I n t e r n a t i o n a l   T e l e c o m m u n i c a t i o n   U n i o n

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.992.3

Amendment 5

(06/2008)

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 5

Recommendation ITU-T G.992.3 (2005) – Amendment 5

ITU-T

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TRANSMISSION MEDIA AND OPTICAL SYSTEMS CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
General	G.900–G.909
Parameters for optical fibre cable systems	G.910–G.919
Digital sections at hierarchical bit rates based on a bit rate of 2048 kbit/s	G.920–G.929
Digital line transmission systems on cable at non-hierarchical bit rates	G.930–G.939
Digital line systems provided by FDM transmission bearers	G.940–G.949
Digital line systems	G.950–G.959
Digital section and digital transmission systems for customer access to ISDN	G.960–G.969
Optical fibre submarine cable systems	G.970–G.979
Optical line systems for local and access networks	G.980–G.989
Access networks	**G.990–G.999**
MULTIMEDIA QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
ACCESS NETWORKS	G.9000–G.9999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T G.992.3

Asymmetric digital subscriber line transceivers 2 (ADSL2)

Amendment 5

Summary

Amendment 5 to Recommendation ITU-T G.992.3 contains the following items:

- Erasure decoding (new functionality).
- Impulse noise monitor (new functionality).
- C-REVERB PRBS (correction).
- Transmitter referred virtual noise (new functionality).
- Annex P on reduced transmit power requirements (new functionality).

Source

Amendment 5 to Recommendation ITU-T G.992.3 (2005) was approved on 22 June 2008 by ITU-T Study Group 15 (2005-2008) under Recommendation ITU-T A.8 procedure.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

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/.

Recommendation ITU-T G.992.3

Asymmetric digital subscriber line transceivers 2 (ADSL2)

Amendment 5

1 Erasure decoding

Change last row of Table 7-7 as follows:

7.6.1 Derived definitions

Table 7-7 displays several definitions of symbols that derive from the PMS-TC control parameters and that are used to describe characteristics of the ATU data frame. These definitions are for clarity only.

Table 7-7 – Derived characteristics of the ATU data frame

Symbols	Definition and value
INP_p	**Definition**: impulse noise protection for latency path p (INP_p) is defined as the number of consecutive DMT symbols or fractions thereof, as seen at the input to the de-interleaver, for which errors can be completely corrected by the error correcting code, regardless of the number of errors within the errored DMT symbols (see Note). When the Reed-Solomon decoder in the receiver does not use erasure decoding, the INP_p shall be computed as: $INP\_no\_erasure_p = \left(\frac{1}{2}\right)\times\left(S_p \times D_p\right)\times\left(\frac{R_p}{N\_FEC_p}\right)$ DMT symbols, where parameters D_p, *and* R_p are defined in Table 7-6 and parameters $N_{FEC,\,p}$ and S_p are defined in this table. When erasure decoding is used, INP_p might not equal $INP\_no\_erasure_p$. NOTE – This is equivalent to the number of consecutive errored octets within any block of $(N_{FEC,\,p} - 1)\cdot D_p + 1$ octets, as seen at the input to the de-interleaver, for which errors can be completely corrected by the error correcting code, divided by $L_p/8$, the number of octets loaded in a DMT symbol for latency path p. The parameter L_p is defined in Table 7-6.~~**Definition**: Impulse Noise Protection~~ ~~INP_p in number of DMT symbols of latency path function #p~~ $\cancel{INP_p = \left(\frac{1}{2}\right)\times\left(S \times D\right)\times\left(\frac{R}{N\_FEC}\right)}$

Change clause 7.10.1.1 as follows:

Insert as second bullet in bullet list:

- Support for erasure decoding reporting;

Change Table 7-18 as follows:

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

Npar(2) bit	Definition of Npar(2) bit
NTR	This bit is set to ~~a one~~ 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.

Change Table 7-19 as follows:

Table 7-19 – Format for PMS-TC mode select information

Npar(2) bit	Definition of Npar(2) bit
NTR	Set to ~~1~~ ONE if and only if this bit was set to ~~1~~ ONE in both the last previous CL message and the last previous CLR message. When set to ~~1~~ ONE, both ATUs shall transport the NTR signal in the downstream direction, such that the NTR signal is made available at the T-R interface. When set to ~~0~~ ZERO, indicates that the NTR signal is not available at the T-R interface.
Erasure decoding reporting	Set to ONE if and only if this bit was set to ONE in both the last previous CL message and the last previous CLR message. When set to ONE, indicates that the R-PARAMS message (see clause 7.10.3) shall report on whether or not erasure decoding is used on the downstream latency paths. When set to ZERO, indicates that the R-PARAMS message (see clause 7.10.3) shall not report on the use of erasure decoding on the downstream latency paths.

