

ANNEX 3B.2

SPECTRAL COMPATIBILITY OF XDSL SYSTEMS PLAN

1. Scope

- 1.1 This Annex (the “Spectral Compatibility of xDSL Systems Plan”) forms part of Schedule 3B of SingTel’s Reference Interconnection Offer (RIO), which specifies the terms and conditions with which Requesting Licensee must comply for SingTel to provide them with Line Sharing.
- 1.2 As the only currently available xDSL loop transmission technology which allows Line Sharing is Asymmetric Digital Subscriber Line (ADSL) technology, this Annex focuses exclusively on the ADSL loop transmission system. This Annex does not address other DSL technologies including ISDN, HDSL or VDSL. SingTel will review this Annex periodically to determine whether further DSL technologies can be used for Line Sharing as well as ADSL, and to amend the plan to provide for such other technologies.
- 1.3 This Annex covers the technical requirements for Requesting Licensee Equipment and Customer Premise Equipment (CPE) for Line Sharing purposes, and the relevant test requirements.
- 1.4 The Annex is intended to minimize the risk of possible Cross-talk interference with existing loop transmission systems and services located in other cable pairs within the same cable sheath as the line being shared. Such undesirable Cross-talk interference could cause unacceptable degradation of performance of the existing loop transmission system and/or services in the SingTel network.
- 1.5 This Annex does not guarantee system performance for any Requesting Licensee’s deployed system.
- 1.6 Spectrum management and spectrum compatibility is a new area which many telecommunications authorities have been studying and working in to develop industry standards. This Annex is therefore subject to periodic review by SingTel, taking these considerations into account.

2. Line Sharing Network Reference Configurations

- 2.1 There are two possible Line Sharing configurations.
- 2.2 Figure 1 depicts Configuration 1 in which the Requesting Licensee uses SingTel's local loop between the local exchange and the customer.
- 2.3 Figure 2 depicts Configuration 2 in which the Requesting Licensee uses SingTel's local loop between the local MDF room and the customer.

ADSL Line Sharing - Network Configuration 1

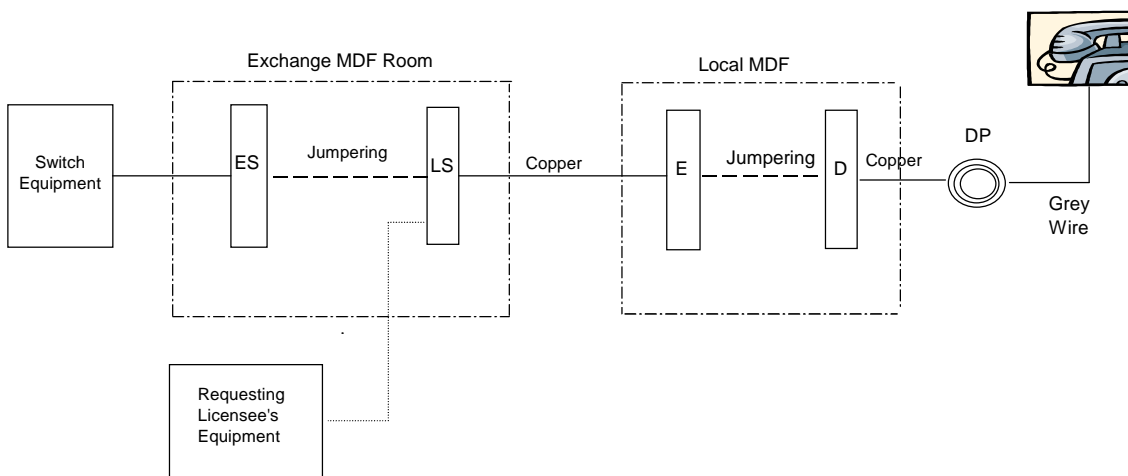
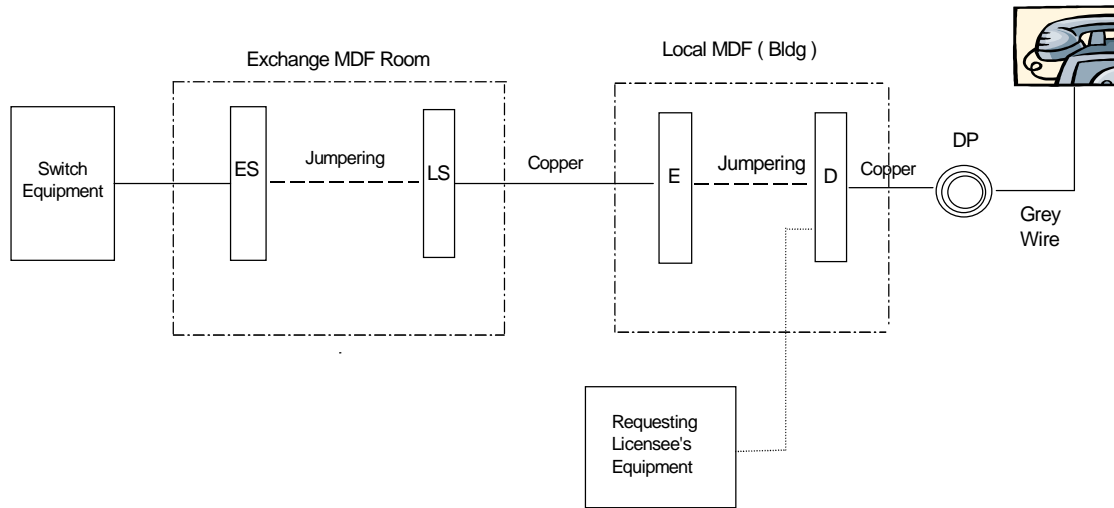


