041 \times \log_2\left(\frac{f}{1411}\right)$	-100 dBm/Hz peak and in the [f, f + 1 MHz] window: $-40 - 48 \times \log_2\left(\frac{f}{1411}\right)$ dBm (See Note 2)
$1630 < f \leq 5275$	$-110 - 1.1804 \times \log_2\left(\frac{f}{1630}\right)$	-100 dBm/Hz peak and in the [f, f + 1 MHz] window: $-50 - 1.18 \times \log_2\left(\frac{f}{1630}\right)$ dBm (See Note 2)
$5275 < f \leq 30175$	-112	-100 dBm/Hz peak and in the [f, f + 1 MHz] window: -52 dBm (See Note 2)

Note 1: The 0 to 4 kHz band total power measurement is in 600 Ω. The limit for the maximum power in the 0 to 4 kHz band assumes that the high pass filter is included in CE. If an external splitter or filter is required to meet this requirement, the specification and installation of such a filter is to be detailed in the CE manual.

Note 2: The power in a 1MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.

## APPENDIX

### I Equipment Classes 6j to 6n

Table I1 provides the Group A and Group B test criteria and Referenced Documents for Equipment Class 6j, 6k, 6l, 6m and 6n. Typical technologies are the transmission masks EU-40, EU-52, EU-56, EU-60 and EU-64, providing extended ADSL upstream bandwidth in Annex M for ADSL2 or ADSL2+.

The termination impedance for Equipment Classes 6j to 6n is 100 Ω.

**Table I1**

**Test criteria and Reference Documents for Equipment Classes 6j to 6n**

Parameter	Sub-parameter	Group A (Value)	Group B
Total average power	Level	12.5 dBm	G.992.5 Clause M.2.2.2 [9]
	Frequency range	see Table I2	G.992.5 Clause M.2.2 [9]
	Averaging time	≥ 10 s	≥ 10 s
PSD mask		Table I3 and Table I4	G.992.5 Clause. M.2.2.1 [9] Maximum power in the 0 to 4kHz band is relaxed to -65 dBm <sub>600Ω</sub>
Line code		Not applicable	G.992.5 Clauses 7 & 8 [9]
Longitudinal balance	Level	40 dB	G.992.5 Clause A 4 [9] and G.992.3 Clause A 4.3.3.1 [8]
	Frequency range	30 kHz to 2208 kHz	G.992.5 Clause A 4 [9]
Longitudinal output voltage	Level	-50 dBV in any 4 kHz band	-50 dBV in any 4 kHz band
	Frequency range	As per longitudinal balance	As per longitudinal balance

**Table I2**

**Total Average Power frequency ranges for Equipment Classes 6j to 6n  
(Group A)**

<b>Equipment class</b>	<b>Frequency Range for Total Average Power (kHz)</b>
6j	25.875 to 172.50 kHz
6k	25.875 to 224.25 kHz
6l	25.875 to 241.50 kHz
6m	25.875 to 258.75 kHz
6n	25.875 to 276.00 kHz

**Table I3**

**Group A PSD mask and testing requirements for Equipment Class 6j to 6n**

Frequency band $f$ (kHz)	PSD (dBm/Hz in Narrow Resolution Bandwidth)	Testing requirements
$0 < f \leq 4$	-101	PSD
$4 < f \leq 25.875$	$-96 + s1 \times \log_2(f/4)$	PSD
$25.875 < f \leq f_1$	<i>Nominal_PSD</i>	PSD
$f_1 < f \leq f_{1\_int\_templ}$	$Nominal\_PSD - s2 \times \log_2(f/ f1)$	PSD
$f_{1\_int\_templ} < f \leq 686$	$PSD\_int\_templ - s3 \times \log_2(f/f_{1\_int\_templ})$	PSD
$686 < f \leq 1411$	-100	PSD
$1411 < f \leq 1630$	$-100 - 48 .041 \times \log_2(f/1411)$	-100 dBm/Hz peak and in the $[f, f+1 \text{ MHz}]$ window: $-40-48 \times \log_2(f/1411)$ dBm
$1630 < f \leq 5275$	$-110 - 1.1804 \times \log_2(f/1630)$	-100 dBm/Hz peak and in the $[f, f+1 \text{ MHz}]$ window: $-50 - 1.18 \times \log_2(f/1630)$ dBm
$5275 < f \leq 30175$	-112	-100 dBm/Hz peak and in the $[f, f+1 \text{ MHz}]$ window: -52 dBm
<p>where:</p> <p>Below 25.875 kHz the peak PSD <b>shall</b> be measured with a 100 Hz resolution bandwidth.</p> <p>Above 25.875 kHz the peak PSD <b>shall</b> be measured with a 10 kHz resolution bandwidth.</p> <p><math>f_1</math>, <math>f_{1\_int\_templ}</math>, <i>Nominal_PSD</i>, <i>PSD_int_templ</i>, <math>s1</math>, <math>s2</math> and <math>s3</math> are defined in Table I4.</p>		

**Table I4**  
**Group A PSD Template Parameters for Equipment Classes 6j to 6n**

Equipment Class	Nominal Designator	$f_1$ (kHz)	Slope $s_1$	Template Peak PSD level Nominal_PSD (dBm/Hz)	Template intercept frequency $f_{1\_int\_templ}$ (kHz)	Slope $s_2$	Template intercept PSD level PSD_int_tmpl (dBm/Hz)	Slope $s_3$
6j	EU-40	174.5	21.1622	-39.0	294.39	71.9721	-94.5	4.5064
6k	EU-52	224.25	20.7538	-40.1	384.95	71.9634	-96.2	4.5589
6l	EU-56	241.5	20.6424	-40.4	415.25	71.9988	-96.7	4.5566
6m	EU-60	258.75	20.5310	-40.7	445.59	72.0518	-97.2	4.4981
6n	EU-64	276	20.4196	-41.0	475.99	71.9861	-97.6	4.5517

where:

The breakpoint frequencies and PSD values are exact.

The breakpoints in the tables **shall** be connected by linear straight lines on a dB/log(f) plot.

## APPENDIX

### J Equipment Class 8b

Table J1 provides the Group A and Group B test criteria and Referenced Documents for Equipment Class 8b. A typical technology is HDSL 2B1Q (1168 kbit/s).

