PART VIII

REQUIREMENTS AND TEST METHODS FOR DIGITAL SUBSCRIBER LINE (XDSL) TERMINAL EQUIPMENT

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1.0 INTRODUCTION

1.1 SCOPE

This Part sets forth the minimum network protection requirements for:

- Asymmetrical Digital Subscriber Line terminal equipment using either Carrierless Amplitude Phase modulation ,Discrete Multi-Tone technology, or Partially and Fully overlapped Echo Cancelled systems (**ADSL** [CAP/DMT/Echo Cancelled]
- High bit rate Digital Subscriber Line terminal equipment using either Carrierless Amplitude Phase modulation or "2 Binary 1 Quaternary" line code (**HDSL** [CAP/2B1Q])
- High bit rate Digital Subscriber Line 2^{nd} generation terminal equipment using Trellis Coded Pulse Amplitude Modulation (**HDSL2** [TC-PAM])
- Symmetrical Digital Subscriber Line terminal equipment using "2 Binary 1 Quaternary" line code (**SDSL** [2B1Q])
- Single pair High speed Digital Subscriber Line terminal equipment using Trellis Coded Pulse Amplitude Modulation (**SHDSL** [G.shdsl - TC-PAM])
- 4-wire High bit rate Digital Subscriber Line 2^{nd} generation terminal equipment using Trellis Coded Pulse Amplitude Modulation (**HDSL4** [TC-PAM])

ADSL equipment uses one cable pair where transmission of voiceband signals and data can occur simultaneously. Asymmetric transmission of data provides a High bit rate downstream (towards the subscriber) and a lower bit rate upstream (towards the central office). Refer to Figure 1.1 for the ADSL Functional Reference Model.

HDSL equipment provides equal bit rate in both directions (downstream and upstream). Both channels can be supported on the same cable pair (1 pair HDSL) or one channel per cable pair (2 pair HDSL). Two HDSL channels are equivalent to a T1 structure. Baseband voice signals cannot be carried simultaneously with data. Refer to Figure 1.2 for the HDSL Reference Model.

HDSL2 is a second generation HDSL loop transmission system that is standardized. The system is designed to transport a 1.544 Mbps payload on a single non-loaded twisted pair at carrier serving area distances. Refer to Figure 1.2 for the HDSL2 Reference Model.

2B1Q SDSL has the same symbol rate, baud rate, and power spectral density at both STU-C and STU-R transceivers. 2B1Q SDSL system may vary its data rate from 64kbps to 2320kbps. Refer to Figure 1.2 for the 2B1Q SDSL Reference Model. Typically, 2B1Q SDSL equipment transmits a symmetric signal on a single copper pair.

SHDSL uses Trellis Coded Pulse Amplitude Modulation (TC-PAM) on a single copper pair to transmit a symmetric signal with data rates from 192kbps to 2.312Mbps. Refer to Figure 1.2 for the SHDSL Reference Model.

HDSL4 is a variant of SHDSL, using TC-PAM on 2 copper pairs (4 wires) to transmit an asymmetric signal with a data rate of 768/776 kbps. Refer to Figure 1.2 for the HDSL4 Reference Model.

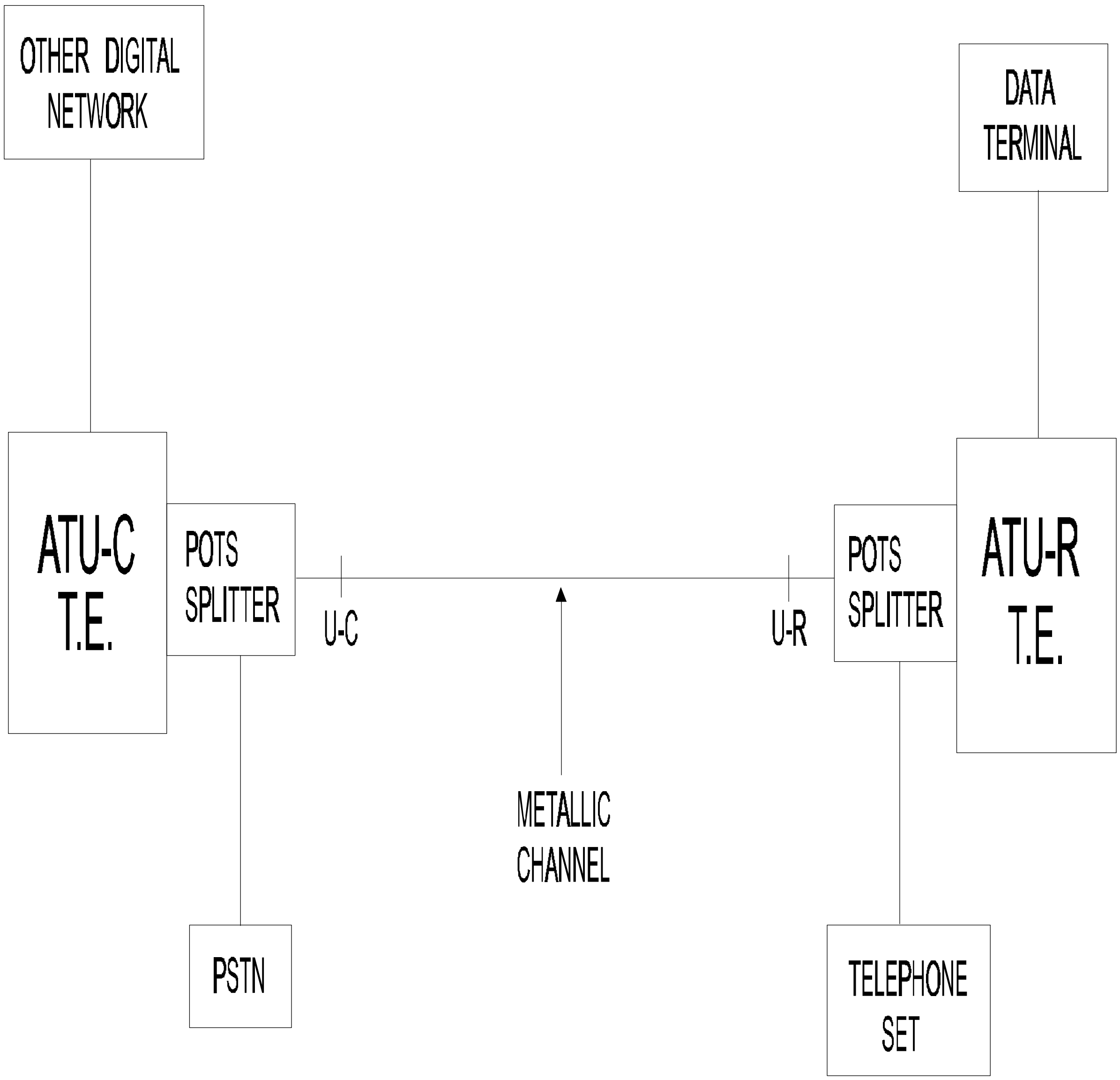


FIGURE 1.1

ADSL TERMINAL EQUIPMENT FUNCTIONAL REFERENCE MODEL

NOTE: ATU-C = ADSL transceiver unit, central office end
ATU-R = ADSL transceiver unit, remote terminal end
PSTN = Public Switched Telephone Network
POTS = Plain Old Telephone Service

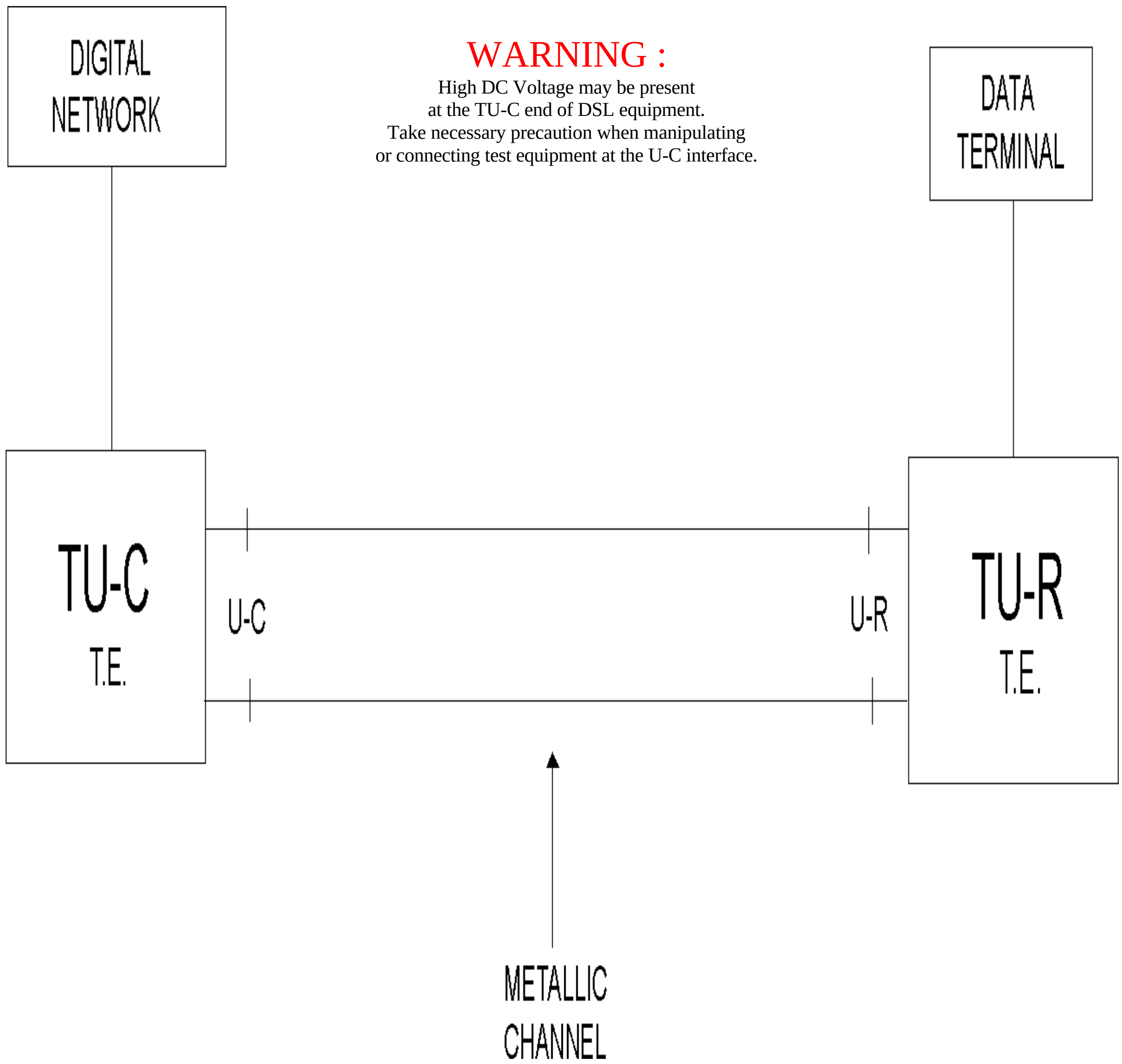


FIGURE 1.2

TERMINAL EQUIPMENT FUNCTIONAL REFERENCE MODEL
FOR HDSL, HDSL2, SDSL, SHDSL, AND HDSL4

NOTE: TU-C = HDSL/HDSL2/SDSL/SHDSL/HDSL4 transceiver unit, central office end

TU-R = HDSL/HDSL2/SDSL/SHDSL/HDSL4 transceiver unit, remote terminal end

1.2 TECHNICAL REQUIREMENTS

1.2.1 TECHNICAL REQUIREMENTS TABLE

The technical requirements table provides a cross reference between the terminal equipment interfaces and the network protection requirements with which they shall comply. These are marked with a single *. Equipment connected to a network interface, covered by another part of the CS-03 specification, shall be assessed in accordance with the requirements and test methods of that part.

TECHNICAL REQUIREMENTS TABLE

NETWORK PROTECTION REQUIREMENTS FOR POTS AND DATA TERMINAL EQUIPMENT (ADSL , HDSL , HDSL2 , SDSL , SHDSL & HDSL4) TO BE CONNECTED AT THE "U-C" OR "U-R" INTERFACE POINT

		Interfaces	
Section	**Requirement**	**U-C**	**U-R**
2	ELECTRICAL AND MECHANICAL STRESSES	*	*
3.2	TRANSMITTED SPECTRAL RESPONSE	*	*
3.3	TOTAL SIGNAL POWER	*	*
3.4	TRANSVERSE BALANCE	*	*
3.5	LONGITUDINAL OUTPUT VOLTAGE	*	*
Annex A	HIGH VOLTAGES	*	

* means the requirement applies

1.3 SEQUENCE OF EQUIPMENT TESTING

1.3.1 OVERALL SEQUENCE

The tests shall be performed in the following order:

(1) Section 1.4 Connecting Arrangements
(2) Section 1.5 Operational Check
(3) Section 2.2 (Part I) Dielectric Strength
(4) Section 2.3 (Part I) Hazardous Voltage Limitations (As applicable)
(5) Section 3.0 Network Protection Requirements and Tests
(6) Section 2.1 (Part I) Mechanical Shock
(7) Section 2.4 (Part I) Surge Voltage
(8) Section 2.5 (Part I) Power Line Surge
(9) Section 1.5 Operational Check
(10) Section 2.2 (Part I) Dielectric Strength
(11) Section 2.3 (Part I) Hazardous Voltage Limitations (As applicable)
(12) Section 3.0 Network Protection Requirements and Tests

1.4 CONNECTING ARRANGEMENTS

Connecting arrangements for ADSL, HDSL , HDSL2 , SDSL , SHDSL & HDSL4 terminal equipment intended for direct electrical connection are described in Part III, Section 10.0.

1.5 OPERATIONAL CHECK

When the operational checks are performed before the application of electrical stress, the TE shall be fully operational, in accordance with the manufacturer's operating instructions, for those features necessary to allow demonstration of compliance with all applicable requirements of Section 3.0. When the operational checks are repeated after the electrical stress of Section 2.0, it is permissible that the TE be partially or fully inoperable.

1.6 DEPLOYMENT GUIDELINES

To ensure spectral compatibility with other xDSL technologies deployed in the loop plant (i.e. to avoid third party harm), ADSL, HDSL, HDSL2, SDSL, SHDSL, and HDSL4 systems should not be deployed on loops longer than the Equivalent Working Length (EWL) identified below:

Table 1.6 (a)
Deployment Guidelines

xDSL	Maximum EWL
ADSL	All non-loaded loops
HDSL	2750 m (9000 ft)
HDSL2	3200 m (10,500ft)
2B1Q SDSL	See Table 1.6 b
SHDSL	See Table 1.6 c
HDSL4	All non-loaded loops

Equivalent Working Length (EWL) is defined as:

$$EWL = L_{26} + 0.75\ (L_{24})$$

Where L_{26} is the length of 26 AWG cable and L_{24} is the length of 24 AWG or larger gauge cable in the assigned loop.

xDSL transceivers using asymmetric spectra (ADSL, HDSL2, HDSL4) shall not be installed with a transceiver (TU-C) transmitting in the downstream frequency band (ADSL: 138-1,104 kHz, HSDL2: 0 - 440kHz, HDSL4: 0 - 600 kHz) located at the customer end of the loop (customer premises).

The administrative procedures to be used by Local Exchange Carriers or other service providers to ensure that systems are installed on loops meeting these deployment guidelines are beyond the scope of this document.

Table 1.6 (b)
Deployment Guidelines for 2B1Q SDSL

PSD	Maximum 2B1Q SDSL line bit rate (kbps)	2B1Q SDSL deployment guideline, EWL (m)
SM1 PSD Mask	300	all non-loaded loops
$SDSL_u$ *(f) with* f_{sym} = 160000	320	4725 (15.5 kft)
$SDSL_u$ *(f) with* f_{sym} = 168000	336	4420 (14.5 kft)
$SDSL_u$ *(f) with* f_{sym} = 192000	384	4115 (13.5 kft)
$SDSL_u$ *(f) with* f_{sym} = 200000	400	4115 (13.5 kft)
$SDSL_u$ *(f) with* f_{sym} = 208000	416	3965 (13 kft)
$SDSL_u$ *(f) with* f_{sym} = 232000	464	3810 (12.5 kft)
$SDSL_u$ *(f) with* f_{sym} = 264000	528	3660 (12 kft)
$SDSL_u$ *(f) with* f_{sym} = 296000	592	3505 (11.5 kft)
$SDSL_u$ *(f) with* f_{sym} = 328000	656	3355 (11 kft)
$SDSL_u$ *(f) with* f_{sym} = 360000	720	3200 (10.5 kft)
$SDSL_u$ *(f) with* f_{sym} = 392000	784	3050 (10 kft)
$SDSL_u$ *(f) with* f_{sym} = 456000	912	2895 (9.5 kft)
$SDSL_u$ *(f) with* f_{sym} = 488000	976	2745 (9 kft)
$SDSL_u$ *(f) with* f_{sym} = 552000	1104	2590 (8.5 kft)
$SDSL_u$ *(f) with* f_{sym} = 616000	1232	2440 (8 kft)
$SDSL_u$ *(f) with* f_{sym} = 712000	1424	2285 (7.5 kft)
$SDSL_u$ *(f) with* f_{sym} = 840000	1680	2135 (7 kft)
$SDSL_u$ *(f) with* f_{sym} = 936000	1872	1980 (6.5 kft)
$SDSL_u$ *(f) with* f_{sym} = 1064000	2128	1830 (6 kft)
$SDSL_u$ *(f) with* f_{sym} = 1128000	2256	1675 (5.5 kft)
$SDSL_u$ *(f) with* f_{sym} = 1160000	2320	1525 (5 kft)

Table 1.6 (c)
Deployment Guidelines for SHDSL

SHDSL line bit rate (kbps)	SHDSL deployment guideline EWL (m)
LBR ≤ 592	all non-loaded loops
600 ≤ LBR ≤ 616	4770 (15.0 kft)
624 ≤ LBR ≤ 628	4420 (14.5 kft)
656 ≤ LBR ≤ 688	4265 (14.0 kft)
696 ≤ LBR ≤ 800	4115 (13.5 kft)
808 ≤ LBR ≤ 832	3810 (12.5 kft)
840 ≤ LBR ≤ 896	3660 (12.0 kft)
904 ≤ LBR ≤ 952	3965 (13.0 kft)
960 ≤ LBR ≤ 1000	3810 (12.5 kft)
1008 ≤ LBR ≤ 1088	3660 (12.0 kft)
1096 ≤ LBR ≤ 1160	3505 (11.5 kft)
1168 ≤ LBR ≤ 1320	3355 (11.0 kft)
1328 ≤ LBR ≤ 1472	3200 (10.5 kft)
1480 ≤ LBR ≤ 1536	3050 (10.0 kft)
1544 ≤ LBR ≤ 1552	3200 (10.5 kft)
1560 ≤ LBR ≤ 1664	3050 (10.0 kft)
1672 ≤ LBR ≤ 1880	2895 (9.5 kft)
1888 ≤ LBR ≤ 2008	2745 (9.0 kft)
2016 ≤ LBR ≤ 2320	2590 (8.5 kft)

1.6.1 REPEATERED SYSTEMS

The spectral compatibility of repeatered systems in under study. The requirements defined in Section 3.2 and the deployment guidelines outlined above are only applicable at the U-C and U-R interfaces, and for systems installed on single spans (without repeaters).