Figure 1

ADSL Line Sharing - Network Configuration 2



Note: POTS could also be provided through fibre-based DLC system which is located in local MDF

Figure 2

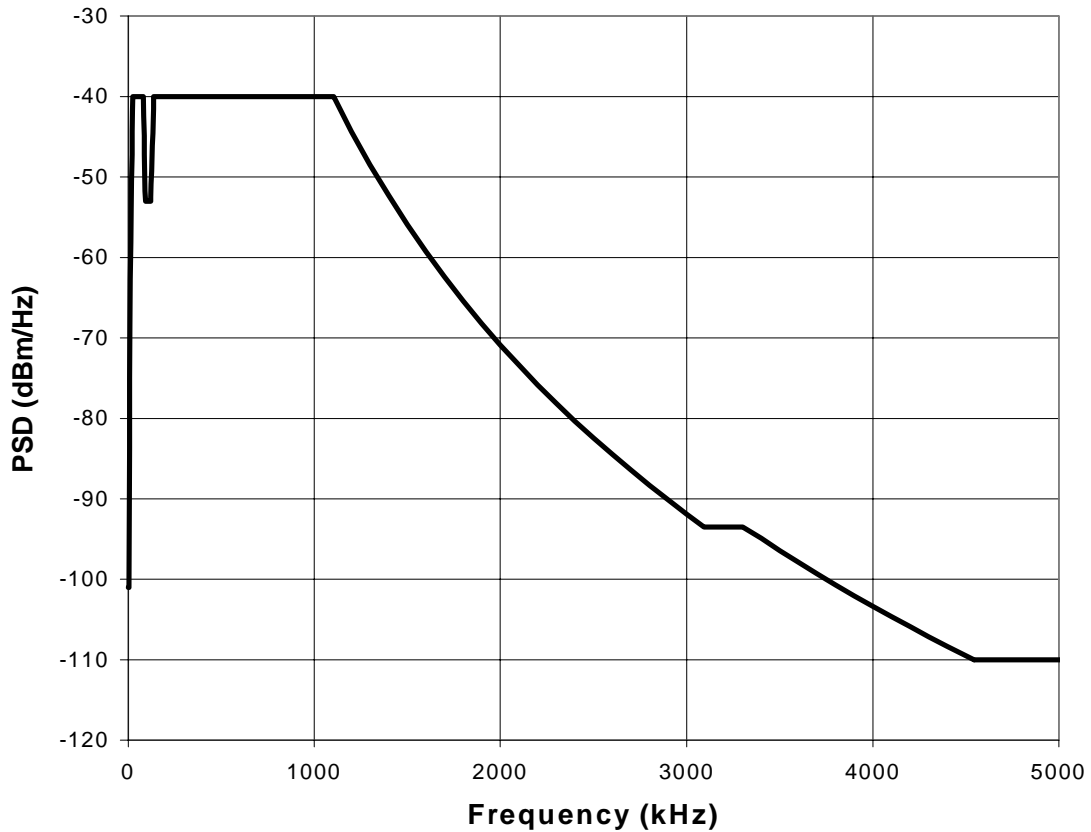
3. **Cross-Talk information (extract from ANSI T1E1.4/2000, Spectrum Management Draft Standard)**
 - 3.1 The electromagnetic energy that couples into a metallic cable pair from services and transmission system technologies in use on other pairs in the same cable unit is unwanted energy, and is called “Cross-talk noise” (“**Cross-talk**”).
 - 3.2 Cross-talk is sensitive to frequency, signal strength, and exposure. High frequency energy couples into other pairs more easily than low frequency energy because as the signal frequency increases, the Cross-talk coupling loss between the pairs of a cable decreases. Hence, for two signals of equal strength, the higher the frequency, the greater the Cross-talk noise which is produced.
 - 3.3 A strong signal will therefore transfer more power into other pairs than a weaker signal will. The amount of Cross-talk noise is directly proportional to the power of the disturbing signal. The stronger the signal, the greater the Cross-talk noise.
 - 3.4 Exposure is a measure of the proximity of metallic pairs at various points along a cable and the length over which pairs are in close proximity. The greater the exposure, the greater the total Cross-talk noise.