Change clause 7.10.3 as follows (add one line in bullet list, and change octet 8 row):

7.10.3 Exchange phase

…

The information in R-PARAM includes:

- The latency path MSG_{LP} to carry the downstream message-oriented portion of the overhead channel.
- Assignment of downstream frame bearers to downstream latency paths.
- The number of message octets MSG_c included in the downstream overhead structure.
- $B_{p,n}$ for each downstream latency path and frame bearer.
- M_p for each downstream latency path.
- R_p for each downstream latency path.
- D_p for each downstream latency path.
- T_p for each downstream latency path.
- L_p corresponding to each downstream latency path.
- The indication whether or not erasure decoding is used for each downstream latency path.

Table 7-21 – Format for PMS-TC PARAMS information

Octet number [i]	PMS-TC format bits [8 × i + 7 to 8 × i + 0]	Description
Octet 8	[~~m~~emmm mmmm] bit 7 to 0	In C-PARAMS, the bit e shall be coded as ZERO. If the last previous MS message has the 'erasure decoding reporting' bit (see Table 7-19) set to ZERO for the selected operating mode, then in R-PARAMS, the bit e shall be coded as ZERO. If the last previous MS message has the 'erasure decoding reporting' bit (see Table 7-19) set to ONE for the selected operating mode, then in R-PARAMS, the bit e shall be coded as: ZERO: Erasure decoding is used; ONE: Erasure decoding is not used. The bit e is always present and set to ZERO if not used. The bits ~~m~~mmmmmmm give the value of M_P for latency path #0. They are always present and set to zero if not used.

Change clause 8.12.3 as follows (add one line to the bullet list):

8.12.3 Test parameters

The following test parameters shall be passed on request from the receive PMD transmit function to the near-end management entity:

- Channel Characteristics Function H(f) per subcarrier (CCF-ps);
- Quiet Line Noise PSD QLN(f) per subcarrier (QLN-ps);
- Signal-to-Noise Ratio SNR(f) per subcarrier (SNR-ps);
- Line Attenuation (LATN);
- Signal Attenuation (SATN);
- Signal-to-Noise Margin (SNRM);
- Attainable Net Data Rate (ATTNDR);
- Far-end Actual Aggregate Transmit Power (ACTATP)~~.~~; and
- Far-end Actual Impulse Noise Protection for each bearer channel (INP_act_n).

Add new clause 8.12.3.9:

8.12.3.9 Actual impulse noise protection (INP_act)

The actual impulse noise protection INP_act_n of bearer channel #n is defined in clauses K.1.7, K.2.7 or K.3.7 (depending on the TPS-TC type). The value shall be represented as an 8-bit unsigned integer ***inpact***, with the value of *INP_act* defined as *INP_act* = ***inpact***/10 DMT symbols. This data format supports an *INP_act* granularity of 0.1 DMT symbols and an *INP_act* dynamic range of 0 to 25.4. The value inpact = 255 is a special value indicating an *INP_act* value higher than 25.4 DMT symbols.

Add row at the end of Table 9-30:

Table 9-30 – PMD test parameter ID values

Test parameter ID	Test parameter name	Length for single read	Length for multiple read	Length for block read
27_{16}	Far-end actual impulse noise protection (INP_act)	4 octets	N/a	N/a

Add paragraph at the end of clause 9.4.1.10:

In transferring the value of INP_act_n for each of the bearer channels, the INP_act_0 for bearer channel #0 shall be inserted into the message first, followed by INP_act_1, INP_act_2 and INP_act_3. The INP_act_n shall be coded as FF_{16} to indicate bearer #n is disabled. Support of the INP_act test parameter reporting is optional. However if in the last previous CLR message, the ATU-R set the 'erasure decoding reporting' bit (see Table 7-19) to ONE for the selected operating mode, then the ATU-R shall support INP_act test parameter reporting.

Add row to Table K.2 after INP_min row (same for Tables K.9 and K.18):

Table K.2 – STM-TC parameters

Parameter	Definition
$INP\_no\_erasure\_not\_required_n$	When set to ZERO for at least one bearer channel transported in latency path #*p*, the receiver shall set the derived parameter $INP_p = INP\_no\_erasure_p$. When set to ONE for all bearer channels transported in latency path #*p*, the receiver is not required to set $INP_p = INP\_no\_erasure_p$. NOTE – For backward compatibility reasons, this bit is named and coded opposite from G.993.2.