2.0 ELECTRICAL AND MECHANICAL STRESSES

The technical requirements and methods of application for electrical and mechanical stresses are given in Part I, Section 2.0.

3.0 NETWORK PROTECTION REQUIREMENTS AND TESTS

3.1 LABORATORY ENVIRONMENT

All tests to determine compliance with these requirements shall be conducted in a laboratory environment at normal room temperature and humidity.

3.2 TRANSMITTED SPECTRAL RESPONSE

3.2.1 REQUIREMENT

3.2.1.1 POWER SPECTRAL DENSITY AT THE U-C INTERFACE FOR ADSL [CAP/DMT] AND ADSL USING FULLY OVERLAPPED ECHO CANCELLED SYSTEMS

The Power Spectral Density (PSD) of the signal transmitted by the ADSL **downstream** channel (ATU-C output) shall not exceed the PSD mask in Figure 3.2.1.1(a).
Table 3.2.1.1(a) provides the numerical values for the mask in Figure 3.2.1.1(a).

TABLE 3.2.1.1(a)
ATU-C PSD Mask definition(ADSL[CAP/DMT/Fully overlapped])

Frequency Band (kHz)	PSD (dBm/Hz)
$0.2 < f \leq 4$	-97.5
$4 < f \leq 25.875$	$-92.5 + 21 \times \log_2(f/4)$
$25.875 < f \leq 1104$	-36.5
$1104 < f \leq 3093$	$-36.5 - 36 \times \log_2(f/1104)$
$3093 < f \leq 30000$	-90

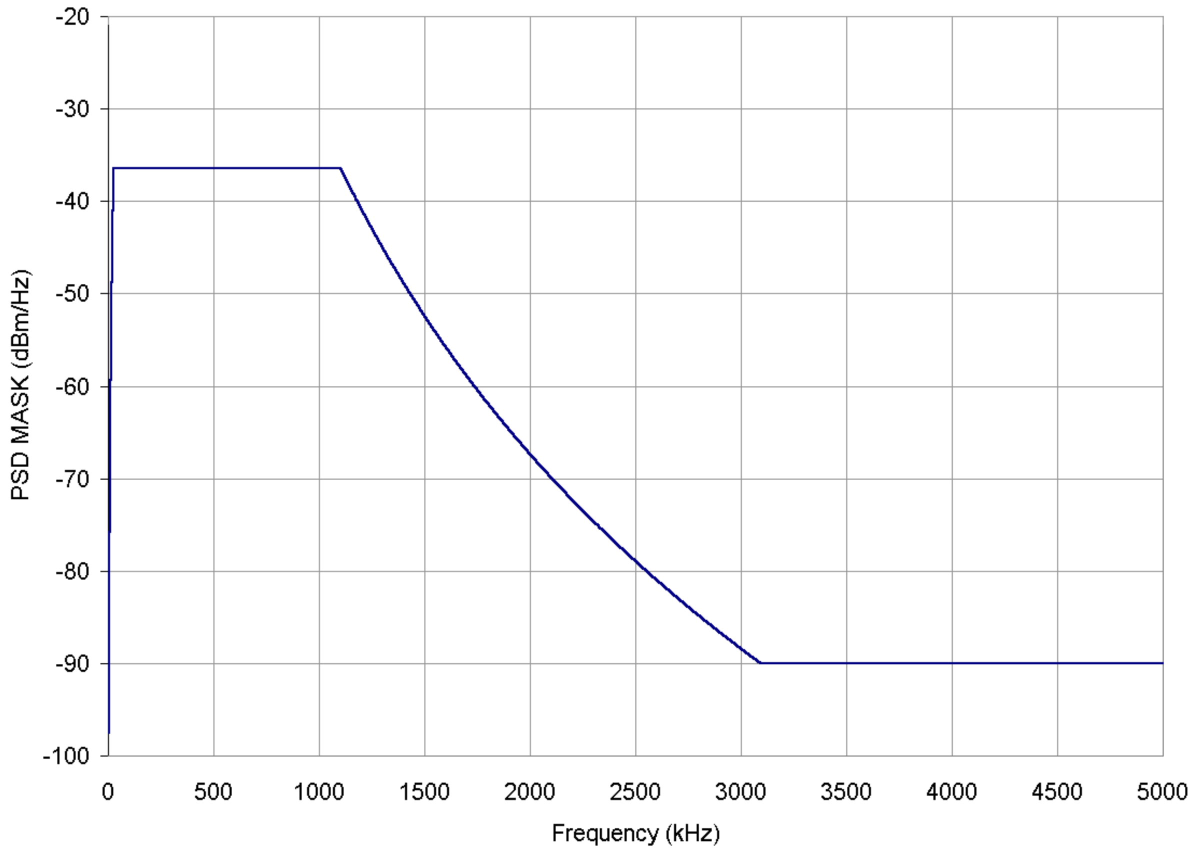


FIGURE 3.2.1.1(a)
ATU-C Downstream Transmission PSD Mask for ADSL [CAP/DMT/Fully Overlapped]

3.2.1.2 POWER SPECTRAL DENSITY AT THE U-C INTERFACE FOR ADSL USING PARTIALLY OVERLAPPED ECHO CANCELLED SYSTEMS

The Power Spectral Density (PSD) of the signal transmitted by the ADSL **downstream** channel (ATU-C output) shall not exceed the PSD mask in Figure 3.2.1.2(a).
Table 3.2.1.2(a) provides the numerical values for the mask in Figure 3.2.1.2(a).

TABLE 3.2.1.2(a)
ATU-C PSD Mask definition (ADSL [Partially overlapped])

Frequency Band (kHz)	PSD (dBm/Hz)
$0.2 < f \le 4$	-97.5
$4 < f \le 25.875$	$-92.5 + 21 \times \log_2(f/4)$
$25.875 < f \le 81$	-36.5
$81 < f \le 92.1$	$-36.5 - 70 \times \log_2(f/81)$
$92.1 < f \le 121.4$	-49.5
$121.4 < f \le 138$	$-49.5 + 70 \times \log_2(f/121.4)$
$138 < f \le 1104$	-36.5
$1104 < f \le 3093$	$-36.5 - 36 \times \log_2(f/1104)$
$3093 < f \le 30000$	-90

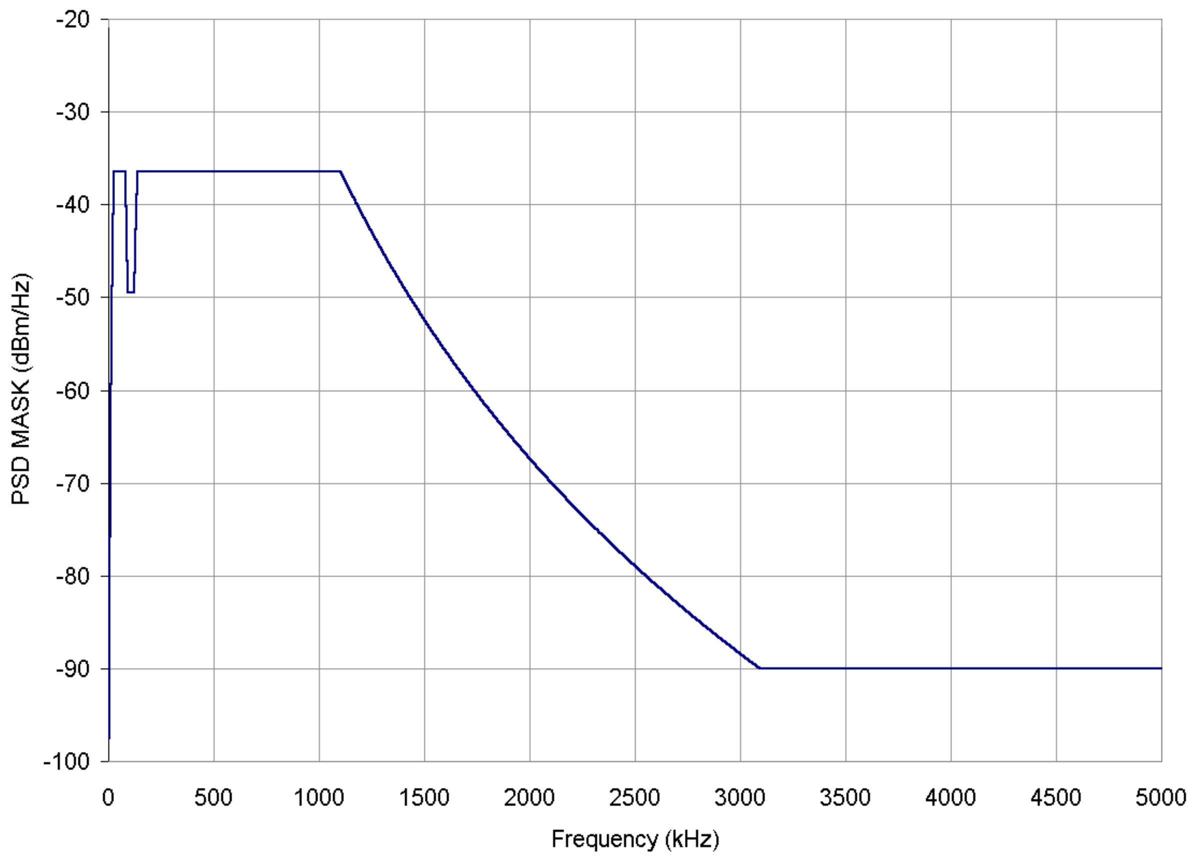


FIGURE 3.2.1.2(a)
ATU-C DownstreamTransmission PSD Mask for ADSL [Partially Overlapped]

3.2.1.3 POWER SPECTRAL DENSITY AT THE U-R INTERFACE FOR ADSL [CAP/DMT] AND ADSL USING FULLY OR PARTIALLY OVERLAPPED ECHO CANCELLED SYSTEMS

The Power Spectral Density (PSD) of the signal transmitted by the ADSL **upstream** channel (ATU-R output) shall not exceed the PSD mask in Figure 3.2.1.3(a).
Table 3.2.1.3(a) provides the numerical values for the mask in figure 3.2.1.3(a).

TABLE 3.2.1.3(a)
ATU-R PSD Mask definition(ADSL[CAP/DMT/ Fully or Partially overlapped])

Frequency Band (kHz)	PSD (dBm/Hz)
$0.2 < f \leq 4$	-97.5
$4 < f \leq 25.875$	$-92.5 + 21.5 \times \log_2(f/4)$
$25.875 < f \leq 138$	-34.5
$138 < f \leq 307$	$-34.5 - 48 \times \log_2(f/138)$
$307 < f \leq 30000$	-90

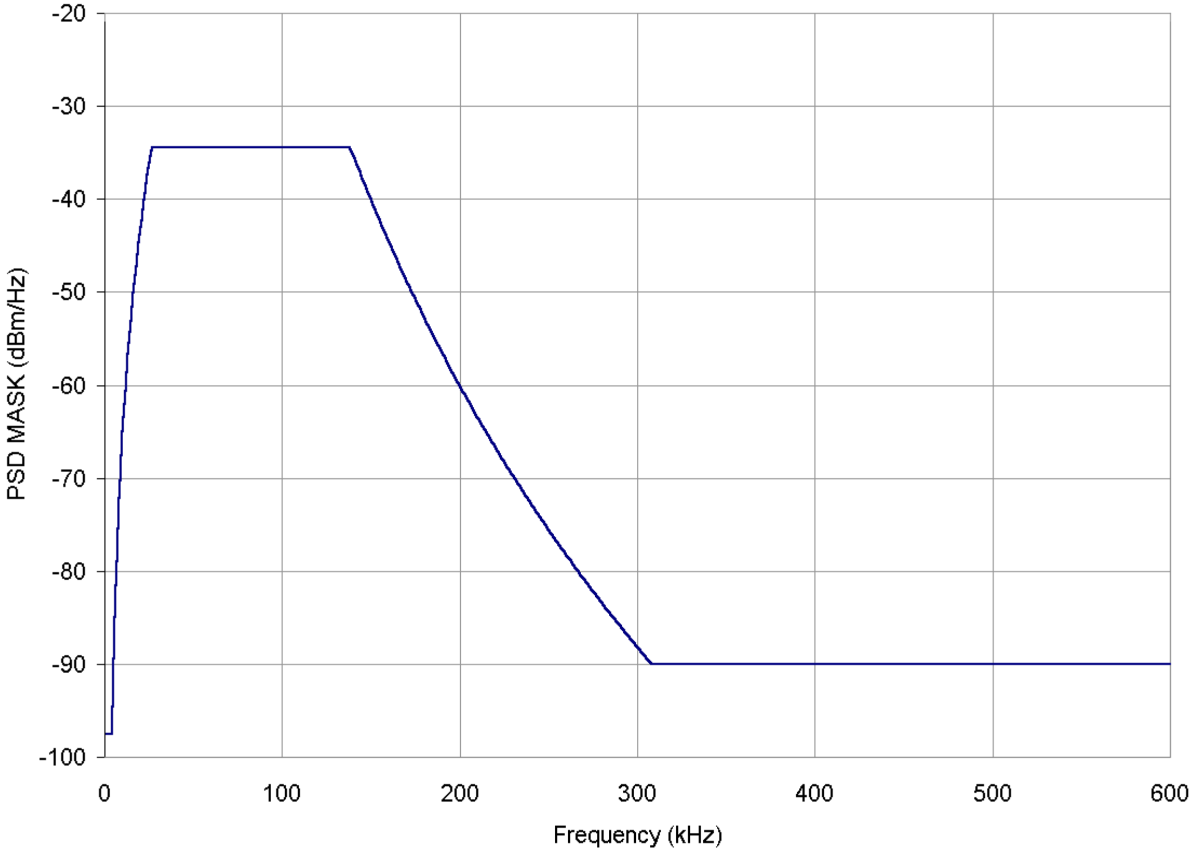


FIGURE 3.2.1.3(a)
ATU-R Upstream Transmission PSD Mask for ADSL
[CAP/DMT/Fully or Partially Overlapped]

3.2.1.4 POWER SPECTRAL DENSITY AT THE 2B1Q SDSL U-C AND U-R INTERFACE

The power spectral density of the signal transmitted by the 2B1Q SDSL transmitter shall follow the following equation:

$$SDSL_u(f) = \frac{2.7 \times 2.7}{135 \times f_{sym}} \left[\frac{\sin\left(p f / f_{sym} \right)}{p f / f_{sym}} \right]^2 \times \frac{1}{1 + \left(\dfrac{f}{\frac{240}{392} f_{sym}} \right)^8}$$

In this equation f_{sym} is the symbol rate (which is equal to one-half of the line bit rate).

The actual 2B1Q PSD may differ from this template specification. However, for data rates below 1568 kbps, it shall comply to the PSD masks associated with each of the related data rates (see Table 3.2.1.4(a)). The PSD limits are defined by the equations and masks in the Tables 3.2.1.4(b), 3.2.1.4(c), 3.2.1.4(d), 3.2.1.4(e), 3.2.1.4(f), and Figures 3.2.1.4(a), 3.2.1.4(b), 3.2.1.4(c), 3.2.1.4(d), 3.2.1.4(e).

The equipment shall not exceed the applicable PSD mask when operated at every data rate that the T.E. can achieve. The T.E. must be tested at least at the maximum data rate for each SDSL class that the T.E. is capable of operating in.

For data rates above 1568 kbps and up to 2320 kbps, the PSD of the transmitted signal shall not exceed the PSD limitations defined by the equation above ($SDSL_u(f)$) , increased by 3.5dB. At frequencies above the point where the PSD mask, as define above, falls below the peak value of the next lobe, the maximum PSD shall be equal to that particular value until the peak PSD point of the next lobe is reached. At frequencies above the point where the PSD Mask ,as defined above, falls below -90 dBm/Hz, the maximum PSD (out-of-band signal) shall not exceed -90 dBm/Hz up to 30MHz.

