Terminal Attachment Programme

Provisional Requirements and Test Methods for Asymmetrical Digital Subscriber Line (ADSL) Terminal Equipment

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# Table of Contents

## 1.0 Introduction

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Scope</td>
<td>1</td>
</tr>
<tr>
<td>1.2 Technical Requirements</td>
<td>1</td>
</tr>
<tr>
<td>1.2.1 Technical Requirements Table</td>
<td>1</td>
</tr>
<tr>
<td>1.3 Sequence of Equipment Testing</td>
<td>3</td>
</tr>
<tr>
<td>1.3.1 Overall Sequence</td>
<td>3</td>
</tr>
<tr>
<td>1.4 Connecting Arrangements</td>
<td>3</td>
</tr>
<tr>
<td>1.5 Operational Check</td>
<td>4</td>
</tr>
</tbody>
</table>

## 2.0 Electrical and Mechanical Stresses

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
</table>

## 3.0 Network Protection Requirements and Tests

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Laboratory Environment</td>
<td>4</td>
</tr>
<tr>
<td>3.2 Transmitted Spectral Response</td>
<td>4</td>
</tr>
<tr>
<td>3.2.1 Requirement</td>
<td>4</td>
</tr>
<tr>
<td>3.2.1.1 Power Spectral Density at the U-C Interface</td>
<td>4</td>
</tr>
<tr>
<td>3.2.1.2 Power Spectral Density at the U-R Interface</td>
<td>4</td>
</tr>
<tr>
<td>3.2.2 Method of Measurement</td>
<td>5</td>
</tr>
<tr>
<td>3.2.2.1 Method of Measurement (when tested with a companion unit)</td>
<td>5</td>
</tr>
<tr>
<td>3.2.2.2 Alternative Method of Measurement (when tested without a</td>
<td>5</td>
</tr>
<tr>
<td>companion unit)</td>
<td></td>
</tr>
<tr>
<td>3.3 Total Signal Power</td>
<td>12</td>
</tr>
<tr>
<td>3.3.1 Requirement</td>
<td>12</td>
</tr>
<tr>
<td>3.3.1.1 ADSL[DMT] Total Signal Power at the U-R and U-C Interface Point</td>
<td>12</td>
</tr>
<tr>
<td>3.3.1.2 ADSL[CAP/QAM] Total Signal Power at the U-R and U-C Interface Point</td>
<td>12</td>
</tr>
<tr>
<td>3.3.2 Method of Measurement for ADSL[DMT]</td>
<td>13</td>
</tr>
<tr>
<td>3.3.2.1 Method of Measurement for ADSL[DMT] (when tested with a companion unit)</td>
<td>13</td>
</tr>
<tr>
<td>3.3.2.2 Alternative Method of Measurement for ADSL[DMT] (when tested without a companion unit)</td>
<td>14</td>
</tr>
<tr>
<td>3.3.3 Method of Measurement for ADSL[CAP/QAM]</td>
<td>15</td>
</tr>
<tr>
<td>3.3.3.1 Method of Measurement for ADSL[CAP/QAM] (when tested with a companion unit)</td>
<td>15</td>
</tr>
<tr>
<td>3.3.3.2 Alternative Method of Measurement for ADSL[CAP/QAM] (when tested without a companion unit)</td>
<td>16</td>
</tr>
<tr>
<td>3.4 Metallic Channel Longitudinal Voltage</td>
<td>21</td>
</tr>
<tr>
<td>3.5 Transverse Balance</td>
<td>21</td>
</tr>
</tbody>
</table>
1.0 Introduction

1.1 Scope

This provisional document sets forth the minimum network protection requirements for the certification of Asymmetrical Digital Subscriber Line using Discrete Multi-tone Technology (ADSL[DMT]) and of Asymmetrical Digital Subscriber Line using either Carrierless Amplitude Phase Modulation (ADSL[CAP]) or Quadrature Amplitude Modulation technology (ADSL[QAM]) terminal equipment (TE). Such terminal equipment is intended for connection to a metallic channel subscriber loop. Transmission of both voice telephone and data occurs on the same cable pair. Asymmetric transmission provides a high bit rate downstream (toward the subscriber) and a lower bit rate upstream (toward the central office). Refer to Figure 1.1 for the ADSL Functional Reference model.