Change the following paragraph of clauses K.1.7, K.2.7 and K.3.7:

The impulse noise protection INP_act_n of transport of stream #*n* shall always be set to the value of the derived parameter INP_p of the underlying PMS-TC path function and constrained such that $INP\_act_n \geq INP\_min_n$ according to the definition of INP_p (see Table 7-7) regardless of any vendor discretionary techniques including, for example, the use of erasure decoding. The values net_act_n, $delay\_act_n$ and INP_act_n are not control parameters; these values are the result of specific initialization and reconfiguration procedures.

Add row to Table K.3 after INP_min row (same for Tables K.10 and K.19):

Table K.3 – Valid configuration for STM-TC function

Parameter	Capability
INP_no_erasure_not_required	0, 1 (Boolean)

Add row to Table K.4 after INP_min row (same for Tables K.11 and K.20):

Table K.4 – Mandatory downstream configuration for STM-TC function #0

Parameter	Capability
INP_no_erasure_not_required	0

Add row to Table K.5 after INP_min row (same for Tables K.12 and K.21):

Table K.5 – Mandatory upstream control configuration for STM-TC function #0

Parameter	Capability
INP_no_erasure_not_required	0

Change Table K.6 as follows:

Table K.6 – Format for an STM-TC CL and CLR message

	Definition of the parameter block of Npar(3) octets
	A parameter block of 10 octets containing: – the maximum supported value of *net_max*; – the maximum supported value of *net_min*; – the maximum supported value of *net_reserve*; – the maximum supported value of *delay_max*; – the maximum supported value of *error_max*; – the minimum Impulse Noise Protection *INP_min*; – the value of *INP_no_erasure_not_required*; and – the *CIpolicy* bitmap. The unsigned 12-bit *net_max*, *net_min* and *net_reserve* values represent the data rate divided by 4000 bit/s. The *delay_max* is a 6-bit unsigned value expressed in ms. A value of 000000 indicates no delay bound is being imposed. The *error_max* is a 2-bit indication, defined as 00 for an error ratio of 1E-3, 01 for an error ratio of 1E-5, and 10 for an error ratio of 1E-7. The value 11 is reserved. The *INP_min* value is an 8-bit indication, with values coded as defined in Table K.6a. The *INP_no_erasure_not_required* is a 1-bit value (Boolean) (see Note 1). The *CIpolicy* (see clause 7.10.3) is a 2-bit bitmap, representing the channel initialization policies ZERO and ONE (see Note 2).

Table K.6 – Format for an STM-TC CL and CLR message

NOTE 1 – This bit is defined for downstream bearer channels only. It shall be set to the same value for all downstream TC types (see clause 6.6.1.1) supported over a particular bearer channel. It may be set to a different value for different downstream bearer channels. In a CL message, this bit shall be set to ZERO if the 'erasure decoding reporting' bit is set to ZERO. In a CLR message, this bit shall be set to the same value as the 'erasure decoding reporting' bit. NOTE 2 – The CLR message shall indicate one or more policies supported by the ATU-R. The CL message shall indicate the single policy enabled by the CO-MIB. Support or enabling of only policy ZERO may be explicitly indicated by setting the related G.994.1 codepoint, or implicitly by not including the policy codepoints in the CLR or CL message.

Change Table K.7 as follows:

Table K.7 – Format for an STM-TC MS message

<table>
<tr><th></th><th>Definition of the parameter block of Npar(3) octets</th></tr>
<tr><td></td><td>A parameter block of 10 octets containing:
– the value of net_max;
– the value of net_min;
– the value of net_reserve;
– the value of delay_max;
– the value of error_max;
– the minimum Impulse Noise Protection INP_min; <s>and</s>
– the value of INP_no_erasure_not_required (see Note 1); and
– the CIpolicy bitmap (see Note 2).
The format and usage of the octets is as described in Table K.6.</td></tr>
<tr><td colspan="2">NOTE 1 – This bit shall be set to ONE if and only if it was set to ONE in both the last previous CL message and the last previous CLR message.
NOTE 2 – The MS message shall indicate the policy enabled for use with the bearer channel. Enabling of policy ZERO may be explicitly indicated by setting the related G.994.1 codepoint, or implicitly by not including the policy codepoints in the MS message.</td></tr>
</table>

Change Table K.15 as follows:

Table K.15 – Format for an ATM-TC CL and CLR message

	Definition of the parameter block of Npar(3) octets
	A parameter block of 10 octets containing: – the maximum supported value of *net_max*; – the maximum supported value of *net_min*; – the maximum supported value of *net_reserve*; – the maximum supported value of *delay_max*; – the maximum supported value of *error_max*; – the minimum Impulse Noise Protection *INP_min*; – the value of *INP_no_erasure_not_required;* – the support of *IMA_flag*; and – the *CIpolicy* bitmap (see Note 2 in Table K.6). The format and usage of the octets is as described in Table K.6. The *IMA_flag* is a single bit indication, set to 1 if IMA is supported and set to 0 if IMA is not supported or disabled.