Table 3.2.1.4(a)
2B1Q SDSL data rate and associated
PSD Mask definition tables and figures

2B1Q SDSL data rate (kbps)	PSD Masks
data rate ≤ 288	Table 3.2.1.4(b) + Figure 3.2.1.4(a)
288 < data rate ≤ 528	Table 3.2.1.4(c) + Figure 3.2.1.4(b)
528 < data rate ≤ 784	Table 3.2.1.4(d) + Figure 3.2.1.4(c)
784 < data rate ≤ 1168	Table 3.2.1.4(e) + Figure 3.2.1.4(d)
1168 < data rate ≤ 1568	Table 3.2.1.4(f) + Figure 3.2.1.4(e)
1568 < data rate	See equation in section 3.2.1.4

Table 3.2.1.4(b)
2B1Q SDSL (data rate ≤ 288 kbps) PSD Mask definition

Frequency Band (kHz)	PSD (dBm/Hz)
$0 < f \le 25$	-29
$25 < f \le 76$	$-29 - 10.35 \times \log_{10}(f/25)$
$76 < f \le 79$	$-34 - 0.5 \times ((f-76)/3)$
$79 < f \le 85$	$-34.5 - 19.6 \times \log_{10}((f-69)/10)$
$85 < f \le 100$	$-38.5 - 4 \times ((f-85)/15)$
$100 < f \le 115$	$-42.5 - 7 \times ((f-100)/15)$
$115 < f \le 120$	-49.5
$120 < f \le 225$	$-49.5 - 55 \times \log_{10}(f/120)$
$225 < f \le 520$	$-64.5 - 70 \times \log_{10}(f/225)$
$520 < f \le 30000$	-90

Table 3.2.1.4(c)
2B1Q SDSL (288 kbps < data rate ≤ 528 kbps) PSD Mask definition

Frequency Band (kHz)	PSD (dBm/Hz)
0	-32.5
25	-32.5
75	-33
100	-35.5
150	-41.5
200	-50.5
230	-60.5
245	-67.5
335	-68.5
390	-72.5
440	-79.5
485 < f ≤ 30000	-90

Table 3.2.1.4(d)
2B1Q SDSL (528 kbps < data rate ≤ 784 kbps) PSD Mask definition

Frequency Band (kHz)	PSD (dBm/Hz)
0	-33.5
50	-33.5
125	-34.5
210	-37.5
310	-53.5
370	-69.5
550	-71.5
670	-81.5
725 < f ≤ 30000	-90

Table 3.2.1.4(e)

2B1Q SDSL (784 kbps < data rate ≤ 1168 kbps) PSD Mask definition

Frequency Band (kHz)	PSD (dBm/Hz)
0	-35.5
60	-35.5
200	-36.5
250	-37
315	-37.5
400	-49.5
500	-62.5
550	-71.5
750	-72.5
950	-80.5
1095 < f ≤ 30000	-90

Table 3.2.1.4(f)
2B1Q SDSL (1168 kbps < data rate ≤ 1568 kbps) PSD Mask definition

Frequency Band (kHz)	PSD (dBm/Hz)
0	-36.5
100	-36.5
150	-37
200	-38
300	-38.5
390	-38.5
420	-39.5
500	-47.5
775	-73.5
1000	-73.5
1100	-76.5
1300	-82.5
1395 < f ≤ 30000	-90

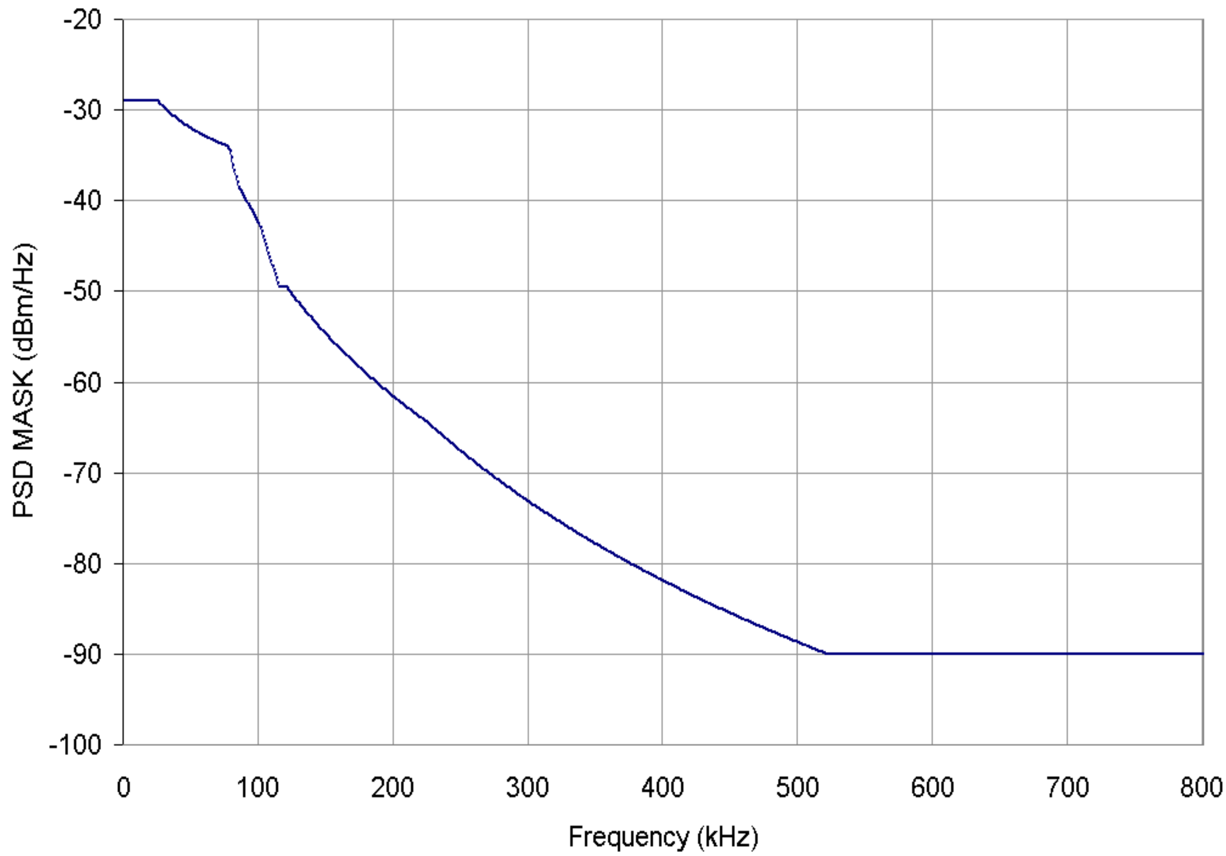


FIGURE 3.2.1.4(a)
PSD Mask for 2B1Q SDSL (Data Rate ≤ 288 kbps)

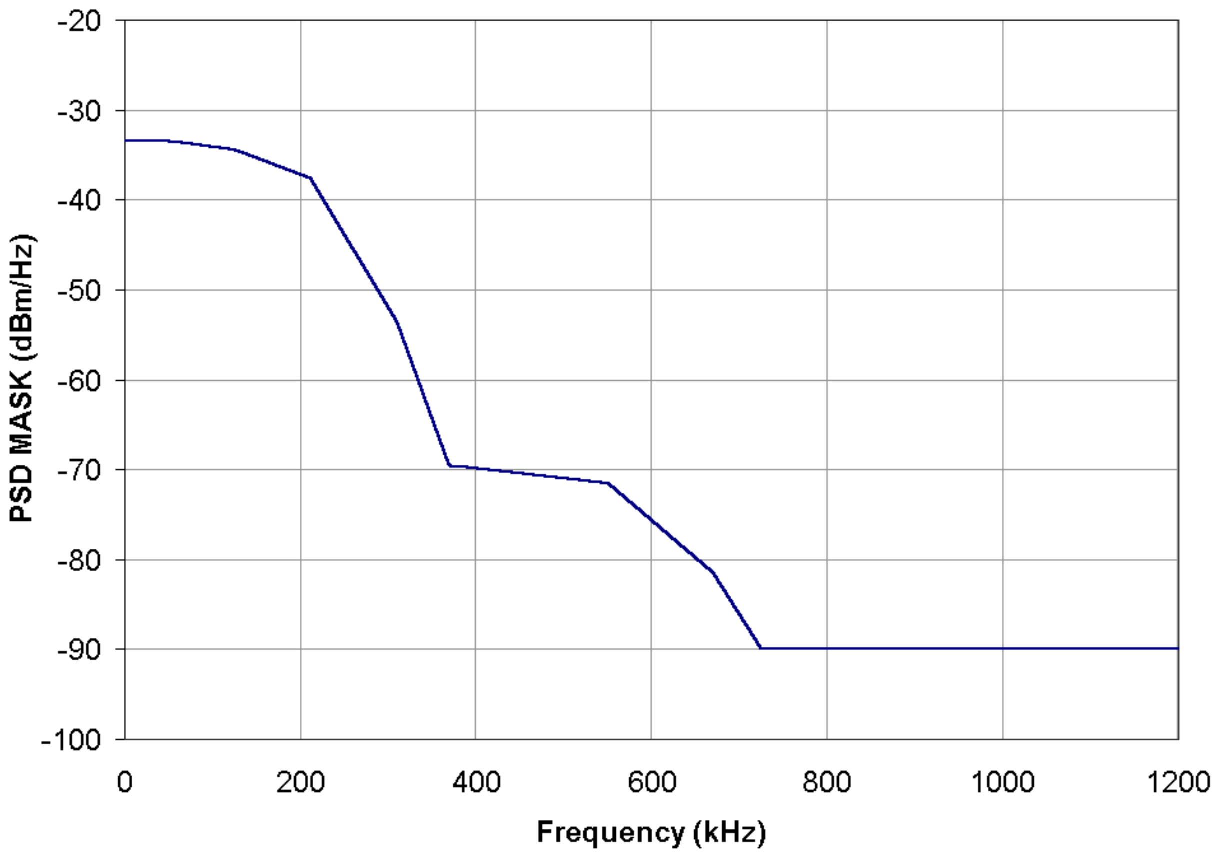


FIGURE 3.2.1.4(b)
PSD Mask for 2B1Q SDSL (288 kbps < Data Rate ≤ 528 kbps)

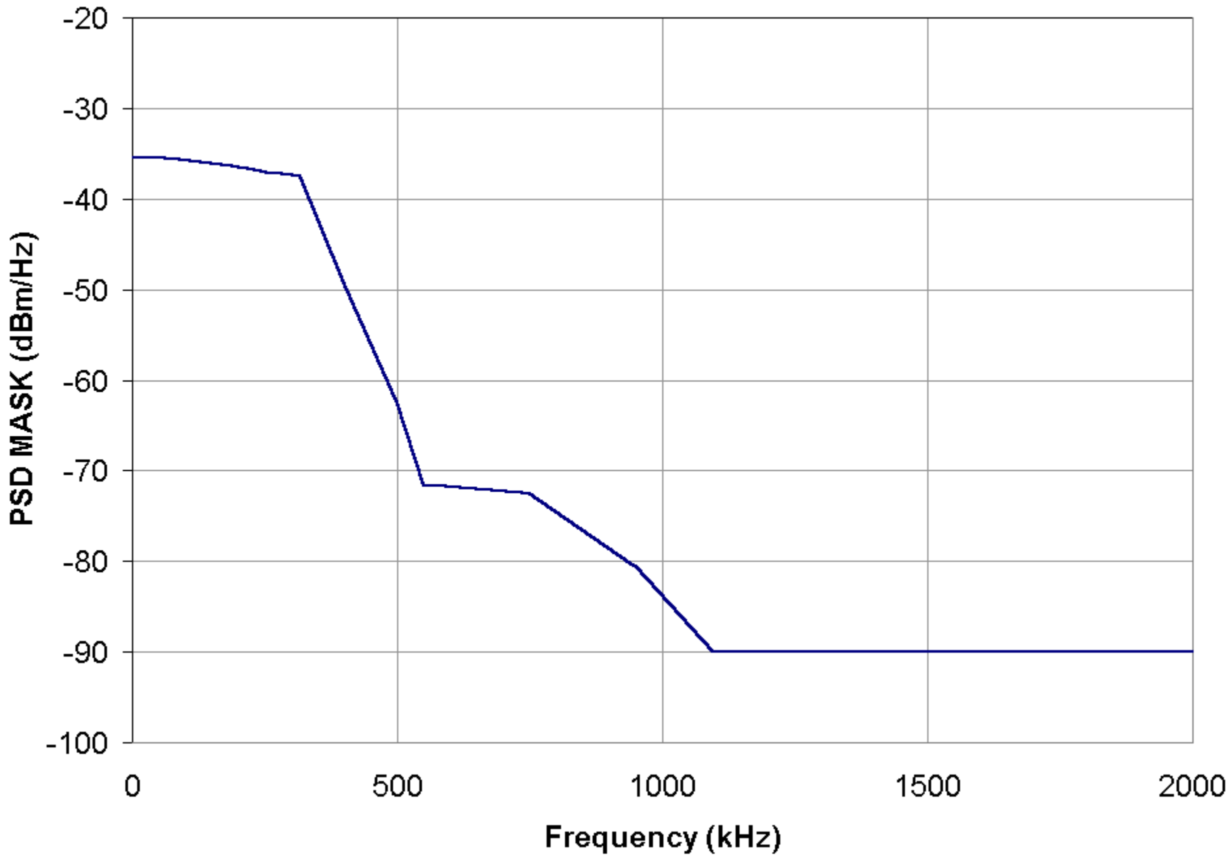


FIGURE 3.2.1.4(c)
PSD Mask for 2B1Q SDSL (528 kbps < Data Rate ≤ 784 kbps)

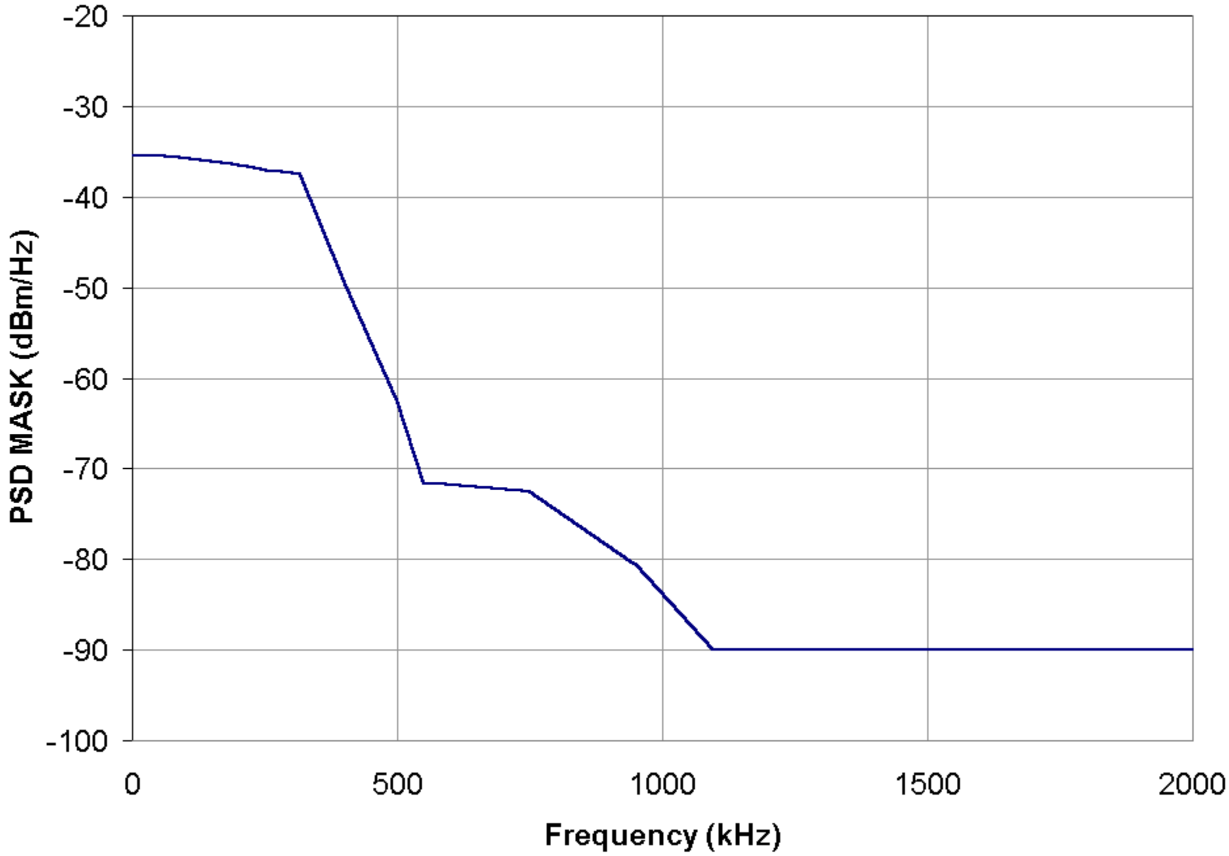


FIGURE 3.2.1.4(d)
PSD Mask for 2B1Q SDSL (784 kbps < Data Rate ≤ 1168 kbps)

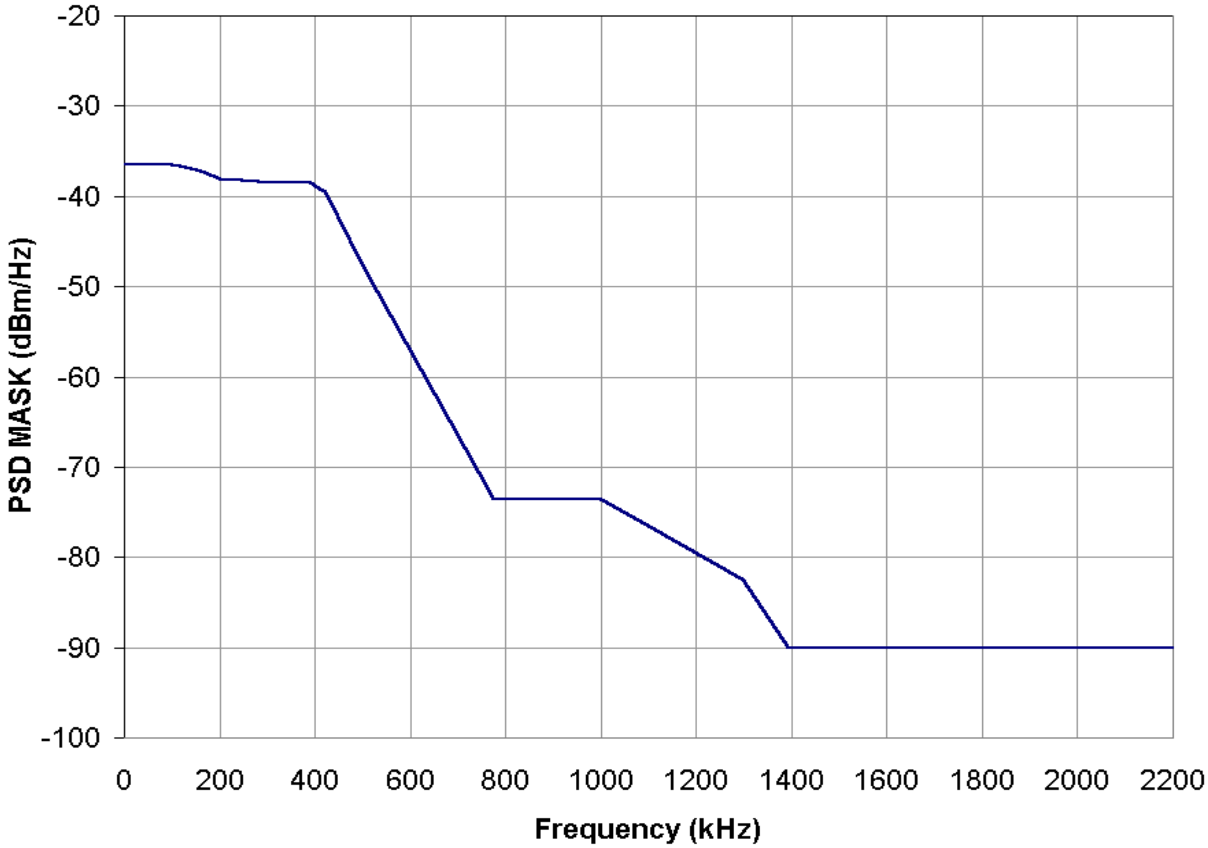


FIGURE 3.2.1.4(e)
PSD Mask for 2B1Q SDSL (1168 kbps < Data Rate ≤ 1568 kbps)

3.2.1.5 POWER SPECTRAL DENSITY AT THE HDSL(2B1Q) U-C AND U-R INTERFACE

The Power Spectral Density (PSD) of the HDSL (2B1Q) transmit signal measured at the U-C or U-R interface shall not exceed the PSD mask in Figure 3.2.1.5(a). Table 3.2.1.5(a) provides the numerical values for the mask in Figure 3.2.1.5(a).