The test termination impedance for Equipment Class 8b is 135  $\Omega$ .

**Table J1**  
**Test criteria and Referenced Documents for**  
**Equipment Class 8b**

Parameter		Group A	Group B
Total Average Power	Level	14 dBm	G.991.1 Clause 5.8.4.4 [5]
	Frequency range	0 Hz to 584 kHz	G.991.1 Clause 5.8.4.4 [5]
	Averaging time	$\geq 10$ s	$\geq 10$ s
PSD Mask	-	Table J2	G.991.1 Clause 5.8.4.3.2 [5] to 12040 kHz
Line Code	-	Not applicable	G.991.1 Clause 5.3.6 [5]
Longitudinal Balance	Level	40 dB from 20 kHz to 292 kHz, with a slope of 20 dB/decade below 20 kHz and -20 dB/decade above 292 kHz	G.991.1 Clause 5.8.5.1 [5]
	Frequency Range	500 Hz to 1168 kHz	G.991.1 Clause 5.8.5.1 [5]
Longitudinal Output Voltage	Level	-50 dBV in any 4 kHz band	G.991.1 Clause 5.8.5.2 [5]
	Frequency Range	As per longitudinal balance	G.991.1 Clause 5.8.5.2 [5]

**Table J2**  
**PSD mask for Equipment Class 8b (Group A)**

Frequency f (kHz)	PSD (dBm/Hz)
0	-38.7
74	-38.7
186	-39.7
313	-42.7
462	-58.7
551	-74.7
819	-76.7
998	-86.7
1117	-98.7
1460	-99.7
1585	-105.5
$1585 < f \leq 30175$	$-143 - 10 \times \log_{10} \left( \frac{(10^3 \times f)^{1.5}}{1.134 \times 10^{13}} \right)$

Note: The values between the specified points are derived by linear interpolation of frequency and PSD limit in dBm/Hz.

## APPENDIX

### K Equipment Classes 9a to 9h

Table K1 provides the Group A and Group B test criteria and Reference Documents for Equipment Classes 9a, 9b, 9c, 9d, 9e, 9f, 9g and 9h. A typical technology is SHDSL for the 16-TCPAM rates and ESHDSL for the 32-TCPAM rates.

The test termination impedance for Equipment Class 9 is 135 Ω.

**Table K1**  
**Test criteria and Reference Documents for**  
**Equipment Classes 9a to 9h**

Parameter	Sub-parameter	Group A	Group B
Total average power	Level	Table K2	Table K2
	Frequency range	0 Hz to 1.5 MHz	0 Hz to 1.5 MHz
	Averaging time	≥ 10 s	≥ 10 s
PSD mask		Table K3 for 16-TCPAM Table L3 for 32-TCPAM.	G.991.2 Clause B4.1 [6] (Table K4 lists the testing requirements)
Line code		Not applicable	Trellis Coded Pulse Amplitude Modulation
Longitudinal balance	Level	40 dB from 20 kHz to $f_{\text{sym}}/2$ kHz, with a slope of 20 dB/decade below 20 kHz and -20dB/decade above $f_{\text{sym}}/2$ .	40 dB from 20 kHz to $f_{\text{sym}}/2$ kHz, with a slope of 20 dB/decade below 20 kHz and -20 dB/decade above $f_{\text{sym}}/2$ kHz. (See Note)
	Frequency Range	20 kHz to 2000 kHz	20 kHz to 2000 kHz
Longitudinal output voltage	Level	-50 dBV in any 4 kHz band	-50 dBV in any 4 kHz band
	Frequency Range	20 kHz to 450 kHz	20 kHz to 450 kHz

Note:  $f_{\text{sym}}$  is the symbol rate or baud rate on the line.

**Table K2**

**List of Parameters for Equipment Classes 9a to 9h**

Class	$f_{\text{sym}}$ (k symbols/sec)	Power (dBm)	K	16-TCPAM Payload Rate (kbps)	32-TCPAM Payload Rate (kbps) (See Note 1)
9a	$66.6 < f_{\text{sym}} < 194.7$	14.0	7.86	$192 \leq \text{PR} \leq 576$	N/A
9b, 9c	$66.6 < f_{\text{sym}} < 261.4$	14.0	7.86	$192 \leq \text{PR} \leq 776$	$768 \leq \text{PR} \leq 1032$
9d	$66.6 < f_{\text{sym}} < 389.4$	14.0	7.86	$192 \leq \text{PR} \leq 1160$	$768 \leq \text{PR} \leq 1544$
9e	$66.6 < f_{\text{sym}} < 517.4$	14.0	7.86	$192 \leq \text{PR} \leq 1544$	$768 \leq \text{PR} \leq 2056$
9f	$66.6 < f_{\text{sym}} < 685.4$	14.0	7.86	$192 \leq \text{PR} \leq 2048$	$768 \leq \text{PR} \leq 2728$
	$685.4 < f_{\text{sym}} \leq 688$	15.0	9.9	$2048 < \text{PR} \leq 2056$	$2728 < \text{PR} \leq 2744$
9g	$66.6 < f_{\text{sym}} < 685.4$	14.0	7.86	$192 \leq \text{PR} \leq 2048$	$768 \leq \text{PR} \leq 2728$
	$685.4 < f_{\text{sym}} < 773.4$	15.0	9.9	$2048 < \text{PR} \leq 2312$	$2728 < \text{PR} \leq 3080$
9h	$66.6 < f_{\text{sym}} < 602.6$	14.0	7.86	$192 \leq \text{PR} \leq 1800$	$768 \leq \text{PR} \leq 2400$

Note 1: For Group A testing requirements for equipment using 32-TCPAM line code refer to Table L3.

