International Telecommunication Union

ITU-T

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G.992.3

Amendment 3
(11/2010)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital sections and digital line system – Access networks

Asymmetric digital subscriber line transceivers 2 (ADSL2)

Amendment 3: Scale factor for downstream transmitter referred virtual noise, and corrigenda

Recommendation ITU-T G.992.3 (2009) – Amendment 3

ITU-T

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Recommendation ITU-T G.992.3

Asymmetric digital subscriber line transceivers 2 (ADSL2)

Amendment 3

Scale factor for downstream transmitter referred virtual noise, and corrigenda

Summary

Amendment 3 to Recommendation ITU-T G.992.3 covers the following functionalities:

- Channel initialization policies (corrigendum).
- Upstream optional D0 values (corrigendum).
- Scale factor for downstream transmitter referred virtual noise (new functionality).
- Loop diagnostics procedures (editorial).

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.992.3	2002-07-29	15
1.1	ITU-T G.992.3 (2002) Amend. 1	2003-05-22	15
1.2	ITU-T G.992.3 (2002) Cor. 1	2003-12-14	15
1.3	ITU-T G.992.3 (2002) Cor. 2	2004-02-22	15
1.4	ITU-T G.992.3 (2002) Amend. 2	2004-04-30	15
1.5	ITU-T G.992.3 (2002) Amend. 3	2004-06-13	15
1.6	ITU-T G.992.3 (2002) Amend. 4	2004-06-13	15
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3.2	ITU-T G.992.3 (2009) Amend. 1	2010-03-01	15
3.3	ITU-T G.992.3 (2009) Amend. 2	2010-07-29	15
3.4	ITU-T G.992.3 (2009) Amend. 3	2010-11-29	15

FOREWORD

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Asymmetric digital subscriber line transceivers 2 (ADSL2)

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Scale factor for downstream transmitter referred virtual noise, and corrigenda

1) Channel initialization policies (correction)

In ITU-T G.992.3 Amendment 1 clause 7.10.3, indicate the following paragraph as deleted text:

This change also applies to ITU-T G.992.5 by normative reference to ITU-T G.992.3.

7.10.3 Exchange phase

• • •

~~If the CO-MIB sets CIPOLICY (see clause 7.3.2.10 of [ITU-T G.997.1]) to ONE for a bearer channel, it shall have the minimum net data rate (see clause 7.3.2.1.1 of [ITU-T G.997.1]) set equal to the maximum net data rate (see clause 7.3.2.1.3 of [ITU-T G.997.1]) and shall have the MAXSNRM set to infinity (see clause 7.3.1.3.3 of [ITU-T G.997.1]).~~

• • •

2) Upstream optional D0 values (correction)

a) Change Table 7-8 in clause 7.6.2 as follows (align with [ITU-T G.994.1]):

7.6.2 Valid framing configurations

• • •

Table 7-8 – Valid framing configurations

Parameter	Capability
D_p	<u>For downstream latency paths: </u>1, 2, 4, 8, 16, 32, 64<u>.</u> For the downstream latency path #0, additional valid D_0 values are: 96, 128, 160, 192, 224, 256, 288, 320, 352, 384, 416, 448, 480, 511<u>.</u> <u>For upstream latency paths: 1, 2, 4, 8.</u> <u>For the upstream latency path #0, additional valid D_0 values are:</u> <u>16, 32, 64.</u> If R_p = 0 then D_p = 1

• • •

b) Change one paragraph in clause 7.7.1.5 as follows:

(revision marks shown are relative to the change made in Corrigendum 1)

This change also applies to ITU-T G.992.5 by normative reference to ITU-T G.992.3.

7.7.1.5 Interleaver

• • •

With D_p one of the mandatory values identified in Table 7-9, Table 7-10, Table 7-11 or Table 7-12, and with the above-defined rule, the output octets from the interleaver always occupy distinct time slots when $N_{FEC.p}$ is odd and D_p is a power of 2. When $N_{FEC.p}$ is even, a dummy octet shall be added at the beginning of the codeword at the input to the interleaver. The resultant odd-length codeword is then convolutionally interleaved, and the dummy octet shall then be removed from the output of the interleaver.