These ADSL requirements are provisional until November 15, 1999 to allow for their finalization. The incorporation of the final requirements into CS-03 (possibly in a new Part VIII) will be based on comments received and experience gained.

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.

**Note:** The telephony interface at the ATU-C end, at the Output of the Pots Splitter, should be tested for compliance according to the applicable sections of CS-03 (e.g. loop start interface requirements, if applicable).
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
Technical Requirements Table A

Network Protection Requirements for Connection of Pots and Data Terminal Equipment to ADSL Facilities at the "U-C" or "U-R" Interface Point

<table>
<thead>
<tr>
<th>Section</th>
<th>Requirement</th>
<th>Interfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>Electrical and Mechanical Stresses</td>
<td>*</td>
</tr>
<tr>
<td>3.2</td>
<td>Transmitted Spectral Response</td>
<td>*</td>
</tr>
<tr>
<td>3.3</td>
<td>Total Signal Power</td>
<td>*</td>
</tr>
<tr>
<td>3.4</td>
<td>Metallic Channel Longitudinal Voltage</td>
<td>*</td>
</tr>
<tr>
<td>3.5</td>
<td>Transverse Balance</td>
<td>*</td>
</tr>
</tbody>
</table>

* 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 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 Network Protection Requirements and Tests

1.4 Connecting Arrangements

Connecting arrangements for ADSL terminal equipment intended for direct electrical connection are described in Part III of CS-03, Section 10.
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. When the operational checks are repeated after the electrical stress of Section 2, it is permissible that the TE be partially or fully inoperable.

2.0 Electrical and Mechanical Stresses

The technical requirements and methods of application for electrical and mechanical stresses are given in Part I of CS-03, Section 2.

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

The Power Spectral Density (PSD) Mask for the downstream channel (ATU-C output) shall have an upper limit of \(-40\ \text{dBm/Hz}\) nominal with no variation exceeding \(-37\ \text{dBm/Hz}\) at any points in the band pass region. Refer to figure 3.2(A).

3.2.1.2 Power Spectral Density at the U-R Interface

The Power Spectral Density (PSD) Mask for the upstream channel (ATU-R output) shall have an upper limit of \(-38\ \text{dBm/Hz}\) nominal with no variation exceeding \(-35\ \text{dBm/Hz}\) at any points in the band pass region. Refer to figure 3.2(B).
3.2.2 Method of Measurement

3.2.2.1 Method of Measurement (when tested with a companion unit)

1. Connect the ADSL equipment as shown in figure 3.2(C).

2. Use an artificial line to force the ADSL equipment to transmit at maximum power.

3. Set the spectrum analyser to capture the upstream band with a suggested resolution bandwidth of 1 kHz and video bandwidth of 100 Hz.

4. Select the highest peak in the band pass region and take a measurement in dBm/Hz, using a reference impedance of 100 ohms.

5. Connect the ADSL equipment as shown in figure 3.2(D) and repeat steps (2) to (4) for the downstream band.

3.2.2.2 Alternative Method of Measurement (when tested without a companion unit)

1. Connect the ADSL equipment as shown in figure 3.2(E).

2. Operate the ADSL equipment (ATU-R working without ATU-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) and (4).

4. Connect the ADSL equipment as shown in figure 3.2(F).

5. Operate the ADSL equipment (ATU-C working without ATU-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) and (4).
Provisional Requirements and Test Methods for Asymmetrical Digital Subscriber Line (ADSL) Terminal Equipment

Downstream Transmit Signal

Legend:

- $f_1$ = Lower stop band frequency
- $f_2$ = Lower nominal 3 dB frequency
- $f_3$ = Lower pass band region limit
- $f_4$ = Upper pass band region limit
- $f_5$ = Upper nominal 3 dB frequency
- $f_6$ = Upper stop band frequency

Figure 3.2(A)
Provisional Requirements and Test Methods for
Asymmetrical Digital Subscriber Line (ADSL) Terminal Equipment

Upstream Transmit Signal

Legend:

f1 = Lower stop frequency
f2 = Lower nominal 3 dB frequency
f3 = Lower pass band region limit
f4 = Upper pass band region limit
f5 = Upper nominal 3 dB frequency
f6 = Upper stop band frequency

Figure 3.2 (B)
Figure 3.2(C)

ADSL Power Spectral Density (ATU-R Band)
when tested with a companion unit

Note: When the Terminal Equipment provides 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.
Figure 3.2(D)

ADSL Power Spectral Density (ATU-C Band) when tested with a companion unit

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.
Provisional Requirements and Test Methods for
Asymmetrical Digital Subscriber Line (ADSL) Terminal Equipment

Figure 3.2(E)

ADSL Power Spectral Density (ATU-R Band)
when tested without a companion unit

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.
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.