**Table K3**

**PSD mask and testing requirements for Equipment Classes 9a to 9h (Group A) using 16-TCPAM**

Frequency in kHz	PSDMASK (f) in dBm/Hz	Testing Requirements
$f < f_{int}$	$10 \times \log_{10} \left[ \frac{K}{135} \times \frac{1}{f_{sym}} \times \frac{\left[ \sin \left( \frac{\pi f}{N f_{sym}} \right) \right]^2}{\left( \frac{\pi f}{N f_{sym}} \right)^2} \times \frac{1}{1 + \left( \frac{f}{f_{3dB}} \right)^{2 \times \text{Order}}} \right]$	PSD
$f_{int} \leq f \leq 1500$	$10 \times \log_{10} [1.7971 \times 10^{-6} \times f^{-1.5}]$	PSD
$1500 < f \leq 11040$	-110	-90 dBm/Hz peak; and Maximum power in the [f, f + 1 MHz] window of -50 dBm
$11040 < f \leq 30175$	-110	-90 dBm/Hz peak

where:

K and  $f_{sym}$  are defined in Table K2                      Order = 6                       $f_{3dB} = f_{sym}/2$                       PSDMASK(f) is in dBm/Hz                      f is in kHz

$f_{int}$  is the frequency where the two equations governing PSDMASK(f) intersect, in kHz.

For each data rate at which the equipment can operate,  $f_{sym}$  **shall not** exceed the PSDMASK generated by choosing a value of  $f_{sym}$  which need not be related to the actual CE parameters but may be any value in the range listed in Table K2 for the relevant Equipment Class. Because the Group A requirement permits such wide freedom to choose any  $f_{sym}$  value in the prescribed range, a party submitting equipment for test under Group A should provide to the test laboratory a detailed list of operating modes and corresponding  $f_{sym}$  values to use in generating the compliance masks.

The PSD **shall** be measured with a resolution bandwidth less than or equal to 10 kHz. Large PSD variations over narrow frequency intervals (for example near the junction of the main lobe with the noise floor) might require a smaller resolution bandwidth (RBW) to be used. An appropriate way would be to choose RBW such that there is no more than 1 dB change in the signal PSD across the RBW.

The power in the 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.

**Table K4**

**PSD mask and testing requirements for Equipment Classes 9a to 9h (Group B) using 16-TCPAM**

$$\text{PSDMASK}(f) = 10 \times \log_{10} \left\{ \begin{array}{ll} \frac{K}{135} \times \frac{1}{f_{\text{sym}}} \times \frac{\left[ \sin\left(\frac{\pi f}{N f_{\text{sym}}}\right) \right]^2}{\left(\frac{\pi f}{N f_{\text{sym}}}\right)^2} \times \frac{1}{1 + \left(\frac{f}{f_{3\text{dB}}}\right)^{2 \times \text{Order}}} \times 10^{\frac{\text{MaskOffset dB}(f)}{10}} & , f < f_{\text{int}} \\ 1.7971 \times 10^{-6} \times f^{-1.5} & , f_{\text{int}} \leq f \leq 1500 \text{ kHz} \end{array} \right.$$

PSDMASK (f) = -90 peak (Max power in the [f, f + 1 MHz] window of -50 dBm) , 1500 kHz < f ≤ 11040 kHz  
 PSDMASK (f) = -90 peak, 11040 kHz < f ≤ 12040 kHz

where:

$$\text{MaskOffset dB}(f) = \begin{cases} 1 + 0.4 \times \frac{f_{3\text{dB}} - f}{f_{3\text{dB}}} & , f < f_{3\text{dB}} \\ 1 & , f \geq f_{3\text{dB}} \end{cases}$$

Order = 6  
 $f_{3\text{dB}} = f_{\text{sym}}/2$   
 PSDMASK(f) is in dBm/Hz, f is in kHz.  
 $f_{\text{int}}$  is the frequency where the two equations governing PSDMASK(f) intersect, in kHz.  
 $f_{\text{sym}} = (\text{payload kbit rate} + \text{overhead kbit rate})/(\text{number of bits per symbol})$   
 The 16-TCPAM constellation has 3 bits per symbol while the 32-TCPAM constellation has 4 bits per symbol.  
 The PSD **shall** be measured with a resolution bandwidth less than or equal to 10 kHz. Large PSD variations over narrow frequency intervals (for example near the junction of the main lobe with the noise floor) might require a smaller resolution bandwidth (RBW) to be used. An appropriate way would be to choose RBW such that there is no more than 1 dB change in the signal PSD across the RBW.  
 The power in the 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.

## APPENDIX

### L Equipment Classes 9i to 9t

Table L1 provides the Group A and Group B test criteria and Reference Documents for Equipment Classes 9i, 9j, 9k, 9l, 9m, 9n, 9o, 9p, 9q, 9r, 9s and 9t. Typical technologies are ESHDSL.

The test termination impedance for Equipment Class 9 is 135 Ω.

**Table L1**

**Test criteria and Reference Documents for Equipment Classes 9i to 9t**

Parameter	Sub-parameter	Group A	Group B
Total average power	Level	Table L2	Table L2
	Frequency range	0 Hz to 3000 kHz	0 Hz to 2000 kHz
	Averaging time	≥ 10 s	≥ 10 s
PSD mask		Table L3	Table L4 For test requirements for 16-TCPAM line code at payload rate(s) ≤ 2312 kbps refer to Table K4
Line code		Not applicable	Trellis Coded Pulse Amplitude Modulation
Longitudinal balance	Level	40 dB from 20 kHz to $f_{sym}/2$ kHz, with a slope of 20 dB/decade below 20 kHz and -20 dB/decade above $f_{sym}/2$ .	40 dB from 20 kHz to $f_{sym}/2$ kHz, with a slope of 20 dB/decade below 20 kHz and -20 dB/decade above $f_{sym}/2$ kHz. (See Note)
	Frequency Range	20 kHz to 3000 kHz	20 kHz to 2000 kHz
Longitudinal output voltage	Level	-50 dBV in any 4 kHz band	-50 dBV in any 4 kHz band
	Frequency Range	20 kHz to 450 kHz	20 kHz to 450 kHz

Note:  $f_{sym}$  is the symbol rate on the line.