With D_0 one of the optional (i.e., valid as identified in Table 7-8, but not mandatory as identified in Table 7-9 for downstream, or Table 7-10 for upstream~~, Table 7-11 or Table 7-12~~) values, the codeword length $N_{FEC.0}$ and D_0 shall be co-prime (i.e., have no common divisors except for 1). No dummy octets shall be used, as with the above-defined rule, the output octets from the interleaver always occupy distinct time slots.

c) Change clause 7.10.1.1 as follows (align with [ITU-T G.994.1]):

7.10.1.1 ITU-T G.994.1 capabilities list message

The following information about the PMS-TC function shall be as defined in [ITU-T G.994.1] as part of the CL and CLR messages. This information may be optionally requested and reported via ITU-T G.994.1 messages at the start of a session. However, the information shall be exchanged at least once between ATU-C and ATU-R but not necessarily at the start of each session. The information exchanged includes:

- capability to transport NTR (downstream only);
- support for erasure decoding reporting;
- minimum downstream message-based overhead channel data rate that is needed;
- minimum upstream message-based overhead channel data rate that is needed;
- maximum downstream net data rate of each latency path can be supported;
- maximum upstream net data rate of each latency path that can be supported;
- $R_{p\ max}$ on each optional latency path that can be supported;
- $D_{p\ max}$ on each optional latency path that can be supported.

In addition, non-standard capabilities may be reported through additional non-standard facility (NSF) messages.

This information is represented using an ITU-T G.994.1 tree model of the information as in Table 7-18. An ATU provides both the upstream and downstream information in response to the capabilities request message.

The latency paths supported shall start from 0 and increase by one. The capability list shall indicate that latency paths supported consists of {#0}, {#0, #1}, {#0, #1, #2} or {#0, #1, #2, #3} (there are only 4 cases). The number of latency paths supported may be different for upstream and downstream.

Table 7-18 – Format for PMS-TC capability list information

Npar(2) bit	Definition of Npar(2) bit
NTR	This bit is set to ONE if the ATU has the capability to transport the NTR signal in the downstream direction.
Erasure decoding reporting	This bit is set to ONE if the ATU supports reporting in R-PARAMS message as to whether or not erasure decoding is being used on the downstream latency paths.
Spar(2) bit	**Definition of related Npar(3) octets**
Downstream overhead data rate	Parameter block of 2 octets that describes the minimum message-based data rate that is needed by the ATU. The unsigned 6-bit value is the data rate divided by 1000 bits per second minus 1 (covering the range 1 to 64 kbit/s) – see Note.
Upstream overhead data rate	Parameter block of 2 octets that describes the minimum message-based data rate that is needed by the ATU. The unsigned 6-bit value is the data rate divided by 1000 bits per second minus 1 (covering the range 1 to 64 kbit/s) – see Note.
Downstream PMS-TC latency path #0 supported (always set to 1)	Parameter block of 6 octets that describes the maximum net_max downstream rate, downstream S_{0min}, and downstream D_0 values supported in the latency path #0. The unsigned 12-bit net_max value is the data rate divided by 4000. The net_max downstream rate shall be greater than or equal to the maximum required downstream data rate for each TPS-TC type that is supported by the ATU. The supported range of S_0 values shall be indicated by its lower bound S_{0min}. S_{0min} shall equal 1/(n+1), with n coded as an unsigned 4-bit value in the 1 to 15 range. The D_0 values supported shall be individually indicated with 1 bit per value.
Upstream PMS-TC latency path #0 supported (always set to 1)	Parameter block of 3 octets that describes the maximum net_max upstream rate and ~~down~~upstream D_{0max} ~~values~~ supported in the latency path #0. The unsigned 12-bit net_max value is the data rate divided by 4000. The net_max upstream rate shall be greater than or equal to the maximum required upstream data rate for each TPS-TC type that is supported by the ATU. D_{0max} is represented as an unsigned 4-bit value n, with $D_{0max} = 8 + 4 \times n$, and n = 0, 2, 6, or 14. ~~The D_0 values supported shall be individually indicated with 1 bit per value.~~
Downstream PMS-TC latency path #1 supported	Parameter block of 4 octets that describes the maximum net_max downstream rate, downstream R_{1max}, and downstream D_1 max supported in the latency path #1. The unsigned 12-bit net_max value is the data rate divided by 4000. R_{1max} is an unsigned 4-bit value and shall be one of the valid R_p values divided by 2. D_{1max} is an unsigned 3-bit value and shall be the logarithm base 2 of one of the valid D_p values.
Upstream PMS-TC latency path #1 supported	Parameter block of 4 octets that describes the maximum net_max upstream rate, upstream R_{1max}, and upstream D_{1max} supported in the latency path #1. The unsigned 12-bit net_max value is the data rate divided by 4000. R_{1max} is an unsigned 4-bit value and shall be one of the valid R_p values divided by 2. D_{1max} is an unsigned 3-bit value and shall be the logarithm base 2 of one of the valid D_p values.
Downstream PMS-TC latency path #2 supported	Parameter block of 4 octets that describes the maximum net_max downstream rate, downstream R_{2max}, and downstream D_{2max} supported in the latency path #2. The unsigned 12-bit net_max value is the data rate divided by 4000. R_{2max} is an unsigned 4-bit value and shall be one of the valid R_p values divided by 2. D_{2max} is an unsigned 3-bit value and shall be the logarithm base 2 of one of the valid D_p values.
Upstream PMS-TC latency path #2 supported	Parameter block of 4 octets that describes the maximum net_max upstream rate, upstream R_{2max}, and upstream D_{2max} supported in the latency path #2. The unsigned 12-bit net_max value is the data rate divided by 4000. R_{2max} is an unsigned 4-bit value and shall be one of the valid R_p values divided by 2. D_{2max} is an unsigned 3-bit value and shall be the logarithm base 2 of one of the valid D_p values.