Figure 3.2(F)

ADSL Power Spectral Density (ATU-C Band)
when tested without a companion unit
3.3 Total Signal Power

3.3.1 Requirement

3.3.1.1 ADSL[DMT] Total Signal Power at the U-R and U-C Interface Points

Total signal power for upstream or downstream is dependent on the number of sub-carriers present in the band (where each sub-carrier has a 4.3125 kHz bandwidth). The total signal power shall not exceed the limit imposed by the following equation:

(A) \[ \text{TOTAL SIGNAL POWER (U-R)} = -2 + 10 \log (\text{NCup}) \]

(B) \[ \text{TOTAL SIGNAL POWER (U-C)} = -4 + 10 \log (\text{NCdown}) \]

Where total signal power is expressed in dBm, NCup is the number of sub-carriers present in the upstream band, NCdown is the number of sub-carriers present in the downstream band, and termination impedance is 100 Ohms.

Note: NCup or NCdown = 3 dB Bandwidth
\[ 4.3125 \text{ kHz} \]

3.3.1.2 ADSL[CAP/QAM] Total Signal Power at the U-R and U-C Interface Points

Total signal power in the passband (upstream/downstream) is dependent on the baud rate and shall not exceed the limit imposed by the following equation:

(A) \[ \text{TOTAL SIGNAL POWER (U-R)} = -38 \text{ dBm/Hz} + 10 \log \text{ (Baud Rate)} \]

(B) \[ \text{TOTAL SIGNAL POWER (U-C)} = -40 \text{ dBm/Hz} + 10 \log \text{ (Baud Rate)} \]

Where total signal power is expressed in dBm, baud rate is equal to the 3 dB bandwidth of the transmit signal in Hz, and termination impedance is 100 Ohms.

Note: The baud rate used in the above formulas is not necessarily the user payload or data rates that are listed in the manufacturer’s specification sheet.
3.3.2 Method of Measurement for ADSL[DMT]

3.3.2.1 Method of Measurement for ADSL[DMT] (when tested with companion unit)

(1) Connect the ADSL equipment as shown in figure 3.2(C).

(2) Set the spectrum analyser 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) Divide the 3 dB bandwidth by 4.3125 kHz. The result is the number of sub-carriers (NCup) used by ATU-R.

(5) Connect the ADSL equipment as shown in figure 3.2(D).

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

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

(8) Divide the 3 dB bandwidth by 4.3125 kHz. The result is the number of sub-carriers (NCdown) used by ATU-C.

(9) Connect the ADSL equipment as shown in figure 3.3(A).

(10) Use an artificial line to force the ADSL equipment to transmit at maximum power.

(11) Use the appropriate band pass filter for ATU-R (upstream lower and upper 3 dB points). Measure and record the total signal power in dBm with a termination impedance of 100 Ohms.

(12) Compare the measured power to the limit imposed by the equation (A) in 3.3.1.1 ADSL[DMT] Total Signal Power (U-R).

(13) Connect the ADSL equipment as shown in figure 3.3(B).

(14) Use an artificial line to force the ADSL equipment to transmit at maximum power.
(15) Use the appropriate band pass filter for ATU-C (downstream lower and upper 3 dB Point). Measure and record the total signal power in dBm with a termination impedance of 100 Ohms.

(16) Compare the measured power to the limit imposed by the equation (B) in 3.3.1.1 ADSL[DMT] Total Signal Power (U-C).

3.3.2.2 Alternative Method of Measurement for ADSL[DMT] (when tested without a companion unit)

(1) Connect the ADSL equipment as shown in figure 3.2(E).

(2) Measure and record the number of sub-carriers (NCup) used by ATU-R, using the test method given in section 3.3.2.1 steps (2) to (4).

(3) Connect the ADSL equipment as shown in figure 3.2(F).