**Table L2**  
**List of Parameters for Equipment Classes 9i to 9t**

Class	$f_{\text{sym}}$ (k symbols/sec)	Power (dBm)	$K_{\text{SHDSL}}$	16-TCPAM Payload Rate (kbps) (See Note 1)	32-TCPAM Payload Rate (kbps) (See Note 2)	64-TCPAM Payload Rate (kbps) (See Note 2)	128-TCPAM Payload Rate (kbps) (See Note 2)
9i	$66.6 < f_{\text{sym}} < 685.4$	14.0	7.86	$192 \leq \text{PR} \leq 2048$	$768 \leq \text{PR} \leq 2728$	N/A	N/A
	$685.4 < f_{\text{sym}} < 877.3$	15.0	9.9	$2048 < \text{PR} \leq 2624$	$2728 < \text{PR} \leq 3496$	N/A	N/A
9j	$66.6 < f_{\text{sym}} < 685.4$	14.0	7.86	$192 \leq \text{PR} \leq 2048$	$768 \leq \text{PR} \leq 2728$	N/A	N/A
	$685.4 < f_{\text{sym}} < 962.7$	15.0	9.9	$2048 < \text{PR} \leq 2880$	$2728 < \text{PR} \leq 3840$	N/A	N/A
9k	$66.6 < f_{\text{sym}} < 685.4$	14.0	7.86	$192 \leq \text{PR} \leq 2048$	$768 \leq \text{PR} \leq 2728$	N/A	N/A
	$685.4 < f_{\text{sym}} < 1026.7$	15.0	9.9	$2048 < \text{PR} \leq 3072$	$2728 < \text{PR} \leq 4096$	N/A	N/A
9l	$66.6 < f_{\text{sym}} < 685.4$	14.0	7.86	$192 \leq \text{PR} \leq 2048$	$768 \leq \text{PR} \leq 2728$	N/A	N/A
	$685.4 < f_{\text{sym}} < 1090.7$	15.0	9.9	$2048 < \text{PR} \leq 3264$	$2728 < \text{PR} \leq 4352$	N/A	N/A
9m	$66.6 < f_{\text{sym}} < 685.4$	14.0	7.86	$192 \leq \text{PR} \leq 2048$	$768 \leq \text{PR} \leq 2728$	N/A	N/A
	$685.4 < f_{\text{sym}} < 1154.7$	15.0	9.9	$2048 < \text{PR} \leq 3456$	$2728 < \text{PR} \leq 4608$	N/A	N/A
9n	$66.6 < f_{\text{sym}} < 685.4$	14.0	7.86	$192 \leq \text{PR} \leq 2048$	$768 \leq \text{PR} \leq 2728$	N/A	N/A
	$685.4 < f_{\text{sym}} < 1218.7$	15.0	9.9	$2048 < \text{PR} \leq 3648$	$2728 < \text{PR} \leq 4864$	N/A	N/A
9o	$66.6 < f_{\text{sym}} < 685.4$	14.0	7.86	$192 \leq \text{PR} \leq 2048$	$768 \leq \text{PR} \leq 2728$	N/A	N/A
	$685.4 < f_{\text{sym}} < 1282.7$	15.0	9.9	$2048 < \text{PR} \leq 3840$	$2728 < \text{PR} \leq 5120$	N/A	N/A
9p	$194 \leq f_{\text{sym}} \leq 684$	14.0	7.86	N/A	$768 \leq \text{PR} \leq 2728$	N/A	N/A
	$684 < f_{\text{sym}} \leq 1346$	15.0	9.9	N/A	$2728 < \text{PR} \leq 5376$	N/A	N/A
9q	$194 \leq f_{\text{sym}} \leq 684$	14.0	7.86	N/A	$768 \leq \text{PR} \leq 2728$	N/A	N/A
	$684 < f_{\text{sym}} \leq 1426$	15.0	9.9	N/A	$2728 < \text{PR} \leq 5696$	N/A	N/A
9r	$194 \leq f_{\text{sym}} \leq 684$	14.0	7.86	N/A	$768 \leq \text{PR} \leq 2728$	$968 \leq \text{PR} \leq 3412$	$1160 \leq \text{PR} \leq 4096$
	$684 < f_{\text{sym}} \leq 1524$	15.0	9.9	N/A	$2728 < \text{PR} \leq 6096$	$3412 < \text{PR} \leq 7624$	$4096 < \text{PR} \leq 9152$

Table L2 continued:

9s	$194 \leq f_{\text{sym}} \leq 684$	14.0	7.86	N/A	$768 \leq \text{PR} \leq 2728$	$968 \leq \text{PR} \leq 3412$	$1160 \leq \text{PR} \leq 4096$
	$684 < f_{\text{sym}} \leq 2028$	15.0	9.9	N/A	$2728 < \text{PR} \leq 8104$	$3412 < \text{PR} \leq 10136$	$4096 < \text{PR} \leq 12160$
9t	$194 \leq f_{\text{sym}} \leq 684$	14.0	7.86	N/A	$768 \leq \text{PR} \leq 2728$	$968 \leq \text{PR} \leq 3412$	$1160 \leq \text{PR} \leq 4096$
	$684 < f_{\text{sym}} \leq 2550$	15.0	9.9	N/A	$2728 < \text{PR} \leq 10192$	$3412 < \text{PR} \leq 12744$	$4096 < \text{PR} \leq 15296$

Note 1: For Group A testing requirements for equipment using 16-TCPAM line code at payload rates less than or equal to 2312 kbps refer to Table K3.

Note 2: For Group A testing requirements for equipment using—

(i) 16-TCPAM line code at payload rate(s) greater than 2312 kbps; or

(ii) 32-TCPAM line code;

refer to Table L3

Note 3: For Group A testing requirements see Table L3. For Group B testing requirements see Table L4.

**Table L3**  
**PSD mask and testing requirements for**  
**Equipment Classes 9i to 9t (Group A) and**  
**Equipment Classes 9a to 9h (Group A) using 32-TCPAM**

Note 1: Refer to Table K3 for Group A testing requirements at 16-TCPAM line rates below 2312 kbps.