4. **Performance Requirement For Requesting Licensee's Equipment For Line Sharing**
- 4.1 As strong signals create more Cross-talk noise than weaker signals, the most effective and widely used method of controlling Cross-talk interference is through the use of Signal Power Limitation. Signal Power Limitations specify the amplitude, frequency distribution, and total power of electrical signals at the point where the signal enters the subscriber loop cable.
- 4.2 To minimize and control the Cross-talk interference introduced by Requesting Licensee's Equipment into the existing loop transmission systems and services, the performance requirements in this clause specify power limits in terms of:
- Transmitted Power Spectral Density (PSD); and
 - Total Average Transmit Power.
- 4.3 The Signal Power Limitations apply to signals transmitted by ADSL transceiver units located in local exchanges (ATU-C) or a remote terminal location (ATU-R) that is usually at the customer premises. This Annex specifies both PSD and total average power for both upstream (the signal travelling away from the customer) and downstream (the signal travelling toward the customer) signals.
- 4.4 The characterization of a transmitted signal by power level and frequency content is called the power spectral density (PSD) of the signal. The primary signal power requirements in this plan are specified through the use of PSD masks and templates. The PSD mask shows the maximum power boundary or limit, in dBm per Hz, for the transmitted signal.
- 4.5 The Requesting Licensee's equipment must not transmit a signal above the PSD Mask or which exceeds the total average power for both upstream and downstream signals.
- 4.6 The PSD masks and templates are drawn from the ANSI T1 E1.4 Spectrum Management Class 5 which is intended for DSL transmission systems that use ATU-C equipment and operate in the frequency spectrum from approximately 25 kHz to approximately 1104 kHz and ATU-R equipment that operates in the frequency spectrum from approximately 25 kHz to approximately 138 kHz.