Table 7-18 – Format for PMS-TC capability list information

Spar(2) bit	Definition of related Npar(3) octets
Downstream PMS-TC latency path #3 supported	Parameter block of 4 octets that describes the maximum net_max downstream rate, downstream R_{3max}, and downstream D_{3max} supported in the latency path #3. The unsigned 12-bit net_max value is the data rate divided by 4000. R_{3max} is an unsigned 4-bit value and shall be one of the valid R_p values divided by 2. D_{3max} is an unsigned 3-bit value and shall be the logarithm base 2 of one of the valid D_p values.
Upstream PMS-TC latency path #3 supported	Parameter block of 4 octets that describes the maximum net_max upstream rate, upstream R_{3max}, and upstream D_{3max} supported in the latency path #3. The unsigned 12-bit net_max value is the data rate divided by 4000. R_{3max} is an unsigned 4-bit value and shall be one of the value R_p values divided by 2. D_{3max} is an unsigned 3-bit value and shall be the logarithm base 2 of one of the valid D_p values.
NOTE – By construction of the ADSL2 framing, the message-based overhead data rate is strictly smaller than 64 kbit/s. Hence, the ITU-T G.994.1 phase of initialization should not request a minimum value of 64 kbit/s.	

~~Table 7-18a – Standard information field –~~
~~Downstream PMS-TC latency path #0 NPar(3) coding – Octet 1~~

~~Bits~~								~~Downstream PMS-TC latency path #0 NPar(3)s – Octet 1~~
~~8~~	~~7~~	~~6~~	~~5~~	~~4~~	~~3~~	~~2~~	~~1~~	
~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~Net_max (maximum net data rate, bits 12 to 7)~~

~~Table 7-18b – Standard information field –~~
~~Downstream PMS-TC latency path #0 NPar(3) coding – Octet 2~~

~~Bits~~								~~Downstream PMS-TC latency path #0 NPar(3)s – Octet 2~~
~~8~~	~~7~~	~~6~~	~~5~~	~~4~~	~~3~~	~~2~~	~~1~~	
~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~Net_max (maximum net data rate, bits 6 to 1)~~

~~Table 7-18c – Standard information field –~~
~~Downstream PMS-TC latency path #0 NPar(3) coding – Octet 3~~

~~Bits~~								~~Downstream PMS-TC latency path #0 NPar(3)s – Octet 3~~
~~8~~	~~7~~	~~6~~	~~5~~	~~4~~	~~3~~	~~2~~	~~1~~	
~~x~~	~~x~~			~~x~~	~~x~~	~~x~~	~~x~~	~~S_{0min} value (=1/(n+1), n coded in bits 4 to 1, n = 1 to 15)~~
~~x~~	~~x~~	~~x~~	~~x~~					~~Reserved for allocation by ITU-T~~

The S_{0min} value shall be less than or equal to 1/2~~ (i.e., n ≥ 1)~~. If the S_{0min} value ~~octet (see Table 7-18c)~~ is not included in the CL or CLR message, the S_{0min} value shall be set equal to 1/2 (implicit indication). The S_0 value selected during the exchange phase (see Table 7-7 and clause 7.10.3) shall be equal to or higher than the highest of the S_{0min} values indicated in the CL and CLR message.