Frequency in kHz	PSDMASK (f) in dBm/Hz	Testing Requirements
$f < f_{int}$	$10 \times \log_{10} \left[ \frac{K_{SHDSL}}{R_s} \times \frac{1}{f_{sym}} \times \frac{\left[ \sin\left(\frac{\pi f}{f_{sym}}\right) \right]^2}{\left(\frac{\pi f}{f_{sym}}\right)^2} \times \frac{1}{1 + \left(\frac{f}{f_{3dB}}\right)^{2 \times \text{Order}}} \times \frac{f^2}{f^2 + f_c^2} \right]$	PSD
$f_{int} \leq f \leq 3184$	$10 \times \log_{10} \left[ 1.7971 \times 10^{-6} \times f^{-1.5} \right]$	PSD
$3184 < f \leq 11040$	-110	-90 dBm/Hz peak; and Maximum power in the [f, f + 1 MHz] window of -50 dBm
$11040 < f \leq 30175$	-110	-90 dBm/Hz peak

where:

$K_{SHDSL}$  and  $f_{sym}$  are defined in Table L2  $f$  = frequency in kHz  $R_s = 135 \Omega$   $f_c$  is the transformer cut-off frequency, assumed to be 5 kHz

$f_{int}$  = lowest frequency above  $f_{3dB}$  where the expressions for  $P_1(f)$  and  $P_2(f)$  intersect

$f_{max} = 11,040$  MHz  $\text{Order} = 6$   $N = 1$   $f_{3dB} = f_{sym}/2$

For each data rate at which the equipment can operate,  $f_{sym}$  **shall not** exceed the PSDMASK generated by choosing a value of  $f_{sym}$  which need not be related to the actual CE parameters but may be any value in the range listed in Table L2 for the relevant Equipment Class. Because the Group A requirement permits such wide freedom to choose any  $f_{sym}$  value in the prescribed range, a party submitting equipment for test under Group A should provide to the test laboratory a detailed list of operating modes and corresponding  $f_{sym}$  values to use in generating the compliance masks.

The PSD **shall** be measured with a resolution bandwidth less than or equal to 10 kHz. Large PSD variations over narrow frequency intervals (for example near the junction of the main lobe with the noise floor) might require a smaller resolution bandwidth (RBW) to be used. An appropriate way would be to choose RBW such that there is no more than 1 dB change in the signal PSD across the RBW.

**Table L4**

**PSD mask and testing requirements for  
Equipment Classes 9i to 9t (Group B) and  
Equipment Classes 9a to 9h (Group B) using 32-TCPAM,  
64-TCPAM or 128-TCPAM**

PSDMASK( $f$ )

$$P_1(f) = 10 \log_{10} \left[ \frac{K_{SDSL}}{R_s} \times \frac{1}{f_{sym}} \times \frac{\left[ \sin \left( \frac{\pi f}{f_{sym}} \right) \right]^2}{\left( \frac{\pi f}{f_{sym}} \right)^2} \times \frac{1}{1 + \left( \frac{f}{f_{3dB}} \right)^{2 \times \text{Order}}} \times 10^{\frac{\text{MaskOffsetdB}(f)}{10}} \right] \quad [\text{dBm/Hz}] \quad f < f_{int}$$

$P_2(f) = -90 \text{ dBm/Hz}$  peak with maximum power in a  $[f, f + 1 \text{ MHz}]$  window of  $[10 * \log_{10}(0,5683 \times 10^{-4} \times f^{-1,5}) + 90] \text{ dBm}$   $f_{int} \leq f \leq 3184 \text{ kHz}$

$P_3(f) = -90 \text{ dBm/Hz}$  peak with maximum power in a  $[f, f + 1 \text{ MHz}]$  window of  $-50 \text{ dBm}$   $3184 \text{ kHz} < f \leq f_{max}$

$P_4(f) = -90 \text{ dBm/Hz}$  peak  $11040 \text{ kHz} < f \leq 12.040 \text{ MHz}$

where:

$K_{SDSL}$  and  $f_{sym}$  are defined in Table L2

$f$  = frequency in kHz

$R_s = 135 \Omega$

$$\text{MaskOffsetdB}(f) = \begin{cases} 1 + 0,4 \times \frac{f_{3dB} - f}{f_{3dB}} & [\text{dB}], \quad f < f_{3dB} \\ 1 & [\text{dB}], \quad f \geq f_{3dB} \end{cases}$$

$f_{int}$  = lowest frequency above  $f_{3dB}$  where the expressions for  $P_1(f)$  and  $P_2(f)$  intersect

$f_{max} = 11.040 \text{ MHz}$

Order = 6;  $N = 1$ ;  $f_{3dB} = f_{sym}/2$

PSDMASK( $f$ ) is in dBm/Hz.

$f_{sym} = (\text{payload kbit rate} + \text{overhead kbit rate}) / (\text{number of bits per symbol})$

The 16-TCPAM constellation has 3 bits per symbol while the 32-TCPAM constellation has 4 bits per symbol.

The PSD **shall** be measured with a resolution bandwidth less than or equal to 10 kHz. Large PSD variations over narrow frequency intervals (for example near the junction of the main lobe with the noise floor) might require a smaller resolution bandwidth (RBW) to be used. An appropriate way would be to choose RBW such that there is no more than 1 dB change in the signal PSD across the RBW.

The power in the 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.

Note 1: Refer to Table K4 for Group A testing requirements at 16-TCPAM line rates below 2312 kbps.

Note 2: Where possible the units of frequency have been expressed in kHz. Therefore in this Standard the value of  $K_{SDSL}$  (see Table L2) is adjusted for frequency in kHz instead of MHz while still aligning the overall equation with ITU-T Recommendation G991.2.

## APPENDIX

### M Equipment Class 10h

Table M1 provides the Group A and Group B test criteria and Referenced Documents for Equipment Class 10h network systems. A typical technology is VDSL2 extending to 17.664 MHz with non-overlapped spectrum in the ADSL2+ band. Note that each VDSL2 Equipment Class meets the spectral masks and other specifications for the corresponding Equipment Class 6 below 2208 kHz.

The termination impedance for Equipment Class 10h is 100  $\Omega$ .

**Table M1**

**Test criteria and Reference Documents for Equipment Class 10h**

Parameter	Sub-parameter	Group A (Value)	Group B
Total average power below 2208 kHz	Level	12.5 dBm	G.992.5 Clause A.2.2.2 [9]
Total average power above 2208 kHz	Level	FFS	FFS
	Frequency range	25.875 kHz to 12 MHz	25.875 kHz to 12 MHz
	Averaging time	$\geq 10$ s	$\geq 10$ s
PSD mask		Clause B.4.1 with B8-11 of G.993.2 [10] (shown in Table M2)	G.993.2 Table B-6 (B8-11) [10] Maximum power in the 0 to 4 kHz band is relaxed to $-65$ dBm <sub>600<math>\Omega</math></sub>
Line code		Not applicable	G.993.2 [10]
Longitudinal Conversion Loss	Level	$>38$ dB	G.993.2 Clause 7.4 [10]
	Frequency range	30 kHz to 12 MHz 12 MHz to 17.664 MHz is FFS	G.993.2 Clause 7.4 [10]
Longitudinal output voltage	Level	$-50$ dBV in any 4 kHz band	$-50$ dBV in any 4 kHz band
	Frequency range	As per longitudinal balance	As per longitudinal balance

**Table M2**

**PSD mask and testing requirements for Equipment Class 10h**

This template is generated from the Group B mask using the rules in G.993.2 B.4.1 [10].