4.7 PSD template (Downstream)

PSD template definition for downstream transmission

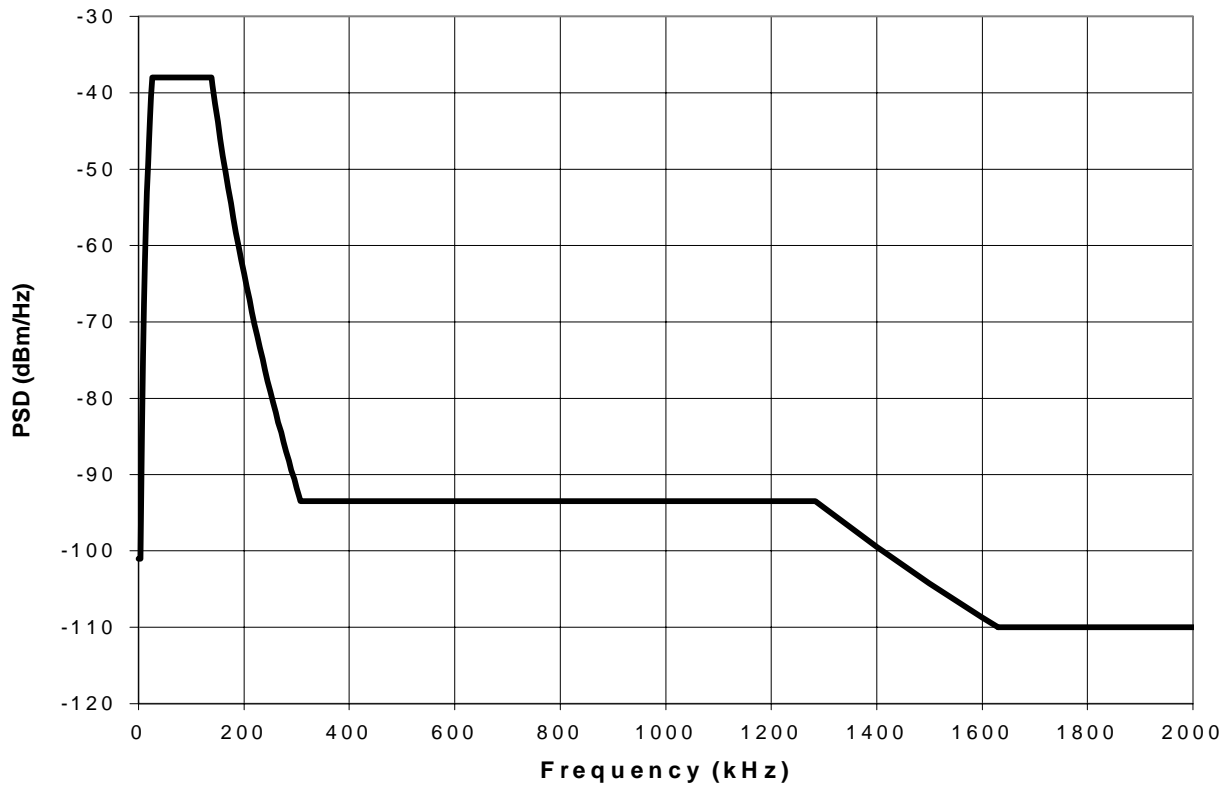
Frequency Band (kHz)	PSD (dBm/Hz)
$0 < f \leq 4$	-101, with max power in the in 0-4 kHz band of +15 dBm
$4 < f \leq 25.875$	$-96 + 21 \times \log_2(f/4)$
$25.875 < f \leq 81$	-40
$81 < f \leq 92.1$	$-40 - 70 \times \log_2(f/81)$
$92.1 < f \leq 121.4$	-53
$121.4 < f \leq 138$	$-53 + 70 \times \log_2(f/121.4)$
$138 < f \leq 1104$	-40
$1104 < f \leq 3093$	$-40 - 36 \times \log_2(f/1104)$
$3093 < f \leq 4545$	$\text{Min}(-36.5 - 36 \times \log_2(f/1104), -93.5)$
$4545 < f \leq 11040$	-110



4.8 PSD template (Upstream)

PSD template definition for upstream transmission

Frequency Band (kHz)	PSD (dBm/Hz)
$0 < f < 4$	-101, with max power in the in 0-4 kHz band of +15 dBm
$4 < f < 25.875$	$-96 + 21.5 \times \log_2(f/4)$
$25.875 < f < 138$	-38
$138 < f < 307$	$-38 - 48 \times \log_2(f/138)$
$307 < f < 1221$	-93.5
$1221 < f < 1630$	$\min(-90 - 48 \times \log_2(f/1221), -93.5)$
$1630 < f < 11040$	-110



4.9 Total average power (Downstream)

Total average downstream power between 25 kHz and 1104 kHz that is transmitted by the ATU-C shall not exceed 20.9 dBm.

4.10 The total average power (Upstream)

The total average upstream power below 138 kHz that is transmitted by the ATU-R shall not exceed 13 dBm.

4.11 There is a higher potential for Cross-talk in Configuration 2 since the Requesting Licensee's equipment is deployed nearer to the customer than under Configuration 1. To reduce such risk, the Requesting Licensee equipment must have Power Cutback feature as specified in ITU standard G992.1 and G922.2.

4.12 Reverse Mode ADSL operation

4.12.1 Reverse Mode ADSL Operation occurs when the ATU-C equipment as defined in the relevant Recommendation ITU G992.1 and G992.2 is used to transmit in the reverse direction, that is away from the customer.