Table 3.2.1.5(a)
HDSL [2B1Q] PSD Mask definition

Frequency Band (kHz)	PSD (dBm/Hz)
0	-33.5
50	-33.5
125	-34.5
210	-37.5
310	-53.5
370	-69.5
550	-71.5
670	-81.5
$725 < f \leq 30000$	-90

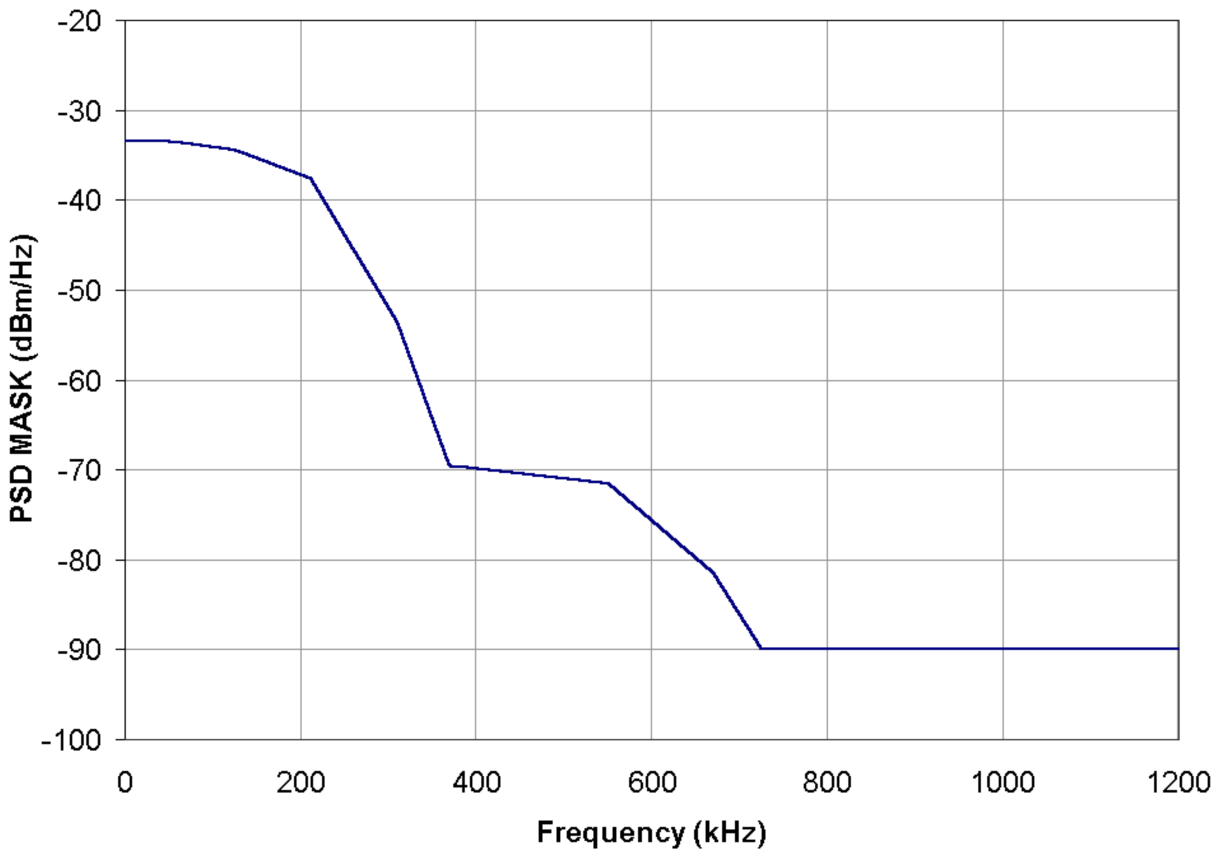


FIGURE 3.2.1.5(a)
PSD Mask for HDSL [2B1Q] TU-C & TU-R

3.2.1.6 POWER SPECTRAL DENSITY AT THE HDSL(CAP) U-C AND U-R INTERFACE

The Power Spectral Density (PSD) of the HDSL (CAP) transmit signal measured at the U-C or U-R interface shall not exceed the PSD mask in Figure 3.2.1.6(a). Table 3.2.1.6(a) provides the numerical values for the mask in Figure 3.2.1.6(a).

Table 3.2.1.6(a)
HDSL [CAP] TU-C & TU-R PSD Mask definition

Frequency Band (kHz)	PSD (dBm/Hz)
0	-36.5
100	-36.5
150	-37
200	-38
300	-38.5
390	-38.5
420	-39.5
500	-47.5
775	-73.5
1000	-73.5
1100	-76.5
1300	-82.5
1395 < f ≤ 30000	-90

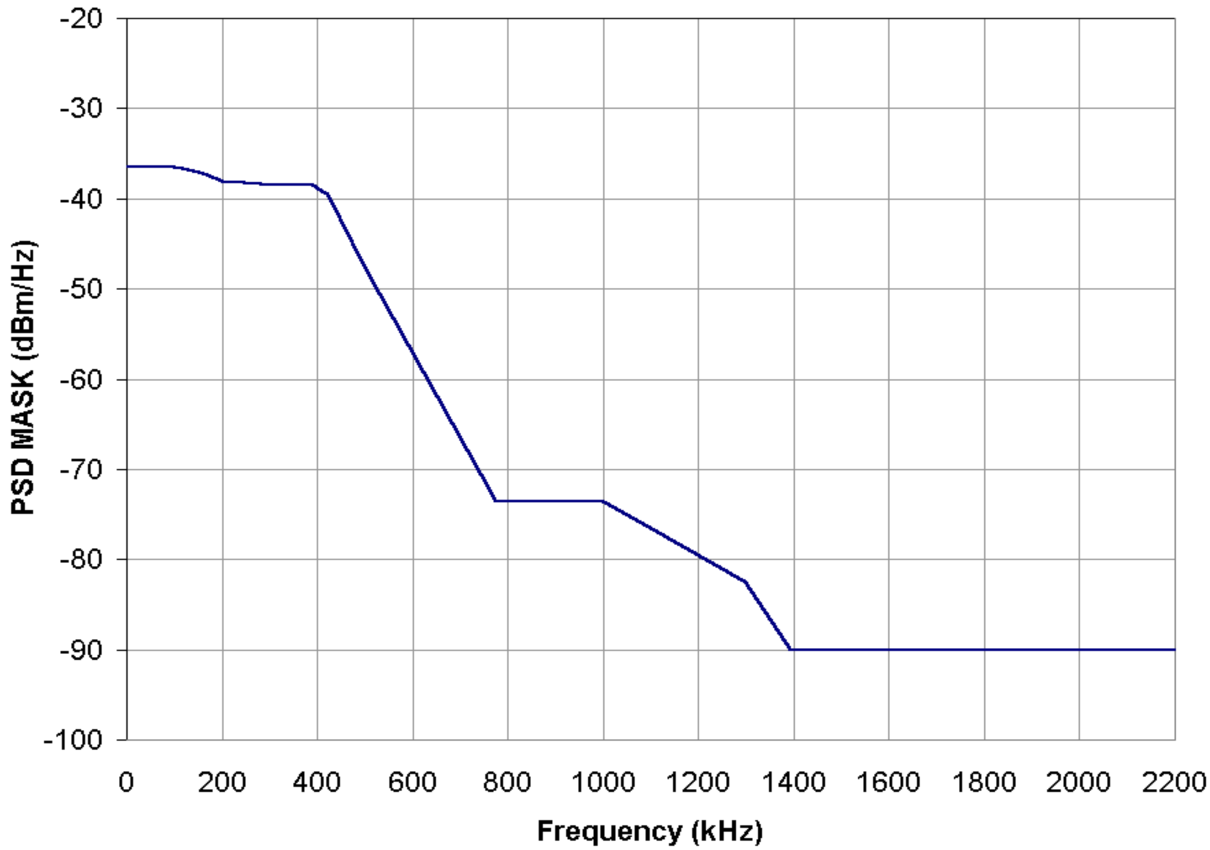


FIGURE 3.2.1.6(a)
PSD Mask for HDSL [CAP] TU-C & TU-R

3.2.1.7 POWER SPECTRAL DENSITY AT THE HDSL2 U-C AND U-R INTERFACE

U-C INTERFACE

The power spectral density (PSD) of the HDSL4 transmit signal measured at the U-C interface shall not exceed the PSD mask defined in Table 3.2.1.7(a) and Figure 3.2.1.7(a).

U-R INTERFACE

The power spectral density (PSD) of the HDSL4 transmit signal measured at the U-R interface shall not exceed the PSD mask defined in Table 3.2.1.7(b) and Figure 3.2.1.7(b).

TABLE 3.2.1.7(a)
HDSL2 Mask values for spectral shaper at the U-C interface

Frequency (kHz)	PSD (dBm/Hz)	Frequency (kHz)	PSD (dBm/Hz)	Frequency (kHz)	PSD (dBm/Hz)
≤1	-54.2	280	-35.7	1000	-89.2
2	-42.2	375	-35.7	1076	-90
12	-39.2	400	-40.2	30000	-90
190	-39.2	440	-68.2		
236	-46.2	600	-76.2		

TABLE 3.2.1.7(b)
HDSL2 Mask values for spectral shaper at the U-R interface

Frequency (kHz)	PSD (dBm/Hz)	Frequency (kHz)	PSD (dBm/Hz)	Frequency (kHz)	PSD (dBm/Hz)
≤1	-54.2	220	-34.4	426	-90
2	-42.1	255	-34.4	30000	-90
10	-37.8	276	-41.1		
175	-37.8	300	-77.6		

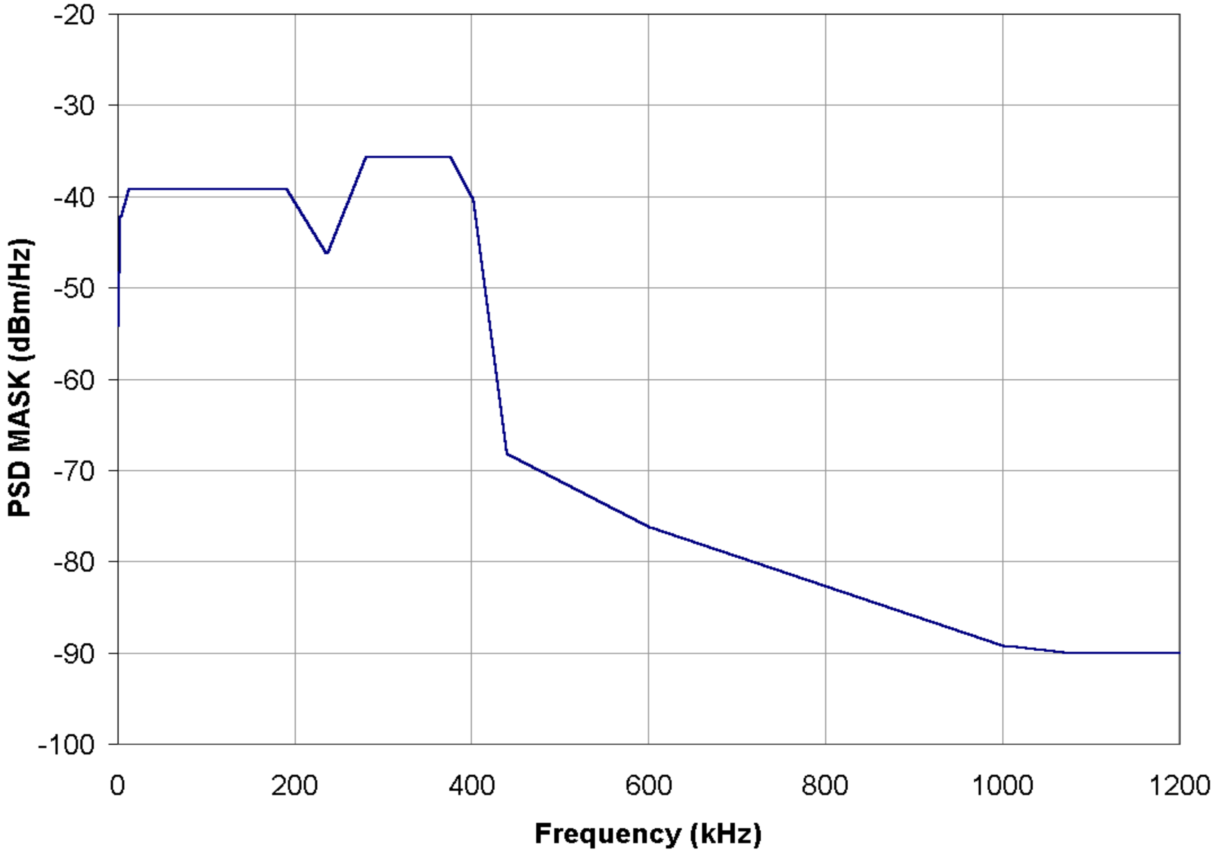


FIGURE 3.2.1.7(a)
HDSL2 TU-C PSD Mask for the Downstream Transmission

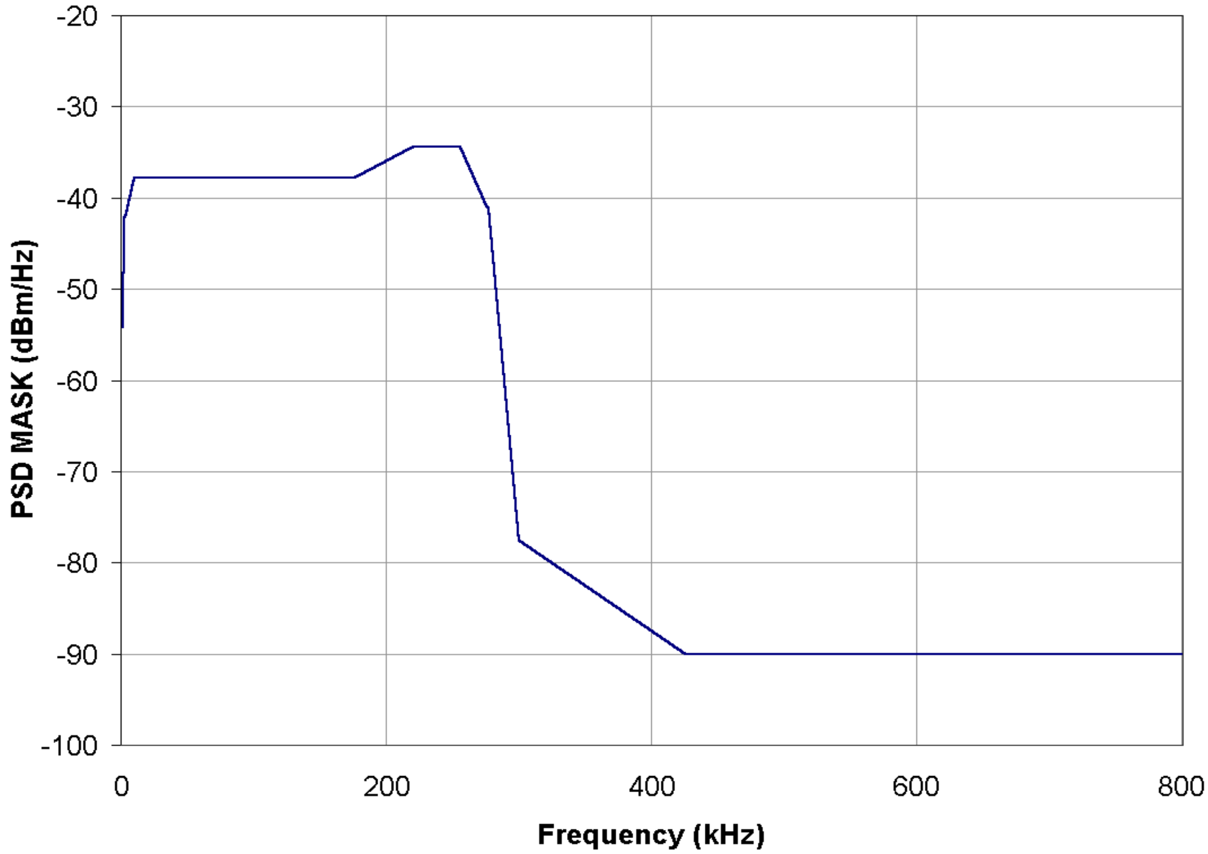


FIGURE 3.2.1.7(b)
HDSL2 TU-R PSD Mask for the Upstream Transmission

3.2.1.8 POWER SPECTRAL DENSITY AT THE SHDSL (SYMMETRIC) U-C AND U-R INTERFACE

The power spectral density (PSD) of the signal transmitted by the SHDSL system shall not exceed the following PSD mask ($SHDSL_M(f)$):

$$SHDSL_M(f) = \begin{cases} \dfrac{K_{SHDSL}}{135} \times \dfrac{1}{f_{sym}} \times \dfrac{\left[sin\left(\dfrac{\pi f}{f_{sym}} \right) \right]^2}{\left(\dfrac{\pi f}{f_{sym}} \right)^2} \times \dfrac{1}{1 + \left(\dfrac{f}{f_{3dB}} \right)^{12}} \times 10^{\frac{MaskedOffsetdB(f)}{10}}, & f < f_{int} \\ 0.5683 \times 10^{-4} \times f^{-1.5}, \quad f_{int} \le f \le 1.1MHz & \end{cases}$$

MaskOffsetdB(f) is defined as

$$MaskOffsetdB(f) = \begin{cases} 1 + 0.4 \times \dfrac{f_{3dB} - f}{f_{3dB}} & , \quad f < f_{3dB} \\ 1 & , \quad f \ge f_{3dB} \end{cases}$$

f_{int} is the frequency where the two functions governing $SHDSL_M(f)$ intersect in the range 0 to f_{sym}. K_{SHDSL}, f_{sym}, f_{3dB} and the payload data rate R are defined in Table 3.2.1.8(a).