Frequency band $f$ (kHz)	PSD (dBm/Hz in Narrow Resolution Bandwidth)	Testing requirements
$0 < f \leq 4$	-100	PSD
$4 < f \leq 25.875$	$-96 + 21.533 \times \log_2(f/4)$	PSD
$25.875 < f \leq 138$	-38	PSD
$138 < f \leq 243$	$-38 - 71.911 \times \log_2(f/138)$	PSD
$243 < f \leq 402.1027$	$-96.7 - 4.5417 \times \log_2(f/243)$	PSD
$402.1027 < f \leq 3605.625$	-100	PSD
$3605.625 < f \leq 3750$	$-103.5 + 0.11429 \times (f - 3575)$	PSD
$3750 < f \leq 5200$	$-54.7 - 0.0010345 \times (f - 3750)$	PSD
$5200 < f \leq 5344.375$	$-83.5 - 0.11429 \times (f - 5200)$	PSD
$5344.375 < f \leq 8355.625$	-112	PSD
$8355.625 < f \leq 8500$	$-103.5 + 0.11429 \times (f - 8325)$	PSD
$8500 < f \leq 10000$	$-58.3 - 0.00046667 \times (f - 8500)$	PSD
$10000 < f \leq 12000$	-59	PSD
$12000 < f \leq 12144.375$	$-83.5 - 0.11429 \times (f - 12000)$	PSD
$12144.375 < f \leq 30175$	-112	PSD
<p>where:</p> <p>Below 25.875 kHz the peak PSD <b>shall</b> be measured with a 100 Hz resolution bandwidth.</p> <p>Above 25.875 kHz the peak PSD <b>shall</b> be measured with a 10 kHz resolution bandwidth.</p>		

**PSD Notching (FFS)**

In addition, the modem **shall** support the PSD notching defined in Table M3 for the specified amateur radio bands, and that notching may be normally turned off but **shall** be turned on for any selected band(s) upon request from the network provider.

**Table M3**

**Frequency limits when notching is required for amateur radio bands**

Frequency limits between which the transmit PSD in the Group B mask **shall not** exceed -80 dBm/Hz when notching is required for that amateur radio band.

Amateur Radio Band Description	Lower Frequency (MHz)	Upper Frequency (MHz)
80 metre (a)	3.5	3.7
80 metre (b)	3.776	3.8
30 metre	10.1	10.15

**Upstream Power Backoff**

The CE **shall** implement line shaped Upstream Power Backoff as defined in ITU-T Rec. G.993.2 Clause 7.2.1.3 [10] based on the estimation of the  $kl_0$  parameter by the modem/DSLAM.

The UPBO Mask **shall** be derived and applied by the CE in accordance with the algorithm described in ITU-T Rec G.993.2 Clause 7.2.1.3.2.2 [10], basing the UPBO mask upon CO-MIB parameters 'a' and 'b' for the US1 and US2 bands.

The CE **shall** receive UPBO a and b values for each of the upstream bands US1 and US2 in the ranges:

- (i) 40 to 80.95 for a; and
- (ii) 0 to 40.95 for b;

as specified in Section 12.3.3.2.1.1 of ITU-T Rec. G.993.2 [10].

**Upstream Power Backoff Length Estimation Method ELE-M0**

The CE **shall** implement ELE-M0 autonomous electrical length derivation method as defined in ITU-T Rec. G.993.2 Clause 7.2.1.3.2.1.1 [10].

The value of  $kl_0$  **shall** be obtained from the measured insertion loss as follows:

$$kl_0 = \max \left[ 1.8, \min \left\{ \frac{\text{InsertionLoss}(f)}{\sqrt{f(\text{MHz})}} \mid 3.75\text{MHz} < f < 12\text{MHz} \right\} \right]$$

*Compliance with this clause should be by attestation by the supplier of the equipment.*

**Upstream Power Backoff Length Estimation Method ELE-M1**

The CE **shall** implement the ELE-M1 autonomous electrical length derivation method as defined in ITU-T Rec. G.993.2 Clause 7.2.1.3.1.2 [10].

The ELE-M1 method is also referred to as 'the alternative electrical length estimation method'.

The CE **shall** use the ELE-M1 method if the CO-MIB parameter "Alternative Electrical Length Estimation Mode" (AELE-MODE) is set by the DSLAM to a value of 1 or higher. Otherwise, the ELE-M0 **shall** be used.

The CE **shall** use the UPBO Electrical Length Minimum Threshold (UPBOELMT) CO-MIB parameter to determine the percentile to be used in finding the qualified minimum of a set of frequency dependent electrical length estimates in a particular VDSL2 band, as described in ITU-T Rec. G.993.2 [10].

The CE **shall** select estimated electrical lengths according to the CO-MIB parameter AELE-MODE, supporting each of the four AELE-MODE options described in ITU-T Rec. G.993.2 [10].

*Compliance with this clause should be by attestation by the supplier of the equipment.*

## APPENDIX

### N Equipment Classes 10j to 10n

Table N1 provides the Group A and Group B test criteria and Referenced Documents for Equipment Classes 10j to 10n network systems. A typical technology is VDSL2 extending to 17.664 MHz, with extended upstream (Annex M) in the ADSL2+ band. Note that each VDSL2 Equipment Class meets the spectral masks and other specifications for the corresponding Equipment Class 6 below 2208 kHz.

The termination impedance for Equipment Classes 10j to 10n is 100 Ω.