(4) Measure and record the number of sub-carriers (NCdown) used by ATU-C, using the test method given in section 3.3.2.1 steps (6) to (8).

(5) Connect the ADSL equipment as shown in figure 3.3(C).

(6) Operate the ADSL equipment (ATU-R working without ATU-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 (11) and (12).

(8) Connect the ADSL equipment as shown in figure 3.3(D).

(9) Operate the ADSL equipment (ATU-C working without ATU-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 (15) and (16).
3.3.3 Method of Measurement for ADSL[CAP/QAM]

3.3.3.1 Method of Measurement for ADSL[CAP/QAM] (when tested with a companion unit)

(1) Connect the ADSL equipment as shown in figure 3.2(C).

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

(3) Measure and record the 3 dB roll off points from the nominal level within the passband.

(4) The 3 dB bandwidth (in Hz) is measured to confirm the manufacturer’s specified baud rate for ATU-R (used to calculate the total signal power) and also to establish the start and stop frequencies for total signal power.

(5) Connect the ADSL equipment as shown in figure 3.2(D).

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

(7) Measure and record the 3 dB roll off points from the nominal level within the passband.

(8) The 3 dB bandwidth (in Hz) is measured to confirm the manufacturer’s specified baud rate for ATU-C (used to calculate the total signal power) and also to establish the start and stop frequencies for total signal power.

(9) Connect the ADSL equipment as shown in figure 3.3(A).

(10) Use an artificial line to force the ADSL equipment to transmit at maximum power.

(11) Use the appropriate band pass filter for the upstream band (3 dB points). Measure and record the total signal power in dBm with a termination impedance of 100 Ohms.

(12) Compare the measured power to the limit imposed by the equation (A) in 3.3.1.2 ADSL[CAP/QAM] Total Signal Power (U-R).
(13) Connect the ADSL equipment as shown in figure 3.3(B).

(14) Use an artificial line to force the ADSL equipment to transmit at maximum power.

(15) Use the appropriate band pass filter for the downstream band (3 dB points). Measure and record the total signal power in dBm with a termination impedance of 100 Ohms.

(16) Compare the measured power to the limit imposed by the equation (B) in 3.3.1.2 ADSL[CAP/QAM] Total Signal Power (U-C).

3.3.3.2 Alternative Method of Measurement for ADSL[CAP/QAM] (when tested without a companion unit)

(1) Connect the ADSL equipment as shown in figure 3.2(E).

(2) Measure and record the baud rate for the upstream band using the test method given in section 3.3.3.1 steps (2) to (4).

(3) Connect the ADSL equipment as shown in figure 3.2(F).

(4) Measure and record the baud rate for the downstream band using the test method given in section 3.3.3.1 steps (6) to (8).

(5) Connect the ADSL equipment as shown in figure 3.3(C).

(6) Operate the ADSL equipment (ATU-R working without ATU-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 3.3.3.1 steps (11) and (12).

(8) Connect the ADSL equipment as shown in figure 3.3(D).

(9) Operate the ADSL equipment (ATU-C working without ATU-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 3.3.3.1 steps (15) and (16).
BANDPASS FILTER: ATU-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.

Figure 3.3(A)

ADSL Total Signal Power (ATU-R BAND)
when tested with a companion unit
BANDPASS FILTER: ATU-C BAND; ATTENUATION SLOPE = 24 dB/OCTAVE; INSERTION LOSS 0dB ±0.5 dB; 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.

Figure 3.3(B)

ADSL Total Signal Power (ATU-C Band)
when tested with a companion unit
BANDPASS FILTER: ATU-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.

Figure 3.3(C)

ADSL Total Signal Power (ATU-R band)
when tested without a companion unit
BANDPASS FILTER: ATU-C BAND; ATTENUATION SLOPE = 24 dB/OCTAVE; INSERTION LOSS 0 dB ±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.

Figure 3.3(D)

ADSL Total Signal Power (ATU-C Band) when tested without a companion unit
3.4 Metallic Channel Longitudinal Voltage

The technical requirements and methods of measurement for Metallic Channel Longitudinal Voltage are given in Part I of CS-03, Section 3.3.4.

3.5 Transverse Balance

The technical requirements and methods of measurement for Transverse Balance are given in Part VI of CS-03, Section 3.4.