At frequencies above the point where the PSD mask, as define above, falls below the peak value of the next lobe, the maximum PSD shall be equal to that particular value until the peak PSD point of the next lobe is reached.
At frequencies above the point where the PSD Mask as defined above falls below – 90 dBm/Hz, the maximum PSD (out-of-band signal) shall not exceed – 90 dBm/Hz up to 30 MHz.

The transmitted spectrum shall not exceed the applicable mask when the equipment is operated at any of the data rates specified in Table 1.6(c). The T.E. must be tested at least at the maximum date rate for each designation shown in Table 1.6(c), in which the T.E. is capable of operating.

TABLE 3.2.1.8(a)

SHDSL Symmetric PSD parameters

Line Bit Rate *LBR* (kbps)	K_{shdsl}	f_{sym} (ksymbols/s)	f_{3dB}
$LBR \neq$ 1544 or 1552	7.86	LBR / 3	1.0 x f_{sym} /2
$LBR =$ 1544 or 1552	8.32	LBR /3	0.9 x f_{sym} /2

3.2.1.9 POWER SPECTRAL DENSITY AT THE HDSL4 U-C AND U-R INTERFACE

U-C INTERFACE

The power spectral density (PSD) of the HDSL4 transmit signal measured at the U-C interface shall not exceed the PSD mask defined in Table 3.2.1.9(a) and Figure 3.2.1.9(a).

U-R INTERFACE

The power spectral density (PSD) of the HDSL4 transmit signal measured at the U-R interface shall not exceed the PSD mask defined in Table 3.2.1.9(b) and Figure 3.2.1.9(b).

TABLE 3.2.1.9(a)
PSD Mask definition for downstream transmission from HDSL4 TU-C

Frequency (kHz)	PSD (dBm/Hz)	Frequency (kHz)	PSD (dBm/Hz)	Frequency (kHz)	PSD (dBm/Hz)
≤ 0.2	-47.5	110	-54.5	250	-48
2	-37.5	135	-43	400	-43
5	-34	145	-37	600	-66.5
50	-34	150	-35	1000	-85.7
80	-37	155	-34	1410	-90
90	-41.5	200	-36.75	30000	-90
105	-54.5	210	-39.5		

TABLE 3.2.1.9(b)
PSD Mask definition for upstream transmission from HDSL4 TU-R

Frequency Band (kHz)	PSD (dBm/Hz)
0 < f ≤ 0.2	- 47.5
0.2 < f ≤ 2	-37.5 + 10(f-2)/1.8
2 < f ≤ 5	-33.5 + 4(f-5)/3
5 < f ≤ 50	-33.5
50 < f ≤ 125	-33.5 - ((f-50)75)
125 < f ≤ 130	-34.5
130 < f ≤ 307	-34.5 - 142 x log 10(f/130)
307 < f ≤ 30000	-90

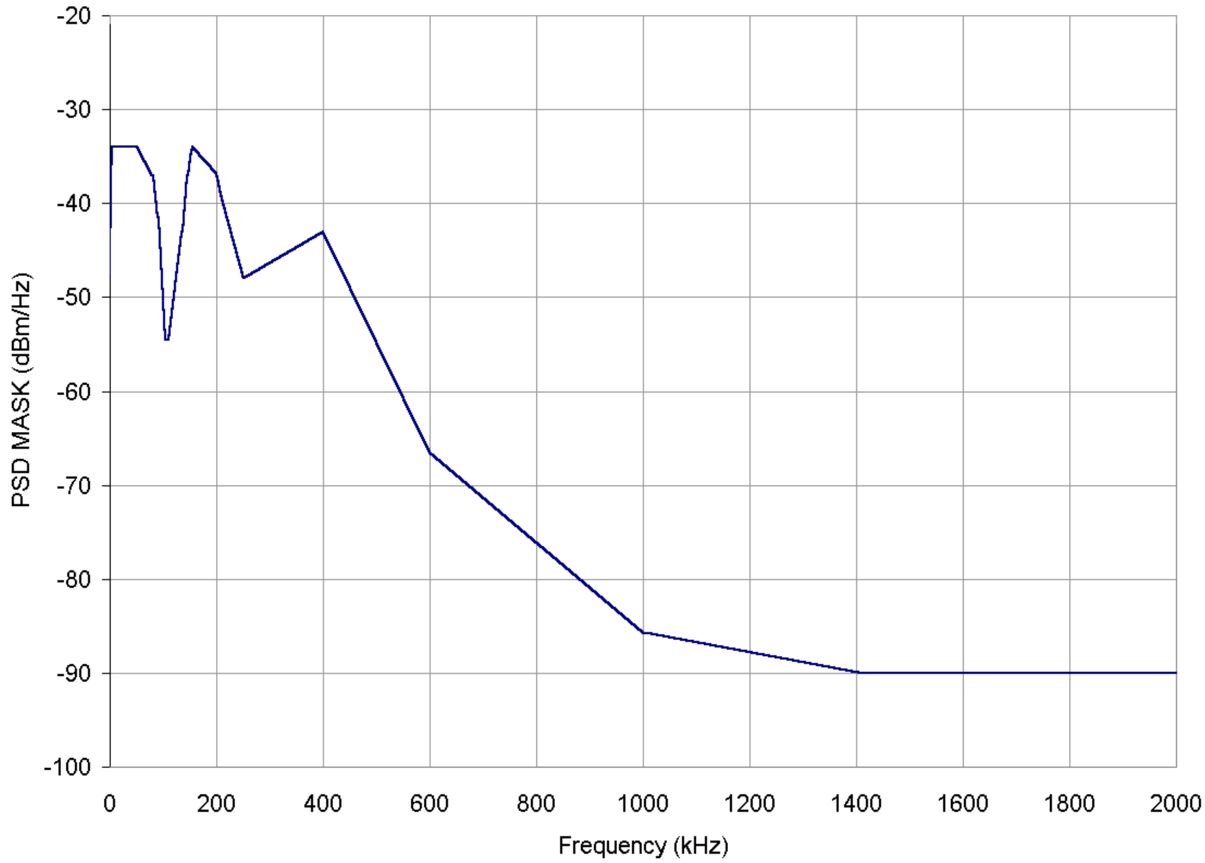


FIGURE 3.2.1.9(a)
PSD Mask for Downstream transmission from HDSL4 TU-C

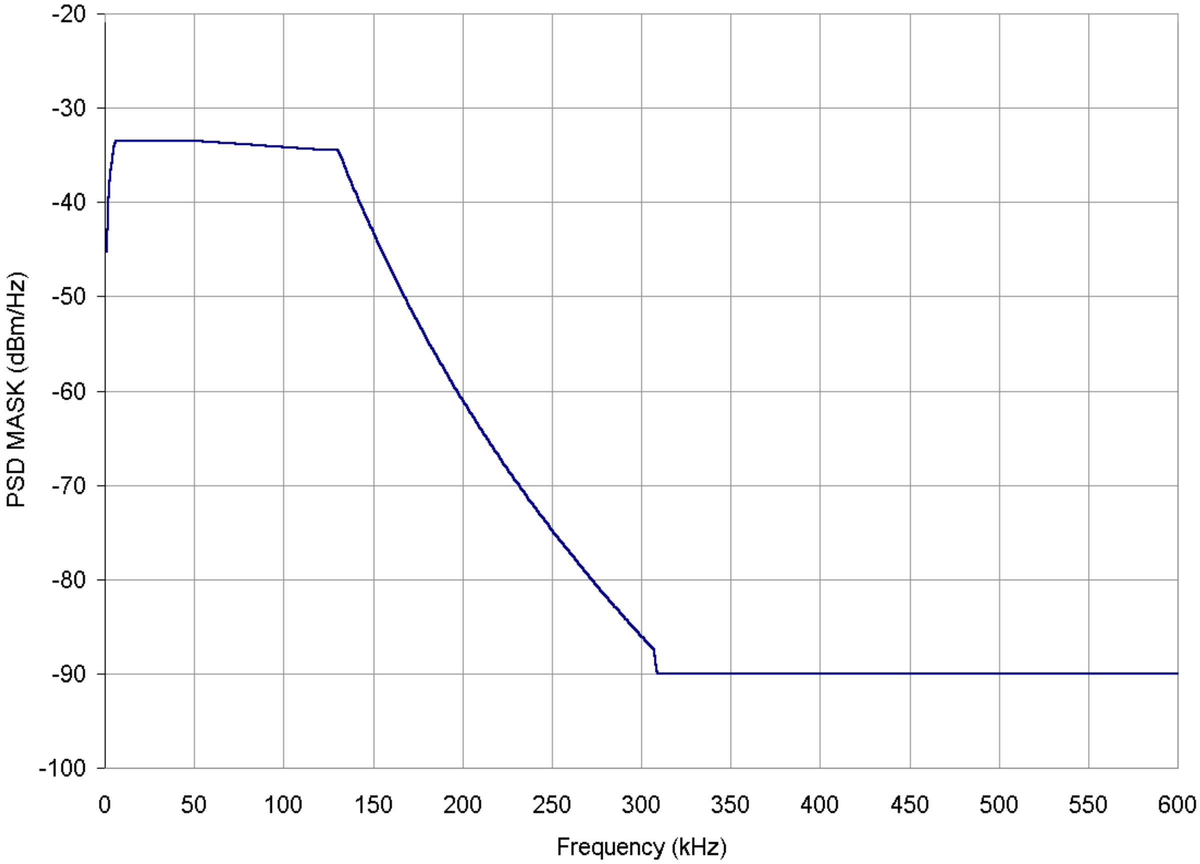


FIGURE 3.2.1.9(b)
PSD Mask for Upstream transmission from HDSL4 TU-R

3.2.2 METHOD OF MEASUREMENT

WARNING :
High DC Voltage may be present at the TU-C end of DSL equipment.
Take necessary precaution when manipulating or connecting test equipment at the U-C interface.

3.2.2.1 METHOD OF MEASUREMENT (WHEN TESTED WITH A COMPANION UNIT)

(1) Connect the xDSL equipment as shown in Figure 3.2.2(a).

(2) Use an artificial line to force the xDSL equipment to transmit at maximum power.

(3) Set S1 to position 'A' (four-pole switch).

(4) Set the spectrum analyzer to capture the top portion of the upstream band with a suggested resolution bandwidth of 10 kHz and video bandwidth of 100 Hz.

(5) Evaluate the T.E. signal for compliance with the appropriate spectrum mask using an impedance of 100 Ohms for ADSL and 135 Ohms for HDSL/HDSL2/HDSL4/ SDSL/SHDSL.

(6) Set S1 to position 'B' (four-pole switch).

(7) Set an appropriate filter to cut the signal passband (working band).

(8) Evaluate the T.E. signal for compliance with the spectrum mask in the lower and upper Out-of-band region using an impedance of 100 Ohms for ADSL and 135 Ohms for HDSL/HDSL2/HDSL4/ SDSL/SHDSL.

(9) Connect the xDSL equipment as shown in Figure 3.2.2(b) and repeat steps (2) to (5) for the downstream band.

(10) Set S1 to position 'B' (four-pole switch).

(11) Set an appropriate filter to cut the signal passband (working band).

(12) Evaluate the T.E. signal for compliance with the spectrum mask in the lower and upper Out-of-band region using an impedance of 100 Ohms for ADSL and 135 Ohms for HDSL/HDSL2/HDSL4/ SDSL/SHDSL.

3.2.2.2 ALTERNATIVE METHOD OF MEASUREMENT (WHEN TESTED WITHOUT A COMPANION UNIT)

(1) Connect the xDSL equipment as shown in Figure 3.2.2(c).

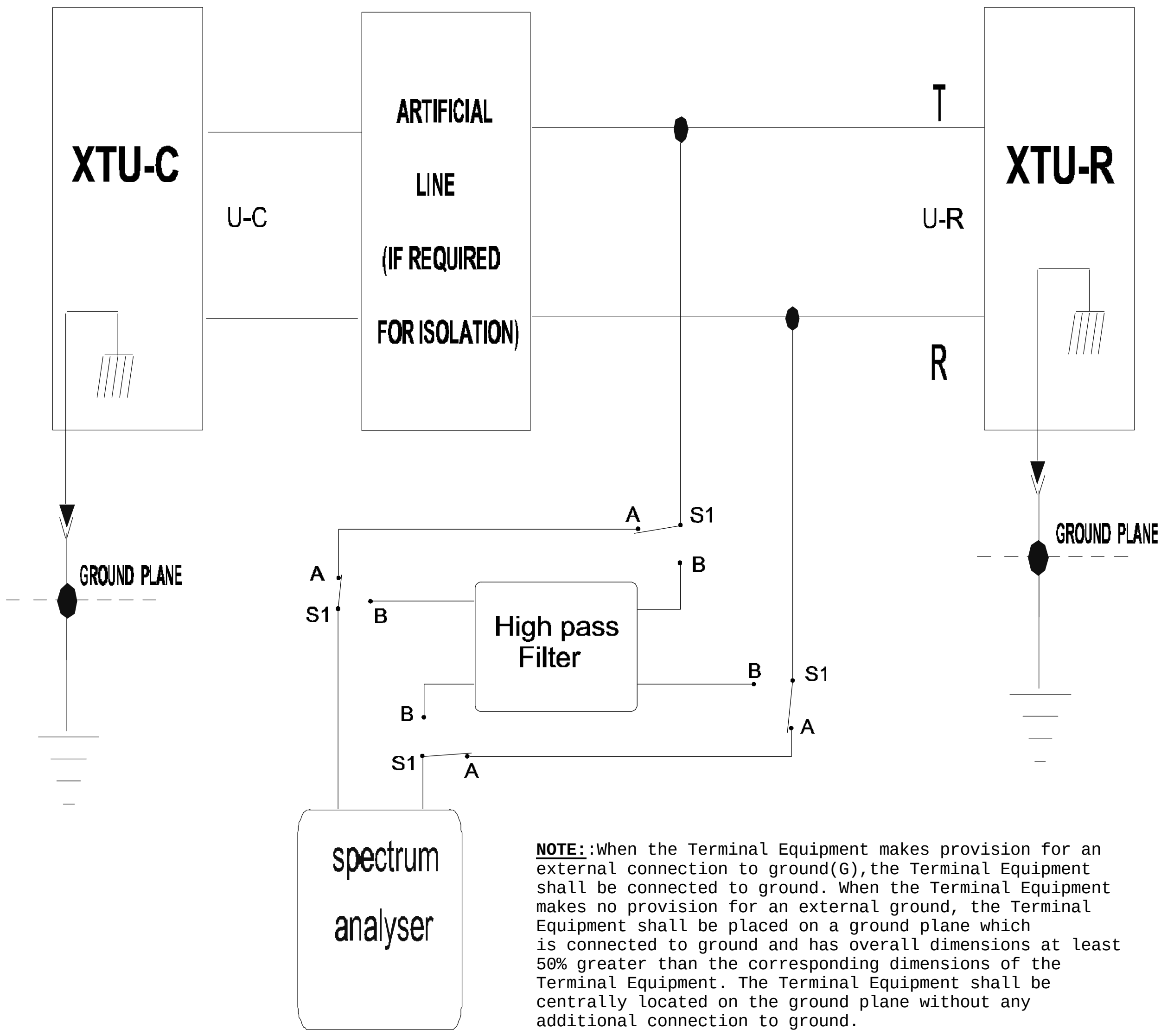
(2) Operate the xDSL equipment (xTU-R working without xTU-C) and force it to transmit at maximum power.

(3) Measure and record the upstream band PSD using the test method given in Section 3.2.2.1 steps (3) to (8).

(4) Connect the xDSL equipment as shown in Figure 3.2.2(d).

(5) Operate the xDSL equipment (xTU-C working without xTU-R) and force it to transmit at maximum power.