~~Table 7-18d – Standard information field – Downstream PMS-TC latency path #0 NPar(3) coding – Octet 4~~

~~Bits~~ 8	~~7~~	~~6~~	~~5~~	4	~~3~~	~~2~~	~~1~~	**~~Downstream PMS-TC latency path #0 NPar(3)s – Octet 4~~**
~~x~~	~~x~~						~~x~~	~~D_0 value of 96 is supported~~
~~x~~	~~x~~					~~x~~		~~D_0 value of 128 is supported~~
~~x~~	~~x~~				~~x~~			~~D_0 value of 160 is supported~~
~~x~~	~~x~~			~~x~~				~~D_0 value of 192 is supported~~
~~x~~	~~x~~		~~x~~					~~D_0 value of 224 is supported~~
~~x~~	~~x~~	~~x~~						~~D_0 value of 256 is supported~~

~~Table 7-18e – Standard information field – Downstream PMS-TC latency path #0 NPar(3) coding – Octet 5~~

~~Bits~~ 8	~~7~~	~~6~~	~~5~~	4	~~3~~	~~2~~	~~1~~	**~~Downstream PMS-TC latency path #0 NPar(3)s – Octet 5~~**
~~x~~	~~x~~						~~x~~	~~D_0 value of 288 is supported~~
~~x~~	~~x~~					~~x~~		~~D_0 value of 320 is supported~~
~~x~~	~~x~~				~~x~~			~~D_0 value of 352 is supported~~
~~x~~	~~x~~			~~x~~				~~D_0 value of 384 is supported~~
~~x~~	~~x~~		~~x~~					~~D_0 value of 416 is supported~~
~~x~~	~~x~~	~~x~~						~~D_0 value of 448 is supported~~

~~Table 7-18f – Standard information field – Downstream PMS-TC latency path #0 NPar(3) coding – Octet 6~~

~~Bits~~ 8	~~7~~	~~6~~	~~5~~	4	~~3~~	~~2~~	~~1~~	**~~Downstream PMS-TC latency path #0 NPar(3)s – Octet 6~~**
							~~x~~	~~D_0 value of 480 is supported~~
~~x~~	~~x~~					~~x~~		~~D_0 value of 511 is supported~~
~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~			~~Reserved for allocation by ITU-T~~

The downstream D_0 value selected during the exchange phase (see clause 7.10.3) shall be one of the mandatory values (see Table 7-9) or one of the optional values (~~see~~ i.e., valid per Table 7-8 but not mandatory per Table 7-9), support of which is indicated in both the CL and CLR messages. The selected downstream D_0 value is not necessarily the highest commonly supported downstream D_0 value.

~~Table 7-18g – Standard information field – Upstream PMS-TC latency path #0 NPar(3) coding – Octet 1~~

~~Bits~~ 8	~~7~~	~~6~~	~~5~~	4	~~3~~	~~2~~	~~1~~	**~~Upstream PMS-TC latency path #0 NPar(3)s – Octet 1~~**
~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~Net_max (maximum net data rate, bits 12 to 7)~~

~~Table 7-18h – Standard information field – Upstream PMS-TC latency path #0 NPar(3) coding – Octet 2~~

~~Bits~~								~~Upstream PMS-TC latency path #0 NPar(3)s – Octet 2~~
~~8~~	~~7~~	~~6~~	~~5~~	~~4~~	~~3~~	~~2~~	~~1~~	
~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~x~~	~~Net_max (maximum net data rate, bits 6 to 1)~~

~~Table 7-18i – Standard information field – Upstream PMS-TC latency path #0 NPar(3) coding – Octet 3~~

~~Bits~~								~~Upstream PMS-TC latency path #0 NPar(3)s – Octet 3~~
~~8~~	~~7~~	~~6~~	~~5~~	~~4~~	~~3~~	~~2~~	~~1~~	
~~x~~	~~x~~						~~x~~	~~D_0 value of 16 is supported~~
~~x~~	~~x~~					~~x~~		~~D_0 value of 32 is supported~~
~~x~~	~~x~~				~~x~~			~~D_0 value of 64 is supported~~
~~x~~	~~x~~	~~x~~	~~x~~	~~x~~				~~Reserved for allocation by ITU-T~~

The upstream D_0 value selected during the exchange phase (see clause 7.10.3) shall be one of the mandatory values (see Table 7-10) or one of the optional values (i.e., valid per ~~see~~ Table 7-8 but not mandatory per Table 7-10), support of which is indicated in both the CL and CLR message. The selected upstream D_0 value is not necessarily the highest commonly supported upstream D_0 value.