**Table N1**

**Test criteria and Reference Documents for Equipment Class 10j to n**

Parameter	Sub-parameter	Group A (Value)	Group B
Total average power below 2208 kHz	Level	12.5 dBm	G.992.5 Clause A.2.2.2 [9]
Total average power above 2208 kHz	Level	FFS	FFS
	Frequency range	25.875 kHz to 12 MHz	25.875 kHz to 12 MHz
	Averaging time	≥ 10 s	≥ 10 s
PSD mask below 1104 kHz		Table I3 and Table I4	G.992.5 Clause. M.2.2.1 [9] Maximum power in the 0 to 4 kHz band is relaxed to -65 dBm <sub>600Ω</sub>
PSD mask above 1104 kHz		Clause B.4.1 with B8-11 of G.993.2 [10] (shown in Table M2)	G.993.2 Table B-6 (B8-11) [10]
Line code		Not applicable	G.993.2 [10]
Longitudinal Conversion Loss	Level	>38 dB	G.993.2 Clause 7.4 [10]
	Frequency range	30 kHz to 12 MHz 12 MHz to 17.664 MHz is FFS	G.993.2 Clause 7.4 [10]
Longitudinal output voltage	Level	-50 dBV in any 4 kHz band	-50 dBV in any 4 kHz band
	Frequency range	As per longitudinal balance	As per longitudinal balance

### PSD Notching (FFS)

In addition, the modem **shall** support the PSD notching defined in Table M3 for the specified amateur radio bands, and that notching may be normally turned off but **shall** be turned on for any selected band(s) upon request from the network provider.

### Upstream Power Backoff

The CE **shall** implement line shaped Upstream Power Backoff as defined in ITU-T Rec. G.993.2 Clause 7.2.1.3 [10] based on the estimation of the  $kl_0$  parameter by the modem/DSLAM.

The UPBO Mask **shall** be derived and applied by the CE in accordance with the algorithm described in ITU-T Rec G993.2 Clause 7.2.1.3.2.2 [10], basing the UPBO mask upon CO-MIB parameters 'a' and 'b' for the US1 and US2 bands.

The CE **shall** receive UPBO a and b values for each of the upstream bands US1 and US2 in the ranges:

- (i) 40 to 80.95 for a; and
- (ii) 0 to 40.95 for b;

as specified in Section 12.3.3.2.1.1 of ITU-T Rec. G.993.2 [10].

### Upstream Power Backoff Length Estimation Method ELE-M0

The CE **shall** implement ELE-M0 autonomous electrical length derivation method as defined in ITU-T Rec. G.993.2 Clause 7.2.1.3.2.1.1 [10].

The value of  $kl_0$  **shall** be obtained from the measured insertion loss as follows:

$$kl_0 = \max \left[ 1.8, \min \left\{ \frac{\text{InsertionLoss}(f)}{\sqrt{f(\text{MHz})}} \mid 3.75\text{MHz} < f < 12\text{MHz} \right\} \right].$$

*Compliance with this clause should be by attestation by the supplier of the equipment.*

### Upstream Power Backoff Length Estimation Method ELE-M1

The CE **shall** implement the ELE-M1 autonomous electrical length derivation method as defined in ITU-T Rec. G.993.2 Clause 7.2.1.3.1.2 [10].

The ELE-M1 method is also referred to as 'the alternative electrical length estimation method'.

The CE **shall** use the ELE-M1 method if the CO-MIB parameter "Alternative Electrical Length Estimation Mode" (AELE-MODE) is set by the DSLAM to a value of 1 or higher. Otherwise, the ELE-M0 method **shall** be used.

The CE **shall** use the UPBO Electrical Length Minimum Threshold (UPBOELMT) CO-MIB parameter to determine the percentile to be used in finding the qualified minimum of a set of frequency dependent electrical length estimates in a particular VDSL2 band, as described in ITU-T Rec. G.993.2 [10].

The CE **shall** select estimated electrical lengths according to the CO-MIB parameter AELE-MODE, supporting each of the four AELE-MODE options described in ITU-T Rec. G.993.2 [10].

*Compliance with this clause should be by attestation by the supplier of the equipment.*

## APPENDIX

### O Equipment Class 10v

Table O1 provides the Group B test criteria and Referenced Documents for Equipment Class 10v network systems. A typical technology is vectored VDSL2 extending to 17.664 MHz using a 998 band plan and mask B8-11, with non-overlapped spectrum in the ADSL2+ band, but spectrum may also extend to 30 MHz.

Note that this Appendix defines a general vectored VDSL2 Equipment Class, that **shall** meet a spectral mask defined in ITU-T G.993.2, and that **shall** be deployed in the modem at the request of the DSLAM.

In order to be compliant with this Equipment Class, customer equipment **shall** be able to perform full vectoring of all bands except US0, according to the requirements of G.993.5.

The termination impedance for Equipment Class 10v is 100  $\Omega$ .

**Table O1**

**Test criteria and Reference Documents for Equipment Class 10v**

Parameter	Sub-parameter	Group B
Total average power below 2208 kHz	Level	G.992.5 Clause A.2.2.2 [9]
Total average power above 2208 kHz	Level	FFS
	Frequency range	25.875 to 30 MHz
	Averaging time	≥ 10 s
PSD mask		Support a band plan in G.993.2 Table B-1, with mask from B-2 or B-3 as defined in Table B4 or B6. (See Note 1)  Maximum power in the 0 to 4 kHz band is relaxed to -68 dBm <sub>600Ω</sub>
Line code		G.993.2 [10]
Longitudinal Conversion Loss	Level	G.993.2 Clause 7.4 [10]
	Frequency range	G.993.2 Clause 7.4 [10]
Longitudinal output voltage	Level	-50 dBV in any 4 kHz band
	Frequency range	As per longitudinal balance

Note 1: Only the following PSD masks from Table B-2 and Table B-3 may be used. CE may support any or all of these masks:

- (i) 997 band plans: B7-9, B7-10.
- (ii) 998 band plans: B8-10, B8-11, B8-16.

Note 2: Frequency masks for testing are described in G.993.2 Table B-4 and G.993.2 Table B-6. PSD templates are for crosstalk calculation only and not for compliance with alternative line codes.

Note 3: Because vectoring is only effective if all systems in the cable use the same line code as specified in G.993.5, there can be no Group A compliance with Equipment Class 10v.

**Table O2**  
**Testing Requirements and nominal PSD**

The B8-11 template is given here as an example.

The CE **shall** be tested to the PSD mask requirement.

The nominal PSD is for crosstalk calculations only.