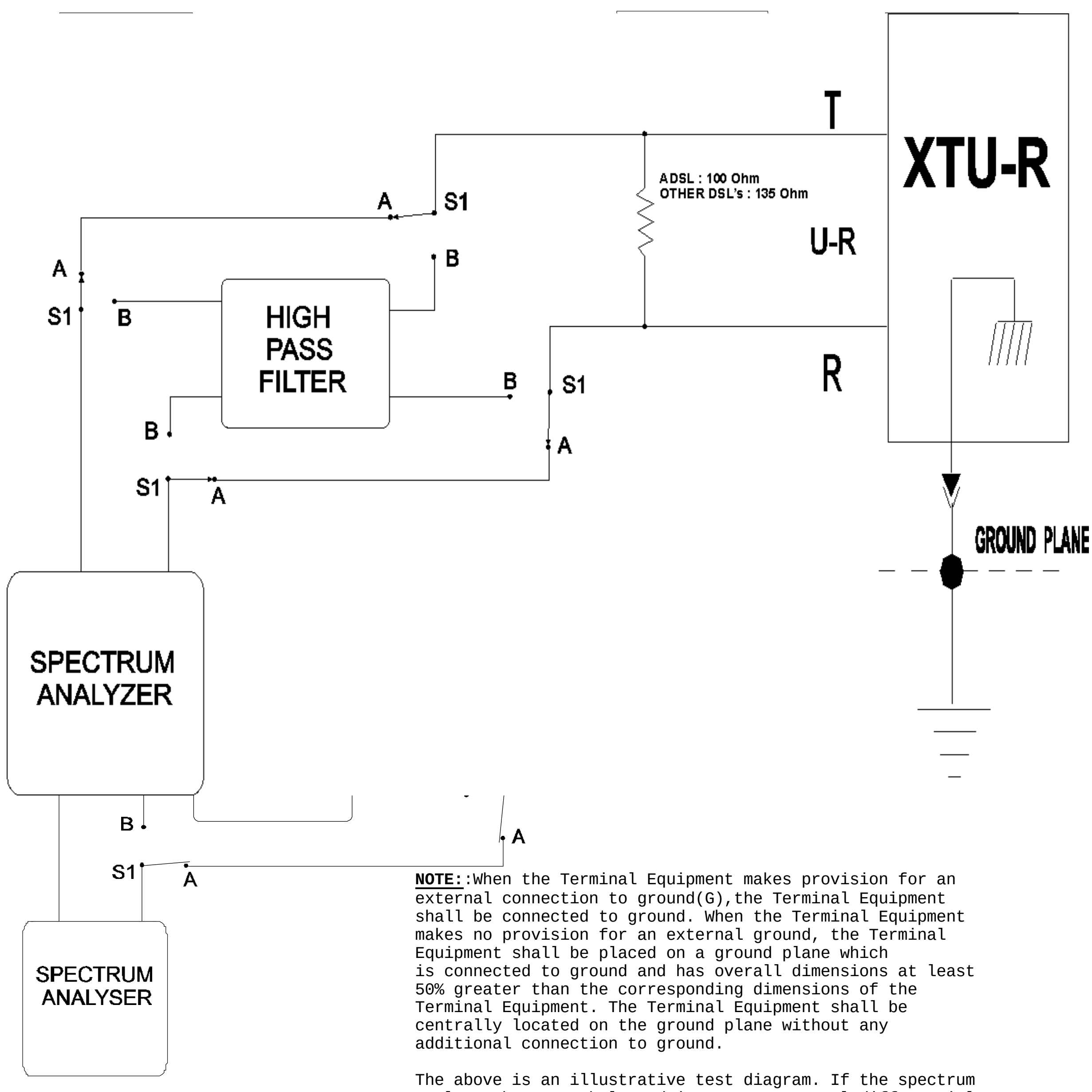
(6) Measure and record the downstream band PSD using the test method given in Section 3.2.2.1 steps (3) to (5) and (10) to (12).



NOTE::When the Terminal Equipment makes provision for an external connection to ground(G),the Terminal Equipment shall be connected to ground. When the Terminal Equipment makes no provision for an external ground, the Terminal Equipment shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the Terminal Equipment. The Terminal Equipment shall be centrally located on the ground plane without any additional connection to ground.

The above is an illustrative test diagram. If the spectrum analyzer has an unbalanced input, an external differential amplifier or balun transformer should be used. Additional high pass filtering may also be necessary to increase measurement sensitivity when making low level PSD measurements.

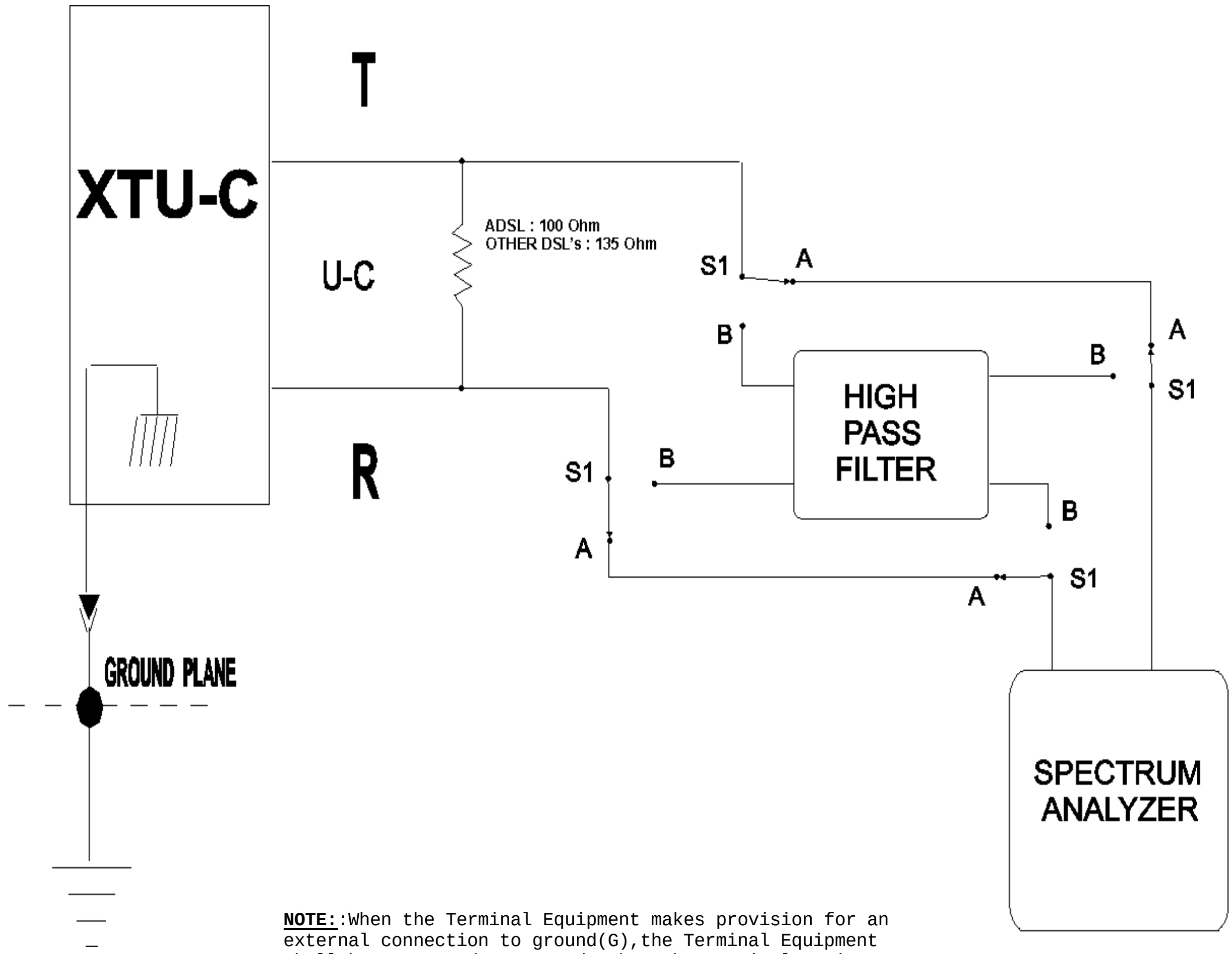
FIGURE 3.2.2(a)
xDSL Power Spectral Density at the
U-R interface when tested with a companion unit
(xTU-R Band = Upstream transmitted signal for all DSL technologies)



NOTE::When the Terminal Equipment makes provision for an external connection to ground(G),the Terminal Equipment shall be connected to ground. When the Terminal Equipment makes no provision for an external ground, the Terminal Equipment shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the Terminal Equipment. The Terminal Equipment shall be centrally located on the ground plane without any additional connection to ground.

The above is an illustrative test diagram. If the spectrum analyzer has an unbalanced input, an external differential amplifier or balun transformer should be used. Additional high pass filtering may also be necessary to increase measurement sensitivity when making low level PSD measurements.

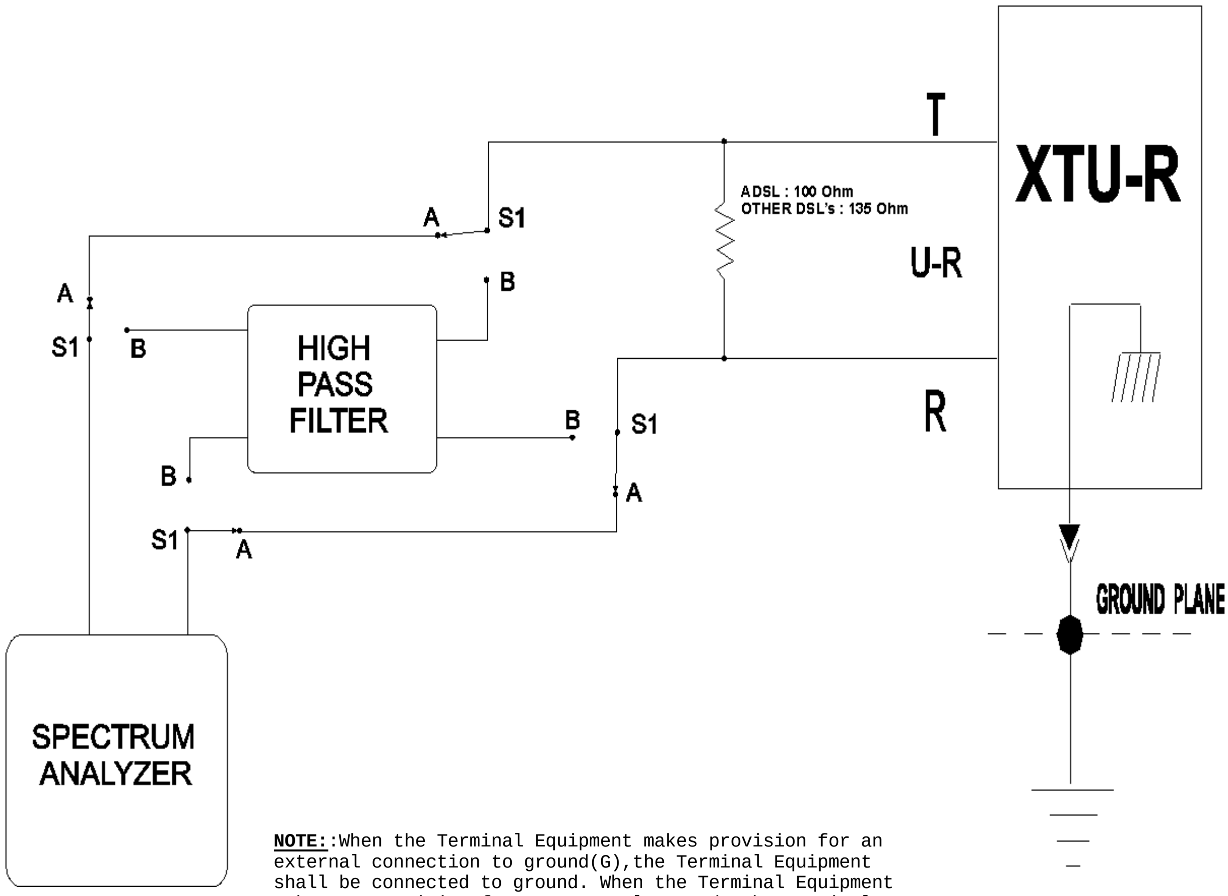
FIGURE 3.2.2(b)
xDSL Power Spectral Density at the
U-C interface when tested with a companion unit
(xTU-C Band = Downstream transmitted signal for all DSL technologies)



NOTE::When the Terminal Equipment makes provision for an external connection to ground(G),the Terminal Equipment shall be connected to ground. When the Terminal Equipment makes no provision for an external ground, the Terminal Equipment shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the Terminal Equipment. The Terminal Equipment shall be centrally located on the ground plane without any additional connection to ground.

The above is an illustrative test diagram. If the spectrum analyzer has an unbalanced input, an external differential amplifier or balun transformer should be used. Additional high pass filtering may also be necessary to increase measurement sensitivity when making low level PSD measurements.

FIGURE 3.2.2(c)
xDSL Power Spectral Density at the
U-R interface when tested without a companion unit
(xTU-R Band = Upstream transmitted signal for all DSL technologies)



NOTE::When the Terminal Equipment makes provision for an external connection to ground(G),the Terminal Equipment shall be connected to ground. When the Terminal Equipment makes no provision for an external ground, the Terminal Equipment shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the Terminal Equipment. The Terminal Equipment shall be centrally located on the ground plane without any additional connection to ground.

The above is an illustrative test diagram. If the spectrum analyzer has an unbalanced input, an external differential amplifier or balun transformer should be used. Additional high pass filtering may also be necessary to increase measurement sensitivity when making low level PSD measurements.

FIGURE 3.2.2(d)
xDSL Power Spectral Density at the
U-C interface when tested without a companion unit
(xTU-C Band = Downstream transmitted signal for all DSL technologies)

3.3 TOTAL SIGNAL POWER

3.3.1 REQUIREMENT

3.3.1.1 ADSL[CAP/DMT/Fully or Partially Overlapped] TOTAL SIGNAL POWER AT THE U-C AND U-R INTERFACE POINTS

Total signal power for upstream or downstream shall not exceed the following limits:

(A) TOTAL SIGNAL POWER (U-C) = **20.9 dBm**

(B) TOTAL SIGNAL POWER (U-R) = **13 dBm**

where termination impedance is 100 Ohms.

3.3.1.2 2B1Q SDSL TOTAL SIGNAL POWER

The T.E. must be tested at least at the maximum data rate for each spectrum management class that the T.E. is capable of operating in.

The equipment must comply with the applicable Power limit when operated at every data rate that the T.E. can achieve.

Excluding remote power feeding, the average power of a signal consisting of equiprobable symbols in all positions shall not exceed **14dBm** over the frequency band of 0Hz to symbol frequency (which is equal to one-half of the line bit rate) into a termination of 135 Ohms.

3.3.1.3 HDSL [2B1Q] TOTAL SIGNAL POWER

Excluding remote power feeding, the average power of a signal consisting of a framed sequence of symbols with a frame word and equiprobable symbols in all other positions shall not exceed **14 dBm** over the frequency band from 0 Hz to 784 kHz into a termination of 135 Ohms.

3.3.1.4 HDSL [CAP] TOTAL SIGNAL POWER

TWO PAIR SYSTEM TOTAL POWER

Excluding remote power feeding, the average transmit power at the transmitter output shall not exceed **14 dBm** (high power mode) or **8 dBm** (low power mode) into a termination of 135 Ohms.

ONE PAIR SYSTEM TOTAL POWER

Excluding remote power feeding, the average transmit power at the transmitter output shall not exceed **16 dBm** (high power mode) or **10 dBm** (low power mode) into a termination of 135 Ohms.

3.3.1.5 HDSL2 TOTAL SIGNAL POWER

The total average transmit power may be tested while span powered or locally powered as required by the intended application of the T.E.. For span powered applications, if the T.E. is an H2TU-C the test shall be performed with the span power supply activated and an appropriate DC current sink (with high AC impedance) attached to the test circuit. If the T.E. is an H2TU-R the test shall be performed with power (DC voltage) applied at the loop interface (TIP/RING) by an external voltage source feeding through an AC blocking impedance. The test circuit must contain provisions for DC power feed and possibly transformer isolation for the measurement instrumentation. Note that the DC current source/sink must present a high impedance (at signal frequencies) to common ground.

The total average transmit power of the H2TU-C (into 135 Ohms) below 450 kHz shall not exceed **17.3 dBm**. The total average transmit power of the H2TU-R (into 135 Ohms) below 350 kHz shall not exceed **17.0 dBm**.

Table 3.3.1(a) : HDSL2 Total average transmit power at the U-R interface

Transmit Mode	Power (dBm)	Bandwith
H2TU-C	17.3	0 - 450 kHz
H2TU-R	17	0 - 350 kHz

3.3.1.6 SHDSL (Symmetric)TOTAL SIGNAL POWER

The total average signal power below f_{sym} transmitted by the SHDSL TU-C or TU-R shall not exceed 14 dBm., where the termination impedance is 135 Ohms.

3.3.1.7 HDSL4 TOTAL SIGNAL POWER AT THE U-C AND U-R INTERFACE

U-C INTERFACE

The total signal power transmitted by HDSL4 TU-C below 600 kHz shall not exceed 14.6 dBm, where the termination impedance is 135 Ohms.

U-R INTERFACE

The total signal power transmitted by HDSL4 TU-R below 307 kHz shall not exceed 14.6 dBm, where the termination impedance is 135 Ohms.

3.3.2 TOTAL SIGNAL POWER - METHOD OF MEASUREMENT FOR ALL DSL TECHNOLOGIES

WARNING :
High DC Voltage may be present at the TU-C end of DSL equipment.
Take necessary precaution when manipulating or connecting test equipment at the U-C interface.

Note: The total average transmit power may be tested while the TE is span-powered or locally powered as required by the intended application of the T.E. For span-powered applications, if the T.E. is a TU-C, the test shall be performed with the TU-C span power supply activated and an appropriate DC current sink (with high AC impedance) attached to the test circuit. If the T.E. is a TU-R, the test shall be performed with the DC power applied at the loop interface by an external voltage source feeding through an AC blocking impedance. The DC current source/sink must present a high impedance (at signal frequencies) to common ground.

3.3.2.1 METHOD OF MEASUREMENT FOR ALL DSL TECHNOLOGIES (WHEN TESTED WITH A COMPANION UNIT)

(1) Connect the xDSL equipment as shown in Figure 3.2.2(a).

(2) Set the spectrum analyzer to capture the upstream band with a suggested resolution bandwidth of 1 kHz and video bandwidth of 100 Hz.

(3) Measure and record the nominal 3 dB roll off points.

(4) Connect the xDSL equipment as shown in Figure 3.2.2(b).

(5) Set the spectrum analyzer to capture the downstream band, with a suggested resolution bandwidth of 1 kHz and video bandwidth of 100 Hz.

(6) Measure and record the nominal 3 dB roll off points.

(7) Connect the xDSL equipment as shown in Figure 3.3.2(a).

(8) Use an artificial line to force the xDSL equipment to transmit at maximum power.

(9) Use the appropriate band pass filter for xTU-R (upstream lower and upper 3 dB points). Measure and record the total signal power in dBm with a termination impedance of 100 Ohms for ADSL and 135 Ohms for all other DSL types.

(10) Connect the xDSL equipment as shown in Figure 3.3.2(b).

(11) Use an artificial line to force the xDSL equipment to transmit at maximum power.

(12) Use the appropriate band pass filter for xTU-C (downstream lower and upper 3 dB Point). Measure and record the total signal power in dBm with a termination impedance of 100 Ohms for ADSL and 135 Ohms for all other DSL types.