3) Scale factor for TXREFVNds (new functionality)

This new functionality also applies to ITU-T G.992.5 by normative reference to ITU-T G.992.3.

a) Change row SNRM_MODE in Table 8-6 in clause 8.5.1 as follows:

8.5.1 Definition of control parameters

• • •

Table 8-6 – The receive PMD function control parameters

Parameter	Definition
SNRM_MODE	This parameter enables the transmitter referred virtual noise. The parameter can be different for ATU-C (*SNRM_MODEus*) and ATU-R (*SNRM_MODEds*), and is configured through the CO-MIB. If set to 1, the virtual noise is disabled. If set to 2, the virtual noise without scale factor is enabled. If set to 4, downstream virtual noise with scale factor is enabled. The SNRM_MODEus values 3 and 4 are reserved for use by ITU-T. The SNRM_MODEds value 3 is reserved for use by ITU-T.

b) Change clause 8.5.1.1 as follows (adding text to the end of the first paragraph):

8.5.1.1 Transmitter-referred virtual noise PSD

This clause describes the transmitter-referred virtual noise PSD parameter *TXREFVN*, used only in the optional SNR margin modes *SNRM_MODE* = 2, and *SNRM_MODE* = 4.

c) Change clause 8.5.1.1.1 as follows (and add new subclauses):

8.5.1.1.1 Definition of parameter *TXREFVN*

Configuration parameter *TXREFVN* defines the transmitter-referred virtual noise PSD to be used in determining the SNR margin.

The CO-MIB shall provide a *TXREFVN* parameter ~~set for each utilized band when~~ in *SNRM_MODE* = 2, or *SNRM_MODE* = 4.

8.5.1.1.1.1 SNRM_MODE = 2

The transmitter-referred virtual noise PSD in the CO-MIB shall be specified by a set of breakpoints.

Each breakpoint shall consist of a subcarrier index t_n and a noise PSD (expressed in dBm/Hz). The *TXREFVN* parameter for each utilized band shall be a set of breakpoints that are represented by $[(t_1, PSD_1), (t_2, PSD_2), ..., (t_n, PSD_n), (t_{NBP}, PSD_{NBP})]$, where t_1 and t_{NBP} are, respectively, the lower and higher passband edge subcarrier indices corresponding to the passband edge frequencies defined in the applicable Annex for the operation mode, and represented by f_L and f_H.

The subcarrier indices t_i shall be coded in the CO-MIB as unsigned integers in the range from $t_1 = roundup(f_L/\Delta f)$ to $t_{NBP} = \text{MIN}(rounddown(f_H/\Delta f), 511)$, where Δf is the subcarrier spacing used by the DMT modulation, defined in clause 8.8.1. The breakpoints shall be defined so that $t_n < t_{n+1}$ for $n = 1$ to $N - 1$; the frequency f_n corresponding to the index t_n can be found as: $f_n = t_n \times \Delta f$.

NOTE – Based on this formula, the last breakpoint of *TXREFVN* is given by the noise PSD on the tone index 128 if f_H = 552 kHz, on the tone index 256 if f_H = 1104 kHz, or on the tone index 511 if f_H = 2208 kHz.

The values for the transmitter-referred virtual noise PSD shall be coded as 8-bit unsigned integers representing virtual noise PSDs from −40 dBm/Hz (coded as 0) to −140 dBm/Hz (coded as 200), in steps of 0.5 dBm/Hz. Values from 201 to 255, inclusive, correspond to a virtual noise PSD of zero Watt/Hz (minus infinity dBm/Hz).

The maximum number of breakpoints is 16 in the downstream and 4 in the upstream direction.

The parameter in the downstream direction is *TXREFVNds*, and the parameter in the upstream direction is *TXREFVNus*.

8.5.1.1.1.2 SNRM_MODE = 4

In *SNRM_MODE* = 4, the CO-MIB shall provide a configuration parameter *TXREFVNds* parameter as described in clause 8.5.1.1.1.1 for *SNRM_MODE* = 2, and a configuration parameter *TXREFVNSFds*. Configuration parameter *TXREFVNSFds* defines the transmitter-referred virtual noise scaling factor.

The values for the *TXREFVNSFds* virtual noise PSD scaling factors shall be coded as 8-bit signed integers representing scaling factors from −64.0 dB (coded as −128) to 63.5 dB (coded as 127), in steps of 0.5 dB.

The ATU-C shall combine the value of the configuration parameter *TXREFVNSFds* (as provided in the CO-MIB) with the value of the configuration parameter *TXREFVNds* (as provided in the CO-MIB) to a control parameter *TXREFVNds* as communicated to the ATU-R in C-MSG-PCB as follows:

$$\mathit{ControlParameter\ TXREFVNds = MIN(MAX(configuration\ parameter\ TXREFVNds}$$
$$\mathit{+\ configuration\ parameter\ TXREFVNSFds, -140\ dBm/Hz), -40\ dBm/Hz).}$$

The transmitter-referred virtual noise PSD applied in the ATU-R receiver shall be as specified through the *TXREFVNds* parameter exchanged during the initialization channel discovery phase.