Frequency band $f$ (kHz)	Nominal PSD	Testing requirements PSD Mask (dBm/Hz in Narrow Resolution Bandwidth)
$0 < f \leq 4$	-100	-97.5
$4 < f \leq 25.875$	$-96 + 21.533 \times \log_2 (f / 4)$	$-92.5 + 21.533 \times \log_2 (f/4)$
$25.875 < f \leq 138$	-38	-34.5
$138 < f \leq 243$	$-38 - 0.55905 \times (f - 138)$	$-34.5 - 0.55905 \times (f - 138)$
$243 < f \leq 686$	$-96.7 - 0.01535 \times (f - 243)$ (see Note 1)	$-93.2 - 0.01535 \times (f - 243)$
$686 < f \leq 3575$	-100	-100
$3575 < f \leq 3750$	$-103.5 + 0.11429 \times (f - 3575)$ (see Note 1)	$-100 + 0.11429 \times (f - 3575)$
$3750 < f \leq 5200$	$-54.7 - 0.0010345 \times (f - 3750)$	$-51.2 - 0.0010345 \times (f - 3750)$
$5200 < f \leq 5375$	$-83.5 - 0.11429 \times (f - 5200)$	$-80 - 0.11429 \times (f - 5200)$
$5375 < f \leq 8325$	-103.5	-100
$8325 < f \leq 8500$	$-103.5 + 0.11429 \times (f - 8325)$	$-100 + 0.11429 \times (f - 8325)$
$8500 < f \leq 10000$	$-58.3 - 0.00046667 \times (f - 8500)$	$-54.8 - 0.00046667 \times (f - 8500)$
$10000 < f \leq 12000$	-59	-55.5
$12000 < f \leq 12175$	$-83.5 - 0.11429 \times (f - 12000)$	$-80 - 0.11429 \times (f - 12000)$
$12175 < f \leq 30000$	-103.5	-100
$30000 < f$	-112	-110

where:

Below 25.875 kHz the peak PSD **shall** be measured with a 100 Hz resolution bandwidth.

Above 25.875 kHz the peak PSD **shall** be measured with a 10 kHz resolution bandwidth.

Note 1: Subject to a minimum of -100 dBm/Hz below 4 MHz.

**PSD Notching (FFS)**

In addition, the modem **shall** support the PSD notching defined in Table O3 for the specified amateur radio bands, and that notching may be normally turned off but **shall** be turned on for any selected band(s) upon request from the network provider.

**Table O3**

**Frequency limits when notching is required for amateur radio bands**

Frequency limits between which the transmit PSD in the Group B mask **shall not** exceed -80 dBm/Hz when notching is required for that amateur radio band.

Amateur Radio Band Description	Lower Frequency (MHz)	Upper Frequency (MHz)
80 metre (a)	3.5	3.7
80 metre (b)	3.776	3.8
30 metre	10.1	10.15

**Upstream Power Backoff**

The CE **shall** implement line shaped Upstream Power Backoff as defined in ITU-T Rec. G.993.2 Clause 7.2.1.3 [10] based on the estimation of the  $kl_0$  parameter by the modem/DSLAM.

The UPBO Mask **shall** be derived and applied by the CE in accordance with the algorithm described in ITU-T Rec G993.2 Clause 7.2.1.3.2.2 [10], basing the UPBO mask upon CO-MIB parameters 'a' and 'b' for the US1 and US2 bands.

The CE **shall** receive UPBO a and b values for each of the upstream bands US1 and US2 in the ranges:

- (i) 40 to 80.95 for a; and
  - (ii) 0 to 40.95 for b
- as specified in Section 12.3.3.2.1.1 of ITU-T Rec. G.993.2 [10].

**Upstream Power Backoff Length Estimation Method ELE-M0**

The CE **shall** implement ELE-M0 autonomous electrical length derivation method as defined in ITU-T Rec. G.993.2 Clause 7.2.1.3.2.1.1 [10].

The value of  $kl_0$  **shall** be obtained from the measured insertion loss as follows:

$$kl_0 = \max \left[ 1.8, \min \left\{ \frac{\text{InsertionLoss}(f)}{\sqrt{f(\text{MHz})}} \mid 3.75\text{MHz} < f < 12\text{MHz} \right\} \right]$$

*Compliance with this clause should be by attestation by the supplier of the equipment.*

**Upstream Power Backoff Length Estimation Method ELE-M1**

The CE **shall** implement the ELE-M1 autonomous electrical length derivation method as defined in ITU-T Rec. G.993.2 Clause 7.2.1.3.2.1.2 [10].

The ELE-M1 method is also referred to as 'the alternative electrical length estimation method'.

The CE **shall** use the ELE-M1 method if the CO-MIB parameter "Alternative Electrical Length Estimation Mode" (AELE-MODE) is set by the DSLAM to a value of 1 or higher. Otherwise, the ELE-M0 **shall** be used.

The CE **shall** use the UPBO Electrical Length Minimum Threshold (UPBOELMT) CO-MIB parameter to determine the percentile to be used in finding the qualified minimum of a set of frequency dependent electrical length estimates in a particular VDSL2 band, as described in ITU-T Rec. G.993.2 [10].

The CE **shall** select estimated electrical lengths according to the CO-MIB parameter AELE-MODE, supporting each of the four AELE-MODE options described in ITU-T Rec. G.993.2 [10].

*Compliance with this clause should be by attestation by the supplier of the equipment.*

## **PARTICIPANTS**

The Working Committee responsible for the revisions made to this Standard consisted of the following organisations:

<b>Organisation</b>	<b>Membership</b>
AAPT	Voting
ADTRAN Networks	Voting
CommScope	Voting
Corning Systems	Voting
Huawei	Voting
iiNet	Voting
International Copper Association (ICAA)	Voting
Layer10	Voting
NBN Co	Voting
Netcomm Wireless	Voting
Nokia	Voting
OneAccess	Voting
Optus	Voting
Telstra	Voting
Vocus	Voting
ACCC	Non-Voting
ACMA	Non-Voting

This Working Committee was chaired by Peter Cooke. James Duck of Communications Alliance provided project management support.

NOTES

Communications Alliance was formed in 2006 to provide a unified voice for the Australian communications industry and to lead it into the next generation of converging networks, technologies and services.

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