3.3.2.2 ALTERNATIVE METHOD OF MEASUREMENT FOR ALL DSL TECHNOLOGIES (WHEN TESTED WITHOUT A COMPANION UNIT)

(1) Connect the xDSL equipment as shown in Figure 3.2.2(c).

(2) Measure and record the nominal 3 dB roll off points of xTU-R, using the test method given in section 3.3.2.1 steps (2) and (3).

(3) Connect the xDSL equipment as shown in Figure 3.2.2(d).

(4) Measure and record the nominal 3 dB roll off points of xTU-C, using the test method given in section 3.3.2.1 steps (5) and (6).

(5) Connect the xDSL equipment as shown in Figure 3.3.2(c).

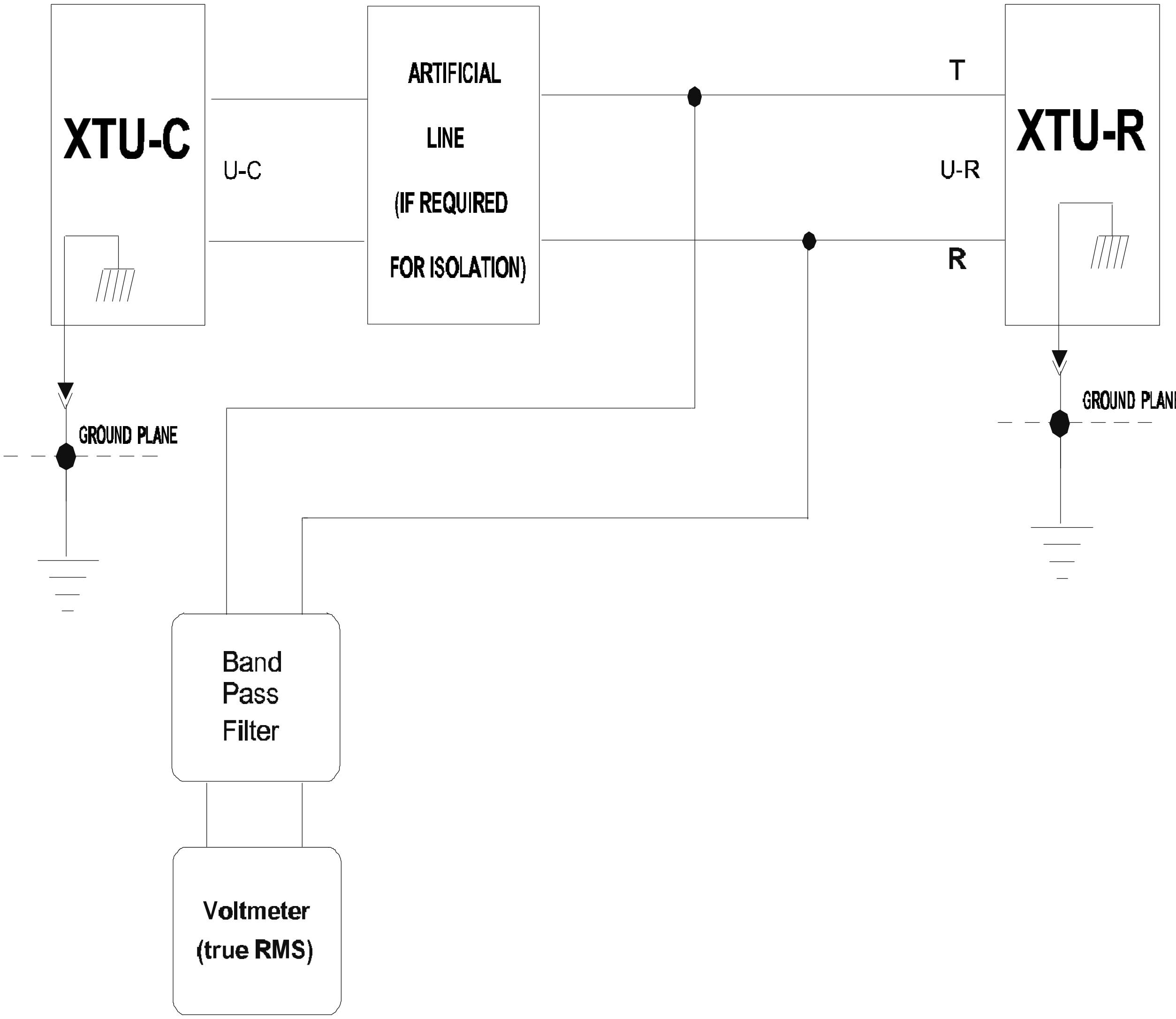
(6) Operate the xDSL equipment (xTU-R working without xTU-C) and force it to transmit at maximum power.

(7) Measure and record the total signal power for the upstream band using the test method given in section 3.3.2.1 steps (9).

(8) Connect the xDSL equipment as shown in Figure 3.3.2(d).

(9) Operate the xDSL equipment (xTU-C working without xTU-R) and force it to transmit at maximum power.

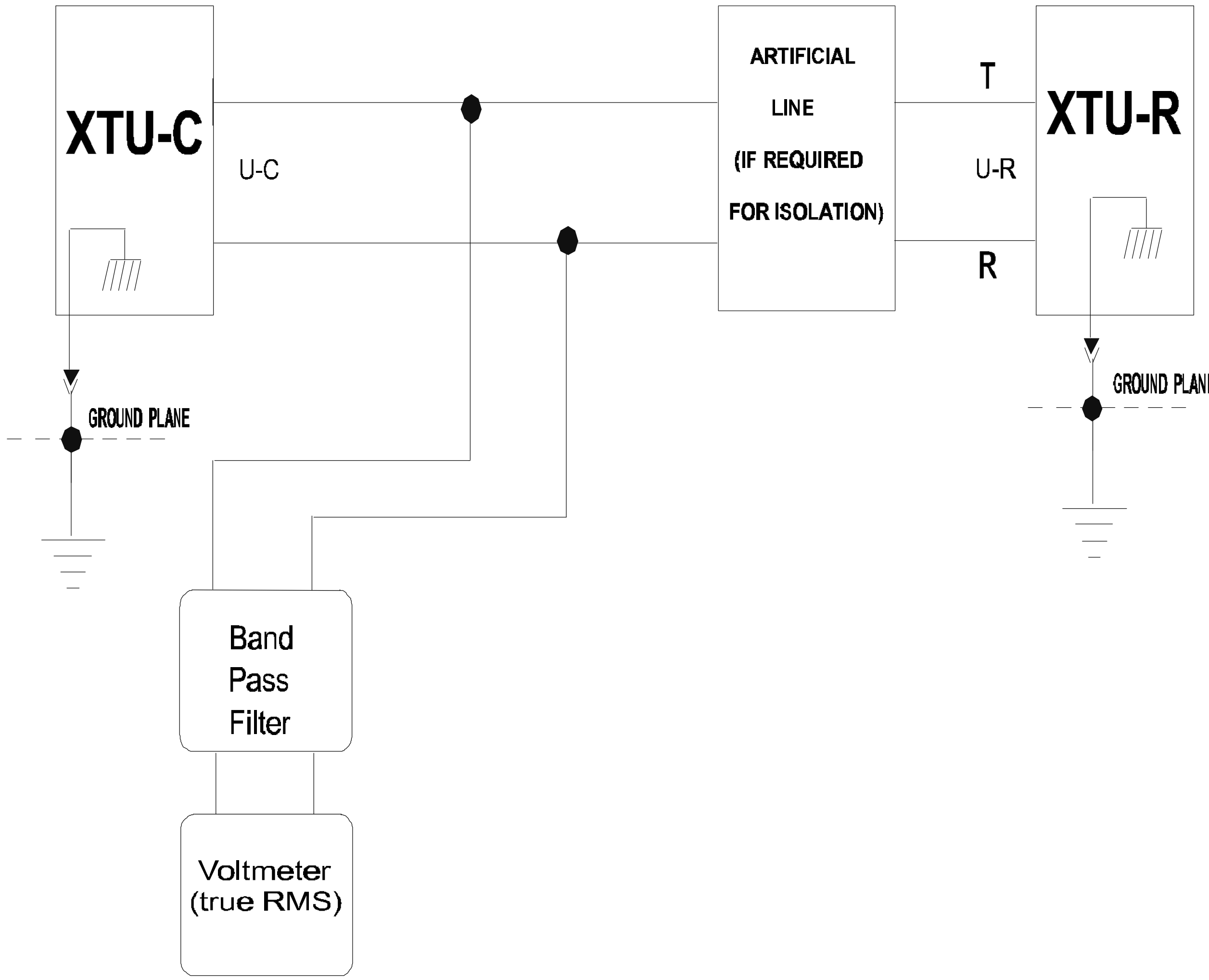
(10) Measure and record the total signal power for the downstream band using the test method given in section 3.3.2.1 steps (12).



BANDPASS FILTER: xTU-R BAND; ATTENUATION SLOPE =24 dB/OCTAVE; INSERTION LOSS 0dB ±0.5dB; INPUT IMPEDANCE= 0100 Kohm minimum in parallel with 50 pF maximum; OUTPUT IMPEDANCE=50 Ohm; HUM and NOISE=100 uVrms maximum.Note:When the Terminal Equipment makes provision for an external connection to ground(G),the Terminal Equipment shall be connected to ground. When the Terminal Equipment makes no provision for an external ground, the Terminal Equipment shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the Terminal Equipment. The Terminal Equipment shall be centrally located on the ground plane without anyadditional connection to ground.

The above is an illustrative test diagram. If the spectrum analyzer has an unbalanced input, an external differential amplifier or balun transformer should be used. Additional high pass filtering may also be necessary to increase measurement sensitivity when making low level PSD measurements.

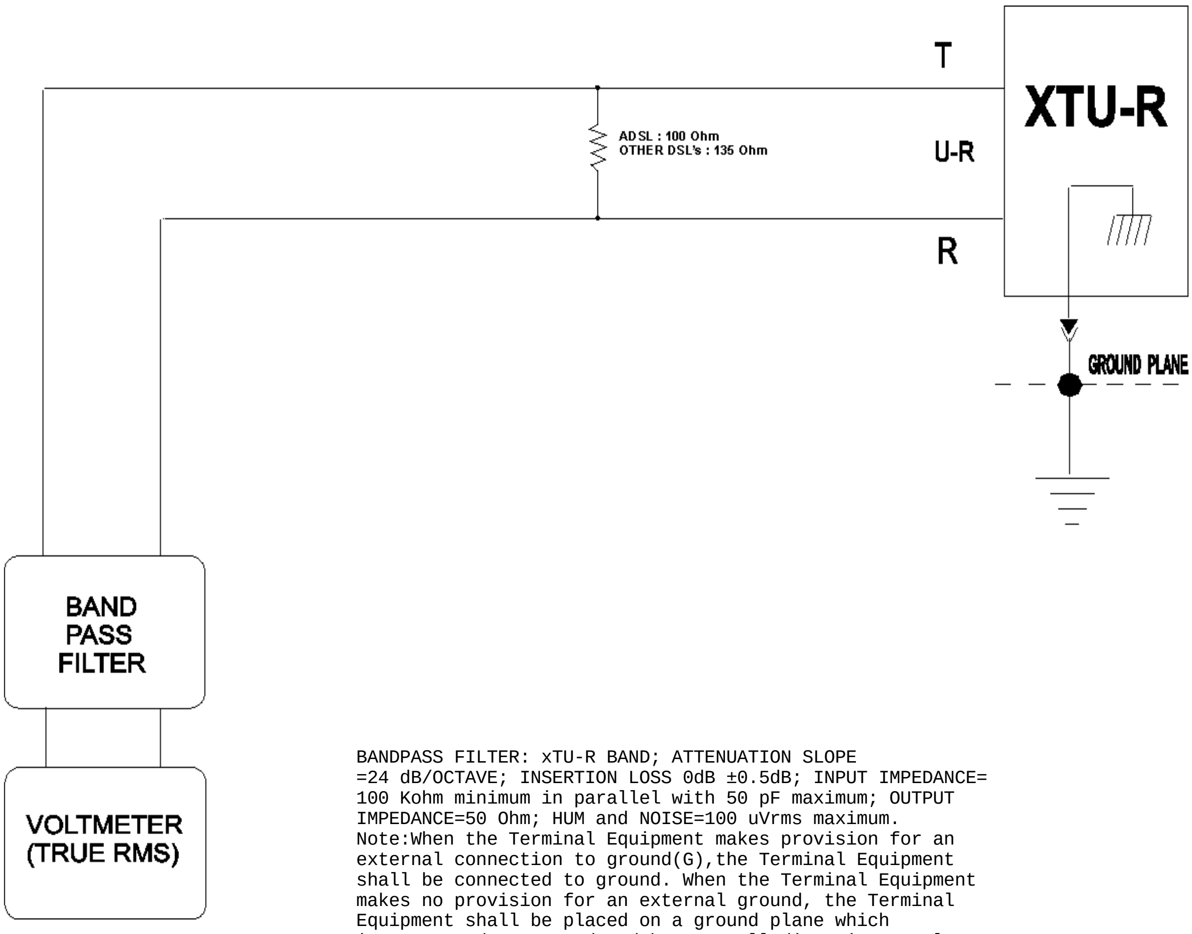
FIGURE 3.3.2(a)
xDSL Total Signal Power at the
U-R interface when tested with a companion unit
(xTU-R Band = Upstream transmitted signal for all DSL technologies)



BANDPASS FILTER: xTU-C BAND; ATTENUATION SLOPE =24 dB/OCTAVE; INSERTION LOSS 0dB ±0.5dB; INPUT IMPEDANCE= 00 Kohm minimum in parallel with 50 pF maximum; OUTPUT IMPEDANCE=50 Ohm; HUM and NOISE=100 uVrms maximum. Note:When the Terminal Equipment makes provision for an external connection to ground(G),the Terminal Equipment shall be connected to ground. When the Terminal Equipment makes no provision for an external ground, the Terminal Equipment shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the Terminal Equipment. The Terminal Equipment shall be centrally located on the ground plane without any additional connection to ground.

The above is an illustrative test diagram. If the spectrum analyzer has an unbalanced input, an external differential amplifier or balun transformer should be used. Additional high pass filtering may also be necessary o increase measurement sensitivity when making low level PSD measurements.

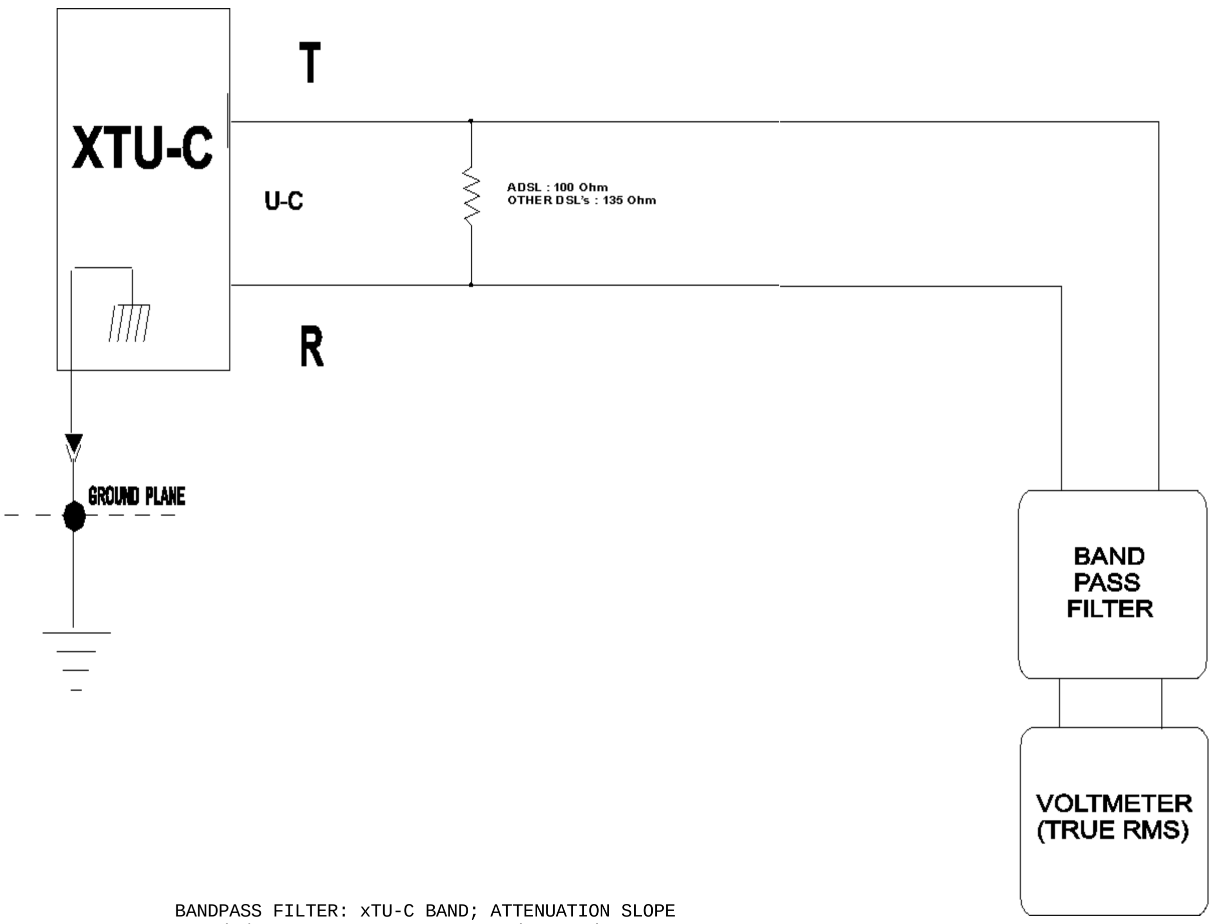
FIGURE 3.3.2(b)
xDSL Total Signal Power at the
U-C interface when tested with a companion unit
(xTU-C Band = Downstream transmitted signal for all DSL technologies)



BANDPASS FILTER: xTU-R BAND; ATTENUATION SLOPE =24 dB/OCTAVE; INSERTION LOSS 0dB ±0.5dB; INPUT IMPEDANCE= 100 Kohm minimum in parallel with 50 pF maximum; OUTPUT IMPEDANCE=50 Ohm; HUM and NOISE=100 uVrms maximum. Note:When the Terminal Equipment makes provision for an external connection to ground(G),the Terminal Equipment shall be connected to ground. When the Terminal Equipment makes no provision for an external ground, the Terminal Equipment shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the Terminal Equipment. The Terminal Equipment shall be centrally located on the ground plane without any additional connection to ground.