NOTE – Per line configuration of the downstream virtual noise may be accomplished through *SNRM_MODE* = 2 by configuration of a different value for the configuration parameter virtual noise (VNds, see clause 7.3.1.7.3 of [ITU-T G.997.1]) on a line-by-line basis. Per line configuration of the downstream virtual noise may also be accomplished through *SNRM_MODE* = 4 by configuration of a common value for the configuration parameter virtual noise (VNds) for a group of lines, combined with the configuration of a scaling factor (*TXREFVNSFds*, see clause 7.3.1.7.6 of [ITU-T G.997.1]) on a line-by-line basis.

d) *Change clause 8.5.1.1.2 as follows:*

8.5.1.1.2 Use of parameter *TXREFVN*

The transmitter-referred virtual noise PSD, for each subcarrier i, shall be obtained by linear interpolation in dB on a linear frequency scale as follows:

$$TX\_referred\_Virtual\_Noise\_PSD(i) \;=\; PSD_n \;+\; \left(PSD_{n+1} - PSD_n\right) \times \frac{i - t_n}{t_{n+1} - t_n} \qquad t_n < i \le t_{n+1}$$

The near-end transceiver should apply the Received_Virtual_Noise_PSD (see clause 8.12.3.6.1.2) at the constellation decoder point (i.e., the transceiver does not need to account for DFT leakage effects from one subcarrier to another subcarrier). All effects are to be taken into account in the setting of the *TXREFVN* in the CO-MIB.

NOTE 1 – Since the inband portion of the spectrum is expected not to significantly depend upon the transmitter filter characteristics (see clause 8.12.3.1), the above method is equivalent to the near-end transceiver calculating its bit loading using the following *Virtual_Noise_SNR* for the subcarrier with index i, at the constellation decoder (all terms are expressed in dB):

$$\text{Virtual\_Noise\_SNR}(i) = S\_tx(i) - N\_tx(i) + 20 \times \log_{10}(g_i)$$

where: $S\_tx(\text{i})$ = REFPSD+log_tss$_\text{i}(i)$

$N\_tx(i)$ = TX_referred_Virtual_Noise_PSD(i)

g_i is the gain adjuster for the subcarrier with index i as defined in clause 8.6.4.

and *REFPSD* is defined in Table 8-5.

TX_referred_Virtual_Noise_PSD(i) is the transmitter-referred virtual noise PSD value for subcarrier with index i, obtained by interpolation of the *NBP* breakpoints of *TXREFVN* (i.e., *NBPds* breakpoints for *TXREFVNds* and *NBPus* breakpoints for *TXREFVNus*).

The downstream *TXREFVNds* is sent in the C-MSG-PCB message during initialization, as breakpoints (t_i, PSD_i) with the value of *NBPds* set during the ITU-T G.994.1 phase. If *SNRM_MODE* = 1 or either ATU does not support downstream virtual noise, then the *NBPds* value = 0 (i.e., no breakpoints for downstream virtual noise PSD shall be included in C-MSG-PCB). Each breakpoint shall be represented in 24 bits, with bits 23 to 17 reserved and coded 0, bits 16 to 8 representing a subcarrier index in range 0 to 511, and bits 7 to 0 representing an 8-bit PSD value as defined in clause 8.5.1.1.1.

NOTE 2 – In *SNRM_MODE* = 4, the value of *TXREFVNds* is sent in the C-MSG-PCB message during initialization, and is different from the *TXREFVNds* CO-MIB value due to the application of the *TXREFVNSFds* scaling factor in the ATU-C.

NOTE ~~2~~3 – Improper setting of *TXREFVN* can interact with the setting of one or more of the following parameters: maximum net data rate, downstream maximum SNR margin, impulse noise protection, and maximum interleaving delay. This interaction can result in high levels of transmit power that can lead to high crosstalk experienced by DSLs on other pairs in the same binder.