4.12.2 Such Reverse Mode ADSL Operation will cause unacceptable Cross-talk interference and performance degradation and is not allowed under this Annex.

5. Test and Measurement Methods

5.1 Measurement setup for PSD and total average power measurement is shown in Figure 3 below.

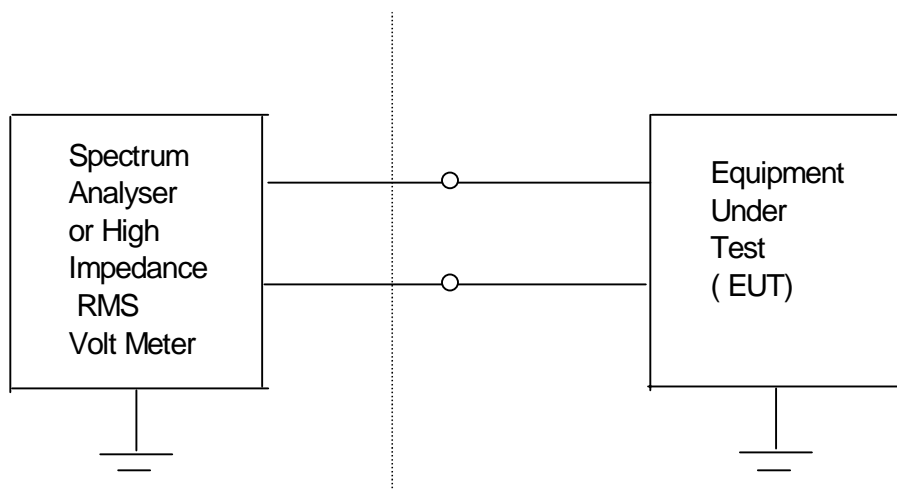


Figure 3 PSD and Total Average Power measurement set up.

5.2 Total average power measurement

- 5.2.1 The total average power shall be measured and averaged over a time span of at least 10 seconds.

5.3 Power spectral density (PSD) measurement

- 5.3.1 The PSD is measured by averaging the observed output power of the EUT on each of a number of contiguous, regularly spaced, small frequency bands, with each frequency band having a defined resolution bandwidth as shown in the Table below:

Resolution bandwidth for measuring an EUT PSD

Frequency Band	Resolution Bandwidth
$f \leq 10 \text{ kHz}$	100 Hz
$10 \text{ kHz} < f \leq 25.875 \text{ kHz}$	1 kHz
$25.875 \text{ kHz} < f \leq 3.1 \text{ MHz}$	10 kHz
$3.1 \text{ MHz} < f \leq 30 \text{ MHz}$	100 kHz

- 5.3.2 Each frequency point of a PSD (corresponding to a measurement in a single resolution bandwidth) shall be measured by averaging the power in the resolution bandwidth of that frequency point for a time period of at least 2.0 seconds. This requirement is equivalent to setting the sweep time for a single sweep of a spectrum analyzer for a duration equal to at least 2.0 seconds per frequency point.
- 5.3.3 The EUT shall be tested while it transmits maximum power and maximum PSD levels at all frequencies over which it can transmit data when deployed. The EUT shall not have any power cutback enabled during testing
- 5.3.4 The EUT input shall consist of a pseudo-random uniformly distributed data sequence, and the EUT output shall be a fully modulated transmitted signal with all overhead, framing, coding, scrambling, modulation, filtering and all other operations performed on the data stream that the modem would normally perform while transmitting data.

6 Definitions

The following definitions apply to this Annex 3B.2

“ADSL” means Asymmetric Digital Subscriber Line.

“Cross Talk” means the unwanted electromagnetic energy that couples into a metallic cable pair from services and transmission system technologies in use on other pairs in the same cable unit.

“Downstream” means signals sent using xDSL technology from the network towards the customer.

[**“DSL”** means Digital Subscriber Line technology.]

[**“EUT”** means Equipment Under Test.]

[**“HDSL”** means High bit-rate Digital Subscriber Line technology.]

[**“ISDN”** means Integrated Services Digital Network technology.]

“Signal Power Limitation” means the specific amplitude, frequency distribution, and total power of electrical signals at the point where the signal enters the subscriber loop cable as specified in Annex 3B.2.

“Upstream” means signals sent using xDSL technology from the customer towards the network.

[**“VDSL”** means Very High bit-rate Digital Subscriber Line technology.]