The above is an illustrative test diagram. If the spectrum analyzer has an unbalanced input, an external differential amplifier or balun transformer should be used. Additional high pass filtering may also be necessary to increase measurement sensitivity when making low level PSD measurements.

FIGURE 3.3.2(c)
xDSL Total Signal Power at the
U-R interface when tested without a companion unit
(xTU-R Band = Upstream transmitted signal for all DSL technologies)



BANDPASS FILTER: xTU-C BAND; ATTENUATION SLOPE =24 dB/OCTAVE; INSERTION LOSS 0dB ±0.5dB; INPUT IMPEDANCE= 100 Kohm minimum in parallel with 50 pF maximum; OUTPUT IMPEDANCE=50 Ohm; HUM and NOISE=100 uVrms maximum.
Note:When the Terminal Equipment makes provision for an external connection to ground(G),the Terminal Equipment shall be connected to ground. When the Terminal Equipment makes no provision for an external ground, the Terminal Equipment shall be placed on a ground plane which is connected to ground and has overall dimensions at least 50% greater than the corresponding dimensions of the Terminal Equipment. The Terminal Equipment shall be centrally located on the ground plane without any additional connection to ground.

The above is an illustrative test diagram. If the spectrum analyzer has an unbalanced input, an external differential amplifier or balun transformer should be used. Additional high pass filtering may also be necessary to increase measurement sensitivity when making low level PSD measurements.

FIGURE 3.3.2(d)
xDSL Total Signal Power at the
U-C interface when tested without a companion unit
(xTU-C Band = Downstream transmitted signal for all DSL technologies)

3.4 TRANSVERSE BALANCE

3.4.1 REQUIREMENT

The transverse balance of the TU-C and TU-R shall exceed the values in Table 3.4 (a) over the entire range of frequencies between the lower and upper - 20 dB points of the signal passband. See Table 3.4 (c) for the appropriate lower and upper - 20 dB points for each DSL types.
The actual - 20 dB points from the transmitted signal may also be used to define the frequency range. The transverse balance shall be measured over the applicable frequency range, using the procedures outline in Part VIII, Section 3.5, with the Z_L ,Z_M and V_M set to the values define in Table 3.4 (b)

NOTE: When using the actual - 20 dB points from the transmitted signal to define the frequency range, the T.E. shall be transmitting at maximum power.

Transverse balance is a comparison of the voltage of a transmitted metallic signal to the voltage of any resulting longitudinal signal. It is defined in dB as:

Transverse Balance $_{M - L}$ = 20 Log $_{10}$ $[V_M(f)/V_L(f)]$

where $V_M (f)$ = the metallic voltage at frequency f applied across tip and ring conductors of the port under test by a balanced source with metallic impedance Z_M , and $V_L\ (f)$ = the resultant longitudinal voltage appearing across a longitudinal impedance Z_L .
The greater the V_M to V_L ratio, the better the transverse balance of the transceiver unit and the less likelihood that it will contribute to a crosstalk interference problem.
When calibrating the testing arrangement, the source metallic voltage should equal V_M volts when a metallic termination of Z_M is substituted for the equipment under test. For all the different types of DSL, please refers to table 3.4(b) to find the correct values for metallic impedance Z_M , longitudinal impedance Z_L , and metallic voltage V_M .

3.4.2 METHOD OF MEASUREMENT

(1) Connect the TE as shown in Figure 3.4 (a).

(2) Set the spectrum analyser/tracking generator to sweep the appropriate frequency range. Refer to Table 3.4(a) for the frequency bands. If the actual - 20 dB points from the transmitted signal are used to define the frequency range, the T.E. shall be transmitting at maximum power.

(3) Adjust the tracking generator voltage to the appropriate value for the type of DSL under test, across the calibration test resistor R3, using switch S1. Refer to Table 3.4(b) for the correct values.

(4) Connect the detector across resistor R2.

(5) Adjust the Differential trimmer capacitor until a minimum voltage across resistor R2 is obtained. This represents the highest degree to which the bridge can be balanced, this balance measurement must be at least 20 dB better than the requirement for the applicable frequency band. If this degree of balance cannot be attained, further attention should be given to the component selection and the construction of the test circuit.

(6) Reverse the polarity using switch, S3. If the longitudinal voltage (E_L) changes by less than 1 dB, the calibration is acceptable. If the longitudinal voltage changes by more than 1 dB it indicates the bridge needs further adjustment to be sufficiently balanced to accurately measure the TE. Repeat the calibration process until the measurements differ by less than 1 dB while maintaining the 20 dB minimum balance noted in step (5) above.

(7) Replace the calibration resistor with the TE, using switch S1 and S2.

(8) Measure the voltage across the tip and ring of the TE.
This is the metallic reference voltage (E_M).

(9) Measure the voltage across resistor R2. This is the longitudinal voltage (E_L).

(10) Calculate the balance using the following formula:

Balance M/L (dB) = 20 log10 (Vm/Vl)

NOTES:

(1) If the readings are taken in dBV, then the equation can be simplified to the following:
Balance M/L (dB) = Vm(dBV) - Vl (dBV)

(2) TE which is not normally grounded should be set in its normal at rest position directly on a grounded plane whose overall dimensions are at least 50% greater than the footprint of the TE. From a transverse balance standpoint, this represents a worst case condition, i.e., the closest proximity to ground is likely to be encountered by the TE.

(3) Transverse balance may be measured while the T.E. is line powered or locally powered. If the T.E. is line powered then the test circuit shall contain a dc voltage source. In such applications, if the T.E. is a TU-C the test shall be performed with TU-C line power activated and an appropriate dc current sink (with high ac impedance) attached to the test circuit. If the T.E. is a TU-R, the test shall be performed with the appropriate dc voltage source applied between the tip and ring conductors through an ac blocking impedance. The dc current source or sink must present high impedance (at signal frequencies) to common ground. In line powered applications, the test circuit shall contain provisions for isolation of the measurement instrumentation from unintentional circuit paths through the common ground of the instrumentation and the T.E. power feed circuitry.

Table 3.4 (a)
Minimum Transverse Balance Requirements

Frequency Band	Minimum Transverse Balance
200 Hz < f $\leq$ 12 kHz	40dB
12kHz < f $\leq$ 1544 kHz	35 dB
1544 kHz < f $\leq$ 3000 kHz	30 dB

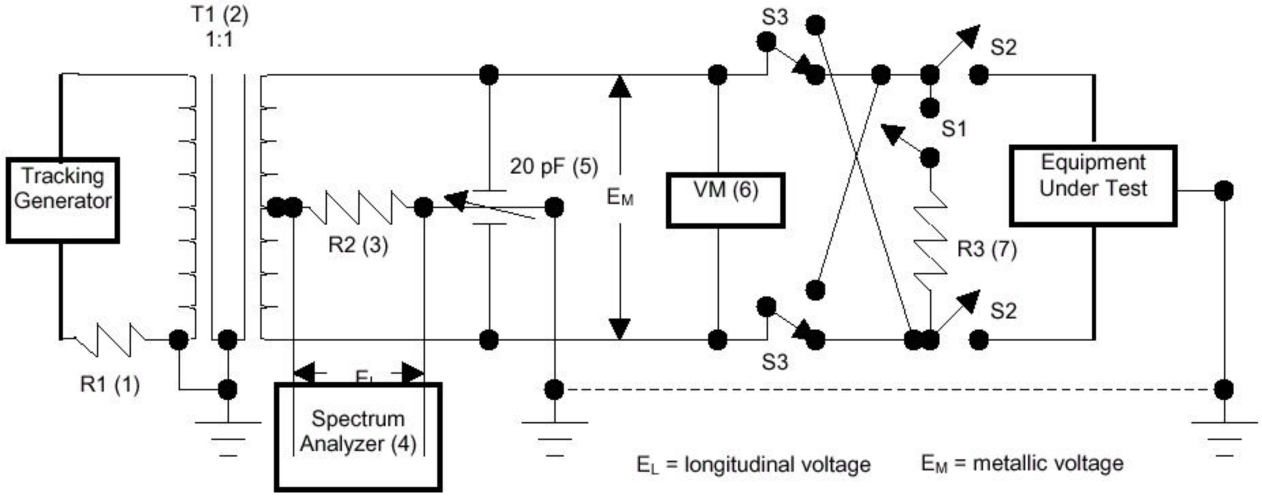
Table 3.4 (b)
Transverse Balance Testing Criteria

	ADSL	All Other xDSLs
Z_L (Ohms)	90 (1)	500/90 (1)
Z_M (Ohms)	100	135
V_M (volts)	0.316	0.367

Note 1: The longitudinal impedance (Z_L) shall be 500 Ohms for frequencies from 200 Hz to 12 kHz, and 90 Ohms for frequencies above 12 kHz.

Table 3.4 (c)
- 20 dB points for all DSL types

DSL type	- 20 dB points (kHz)			
	Lower		Upper	
	TU-C	TU-R	TU-C	TU-R
ADSL	13.1	13.6	1622.6	184.2
SDSL ≤ 288 kbps	0		113.9	
288 kbps < SDSL ≤ 528 kbps	0		206	
528 kbps < SDSL ≤ 784 kbps	0		310	
784 kbps < SDSL ≤ 1168 kbps	0		446.2	
1168 kbps < SDSL ≤ 1568 kbps	0		595.2	
1568 kbps < SDSL ≤ 2320 kbps	0		Use equation in 3.2.1.4	
HDSL (CAP)	0		595.2	
HDSL (2B1Q)	0		310	
HDSL2	0	0	422.1	284.7
SHDSL	0		Use equation in 3.2.1.8	
HDSL4	0	0	493.6	176.9



1- Combined resistance of R1 and tracking generator output resistance shall equal T.E. impedance (100 or 135 Ohms).
2- Use center-tapped 1:1 transformer (e.g., Midcom 671-5767 or equivalent).
3- R2 provides the desired longitudinal impedance using 90 Ohms or 500 Ohms metal film or other non-inductive resistor.
4- High impedance spectrum analyzer or frequency selective voltmeter. It may be unbalanced.
5- Differential trimmer capacitor, 2.4 to 24.5 pF, Johnson 189-0759-005 or equivalent.
6- Any high impedance balanced or floating voltmeter with adequate frequency response. It need not be frequency selective.
7- R3 provides the desired calibration impedance. Should be a 100 or 135 Ohms metal film or other non-inductive resistor.

Figure 3.4(a)
Illustrative test configuration for transverse balance conformance testing

3.5 LONGITUDINAL OUTPUT VOLTAGE

Compliance with the limits for each DSL type is required with a longitudinal termination having an impedance equal to or greater than a 100 Ohms resistor in series with a 0.15 :F capacitor. The longitudinal output voltage in all 4 kHz frequency bands averaged over a minimum period of 1 second shall not exceed the values in Table 3.5 (a) over the indicated range of frequencies between the lower and upper -30 dB points (relative to peak PSD) of the signal passband as determined from the appropriate PSD mask for the DSL type. See Table 3.5 (b) for the appropriate lower, upper, and 4x upper -30 dB points for each DSL types. The actual - 30 dB points from the transmitted signal may also be used to define the frequency range. There is no requirement for frequencies below the operating band. An illustrative test configuration is shown in Figure 3.5 (a). The metallic test impedance Z_M is defined in Table 3.4 (b). For direct use of the test configuration, the near end transmitter shall be able to generate a signal in the absence of the far end transceiver. The ground reference for these measurements shall be the building ground or green-wire ground of the T.E.

NOTE: When using the actual - 30 dB points from the transmitted signal to define the frequency range, the T.E. shall be transmitting at maximum power.

3.5.2 METHOD OF MEASUREMENT

(1) Connect the TE as shown in Figure 3.5 (a).

(2) Set the spectrum analyzer to sweep the appropriate frequency range for the operating band of the DSL system tested. Refer to Table 3.5(b) for the frequency bands or use the actual - 30 dB points from the transmitted signal to set the frequency bands. If the actual - 30 dB points from the transmitted signal are used to set the frequency bands, the T.E. shall be transmitting at maximum power.

(3) Measure and record the true rms longitudinal voltage in all 4 kHz frequency bands, averaged over a minimum period of 1 second . An alternative resolution bandwith of 3 kHz may be used provided that either the limits are reduced by 1.3 dB (to -51.3 dBV or -81.3 dBV) or the readings are corrected by adding 1.3 dB.

(4) Compare the values obtained in step (4) with the limits of Table 3.5(a).

(5) Set the spectrum analyzer to sweep the appropriate frequency range for the Out-of-band region of the DSL system tested. Refer to Table 3.5(a) for the frequency bands or use the actual - 30 dB points from the transmitted signal to set the frequency bands. If the actual - 30 dB points from the transmitted signal are used to set the frequency bands, the T.E. shall be transmitting at maximum power.

(6) Repeat steps (3) and (4) for the Out-of-band frequency range.

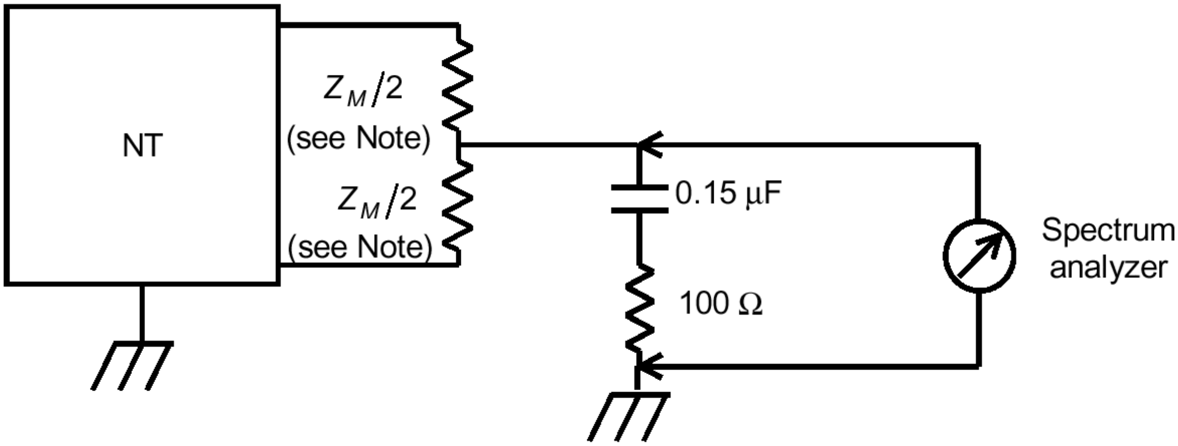
Table 3.5 (a) Maximum Longitudinal output voltage limit

Applicable Frequency Range	**Maximum Longitudinal Output Voltage (rms) in all 4 kHz Frequency Bands averaged over 1 second**
Operating Band	-50 dBV
From upper -30dB (relative to peak PSD) Frequency to 4 x the upper -30dB Frequency	-80 dBV

Table 3.5 (b)
- 30 dB points for all DSL types

DSL type	**- 30 dB points (kHz)**					
	Lower		**Upper**		**4x upper**	
	TU-C	TU-R	TU-C	TU-R	TU-C	TU-R
ADSL	9.4	9.9	1967.1	212.8	7868.4	851.2
SDSL ≤ 288 kbps	0		178.6		714.4	
288 kbps < SDSL ≤ 528 kbps	0		234.3		937.1	
528 kbps < SDSL ≤ 784 kbps	0		347.5		1390	
784 kbps < SDSL ≤ 1168 kbps	0		516.7		2066.7	
1168 kbps < SDSL ≤ 1568 kbps	0		701		2804	
1568 kbps < SDSL ≤ 2320 kbps	0		Use equation in 3.2.1.4		Use equation in 3.2.1.4	
HDSL (CAP)	0		701		2804	
HDSL (2B1Q)	0		347.5		1390	
HDSL2	0	0	436.4	291.3	1745.7	1165.3
SHDSL	0		Use equation in 3.2.1.8		Use equation in 3.2.1.8	

HDSL4	0	0	578.7	208.1	2314.9	832.4



NOTE : - These resistors to be matched better than 0.1% tolerance

Figure 3.5 (a) Measurement method for longitudinal voltage

Annex A
(NORMATIVE)
HIGH VOLTAGE REQUIREMENT

A.1 INTRODUCTION

The TU-C units of some types of DSL equipment apply span-powering voltages to the telecommunications loop facilities (cable pairs) to provide remote powering of network based repeaters or TU-R units. This section defines requirements on the maximum voltage, current and power levels to protect personnel and network equipment from harm.

A.2 REQUIREMENTS

A.2.1 APPLIED VOLTAGES AND CURRENTS

The steady state open circuit voltage from each conductor to ground shall not exceed:

±140 volts d.c., or ±200 volts d.c. if the current to ground is limited to 10 mA.

The maximum steady state current on the loop shall not exceed 1.3 A

A.2.2 POWER LIMIT

The maximum power applied to the loop shall not exceed 100 volt-amperes (100 watts) after 1 second.

A.3 METHOD OF MEASUREMENT

(1) Measure and record voltage from tip to ground and ring to ground.

(2) Measure and record the maximum loop current by connecting the tip and ring connectors together (0 Ohm loop) using a 16 AWG wire or larger.
The maximum current shall be 1.3A or less after 60 seconds.

(3) Measure and record the maximum output wattage by connecting a variable resistor of 2500 Ohms between tip and ring connectors.
The power shall not exceed 100 watts with resistor set to any value from 0 – 2500 Ohms.

(4) If the voltage between tip or ring to ground exceeds 140 volts, go to step (5).

(5) Measure and record the current to ground by connecting a 5000 Ohms resistor between tip/ring and ground. The current to ground shall not exceed 10mA after 200 ms.

Annex B

INFORMATIVE REFERENCES

[1] T1.417 - 2001 : Spectrum Management for Loop Transmission Systems

[2] ITU-T Recommendation K.50

[3] T1 TRQ - XX : Technical Requirements for Maximum Voltage, Current and Power Levels for Network-Powered Transport Systems.

[4] CAN/CSA-C22.2 NO. 60950-00: Safety of Information Technology Equipment