NOTE ~~3~~4 – Improper setting of one or more of the following parameters – maximum net data rate, maximum SNR margin, impulse noise protection, maximum interleaving delay (in *SNRM_MODE* = 1), and *TXREFVN* (in *SNRM_MODE* = 2 and *SNRM_MODE* = 4) – can result in high levels of transmit power that can lead to high crosstalk experienced by DSLs on other pairs in the same binder. Specifically, high values of maximum net data rate, maximum SNR margin, impulse noise protection, low values of maximum interleaving delay (in *SNRM_MODE* = 1), and high values of *TXREFVN* (in *SNRM_MODE* = 2 and *SNRM_MODE* = 4) are of concern.

e) Change clause 8.12.3.6.1.2 as follows (change the equation for Received_Virtual_Noise_PSD):

8.12.3.6.1.2 SNRM_MODE = 2

SNRM_MODE = 2 is an optional capability for both ATUs.

The reference noise PSD equals the maximum of the received current-condition external noise PSD (as defined in *SNRM_MODE* = 1) and the received virtual noise PSD, at a common internal reference point.

The received virtual noise PSD shall be determined by the transceiver as defined in the following equation:

$$\text{Received\_Virtual\_Noise\_PSD} = 10 \times \log(|\,H(f)\,|^2)\ \cancel{\times} + \text{TXREFVN dBm/Hz},$$

where *TXREFVN* is the transmitter-referred virtual noise PSD MIB parameter.

f) Insert new clause 8.12.3.6.1.3 as follows:

8.12.3.6.1.3 SNRM_MODE = 4

SNRM_MODE = 4 is an optional capability in downstream for both ATUs.

The reference noise PSD equals the maximum of the received current-condition external noise PSD (as defined in *SNRM_MODE* = 1) and the received virtual noise PSD, at a common internal reference point.

The received virtual noise PSD shall be determined by the ATU-R as defined in the following equation:

$$\text{Received\_Virtual\_Noise\_PSD} = 10 \times \log(|\,H(f)\,|^2) + \text{TXREFVNds dBm/Hz}$$

where *TXREFVNds* is the downstream transmitter-referred virtual noise PSD control parameter (see clause 8.5.1.1.1.2) and where $|\,H(f)\,|^2$ is calculated as for *SNRM_MODE* = 2 (see clause 8.12.3.6.1.2).

g) Change clause 8.12.3.6.2 as follows (adding text to the end of the first paragraph):

8.12.3.6.2 Signal-to-noise ratio margin parameter (SNRM)

The signal-to-noise ratio margin parameter (SNRM) is the signal-to-noise ratio margin (as defined in clause 8.12.3.6.1) measured over all subcarriers in a transmission direction for which $b_i > 0$. The received virtual noise PSD as defined in clause 8.12.3.6.1.2 shall be taken into account when configured in *SNRM_MODE* = 2, and the received virtual noise PSD as defined in clause 8.12.3.6.1.3 shall be taken into account when configured in *SNRM_MODE* = 4.

h) Change clause 8.12.3.7 as follows (add bullet to list):

8.12.3.7 Attainable net data rate (*ATTNDR*)

The attainable net data rate is the maximum net data rate that the receive PMS-TC and PMD functions are designed to support, under the following conditions:

- single frame bearer and single latency operation;
- signal-to-noise ratio margin (*SNRM*) to equal or be above the *SNR* target margin;
- BER not to exceed the highest BER configured for one (or more) of the latency paths;
- latency not to exceed the highest latency configured for one (or more) of the latency paths;
- accounting for all coding gains available (e.g., trellis coding, RS FEC) within latency bound;
- accounting for the loop characteristics at the instant of measurement;

- accounting for the received virtual noise PSD when configured in SNRM_MODE = 2;
- accounting for the received virtual noise PSD when configured in SNRM_MODE = 4.

i) Change clause 8.12.3.2 as follows (add sentence to first paragraph):

8.12.3.2 Quiet line noise PSD per subcarrier (QLNps)

The quiet line noise PSD QLN(*f*) for a particular subcarrier is the rms level of the noise present on the line when no ADSL signals are present on the line. The received virtual noise PSD as defined in SNRM_MODE = 2 shall not be taken into account in QLN(*f*). The received virtual noise PSD as defined in SNRM_MODE = 4 shall not be taken into account in QLN(*f*).

j) Change clause 8.12.3.3 as follows (add sentence to first paragraph):

8.12.3.3 Signal-to-noise ratio per subcarrier (SNRps)

The signal-to-noise ratio SNR(*f*) for a particular subcarrier is a real value which shall represent the ratio between the received signal power and the received noise power for that subcarrier. The received virtual noise PSD as defined in SNRM_MODE = 2 shall not be taken into account in SNR(*f*). The received virtual noise PSD as defined in SNRM_MODE = 4 shall not be taken into account in SNR(*f*).

k) Change Table 8-20 in clause 8.13.2.1.1 as follows:

8.13.2.1.1 CL messages

Table 8-20 – ATU-C CL message Par(2) PMD bit definitions

NPar(2) bit	Definition
Support of downstream virtual noise	When set to 1, indicates that the ATU-C supports the use of the downstream virtual noise mechanism, ~~and~~i.e., supports SNRM_MODEds = 2 or SNRM_MODEds = 4 or both. When set to 0, indicates that the ATU-C does not support the use of the downstream virtual noise mechanism, ~~or~~i.e., supports SNRM_MODEds = 1.

l) Change clause C.8.5.1.1.2 as follows:

C.8.5.1.1.2 Use of parameter *TXREFVN*

The transmitter-referred virtual noise PSD, for each subcarrier *i*, shall be obtained by linear interpolation in dB on a linear frequency scale as follows:

$$TX\_referred\_Virtual\_Noise\_PSD(i) = PSD_n + \left(PSD_{n+1} - PSD_n\right) \times \frac{i - t_n}{t_{n+1} - t_n} \quad t_n < i \le t_{n+1}$$

The near-end transceiver should apply the Received_Virtual_Noise_PSD (see clause C.8.12.3.6.1.2) at the constellation decoder point (i.e., the transceiver does not need to account for DFT leakage effects from one subcarrier to another subcarrier). All effects are to be taken into account in the setting of the *TXREFVN* in the CO-MIB.

NOTE 1 – Since the inband portion of the spectrum is expected not to significantly depend upon the transmitter filter characteristics (see clause C.8.12.3.1), the above method is equivalent to the near-end transceiver calculating its bit loading using the following *Virtual_Noise_SNR* for the subcarrier with index *i*, at the constellation decoder (all terms are expressed in dB):

$$\text{Virtual\_Noise\_SNR}(i) = S\_tx(i) - N\_tx(i) + 20 \times \log_{10}(g_i)$$

where: $S\_tx(i)$ = REFPSD+log_tss$_i(i)$

$N\_tx(i)$ = TX_referred_Virtual_Noise_PSD(i)

g_i is the gain adjuster for the subcarrier with index *i* as defined in clause C.8.6.4.

and *REFPSD* is defined in Table C.8-5.

TX_referred_Virtual_Noise_PSD(i) is the transmitter-referred virtual noise PSD value for subcarrier with index *i*, obtained by interpolation of the *NBP* breakpoints of *TXREFVN* (i.e., *NBPds* breakpoints for *TXREFVNds* and *NBPus* breakpoints for *TXREFVNus*).

The downstream *TXREFVNds* for FEXT duration and the downstream *TXREFVNds* for NEXT duration are sent in the C-MSG-PCB message during initialization, with the value of *NBPds* set during the ITU-T G.994.1 phase. If *SNRM_MODE* = 1 or either ATU does not support downstream virtual noise, then the *NBPds* value = 0 (i.e., no breakpoints for downstream virtual noise PSD shall be included in C-MSG-PCB). Each breakpoint shall be represented in 24 bits, with bits 23 to 18 reserved and coded 0, bit 17 coded 0 representing FEXT duration and coded 1 NEXT duration, bits 16 to 8 representing a subcarrier index in range 0 to *NSCds* – 1, and bits 7 to 0 representing an 8-bit PSD value as defined in clause C.8.5.1.1.1.

NOTE 2 – Improper setting of *TXREFVN* can interact with the setting of one or more of the following parameters: maximum net data rate, downstream maximum SNR margin, impulse noise protection, and maximum interleaving delay. This interaction can result in high levels of transmit power that can lead to high crosstalk experienced by DSLs on other pairs in the same binder.

NOTE 3 – Improper setting of one or more of the following parameters – maximum net data rate, maximum SNR margin, impulse noise protection, maximum interleaving delay (in *SNRM_MODE* = 1), and *TXREFVN* (in *SNRM_MODE* = 2 <u>or *SNRM_MODE* = 4</u>) – can result in high levels of transmit power that can lead to high crosstalk experienced by DSLs on other pairs in the same binder. Specifically, high values of maximum net data rate, maximum SNR margin, impulse noise protection, low values of maximum interleaving delay (in *SNRM_MODE* = 1), and high values of *TXREFVN* (in *SNRM_MODE* = 2 <u>or *SNRM_MODE* = 4</u>) are of concern.

4) Loop diagnostics procedures

Insert the following clause heading and sentence just before Figure 8-35:

8.15.6 Timing diagram of the loop diagnostics procedures

The timing diagram of the loop diagnostics procedures is shown in Figures 8-35 and 8-36.

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