Change Table K.16 as follows:

Table K.16 – Format for an ATM-TC MS message

	Definition of the parameter block of Npar(3) octets
	A parameter block of 10 octets containing: – the value of *net_max*; – the value of *net_min*; – the value of *net_reserve*; – the value of *delay_max*; – the value of *error_max*; – the minimum Impulse Noise Protection *INP_min*; – the value of *INP_no_erasure_not_required;* – the value of the *IMA_flag*; and – the *CIpolicy* bitmap (see Note 2 in Table K.7). The format and usage of the octets is as described in Table K.15 and Table K.7.

Change Table K.22 as follows:

Table K.22 – Format for a PTM-TC CL and CLR message

	Definition of the parameter block of Npar(3) octets
	A parameter block of 11 octets containing: – the maximum supported value of *net_max*; – the maximum supported value of *net_min*; – the maximum supported value of *net_reserve*; – the maximum supported value of *delay_max*; – the maximum supported value of *error_max*; – the minimum Impulse Noise Protection *INP_min*; – the value of *INP_no_erasure_not_required*; – the encapsulation type (see clause K.3.8); and – the *CIpolicy* bitmap (see Note 2 in Table K.6). The format and usage of the octets is as described in Tables K.6 and K.22a.

Change Table K.23 as follows:

Table K.23 – Format for an PTM-TC MS message

	Definition of the parameter block of Npar(3) octets
	A parameter block of 11 octets containing: – the value of *net_max*; – the value of *net_min*; – the value of *net_reserve*; – the value of *delay_max*; – the value of *error_max*; – the minimum Impulse Noise Protection *INP_min*; – the value of *INP_no_erasure_not_required*; – the encapsulation type (see clause K.3.8); and – the *CIpolicy* bitmap (see Note 2 in Table K.7). The format and usage of the octets is as described in Tables K.~~6~~7, K.22 and K.22a.

2 Impulse noise monitor

Add at end of clause 8.12.1 (ADSL line primitives)

Impulse noise monitoring primitives: see clause 8.12.6.3.

Add new clause 8.12.6 as follows:

8.12.6 Impulse noise monitoring (INM) facility

The INM facility is defined only for the ATU-R.

This clause describes the INM procedure (clause 8.12.6.1) and associated INM configuration parameters (clause 8.12.6.2) and INM primitives (clause 8.12.6.3).

8.12.6.1 Procedure of the INM facility

Figure 8-22a shows the INM facility functional block diagram.

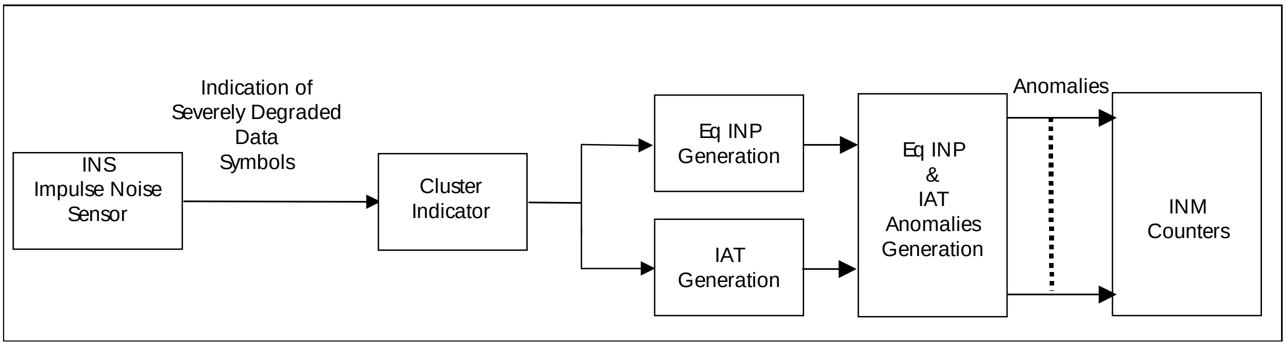

Figure 8-22a – Impulse noise monitor facility functional block diagram

The impulse noise sensor (INS) indicates whether a data symbol is severely degraded or not. A data symbol is considered to be severely degraded when it would lead to severe errors on the gamma interface when there would be no impulse noise protection (i.e., RS only used for coding gain). The implementation details for this sensor are vendor-discretionary.

NOTE 1 – Performance requirements for the INS are for further study.

If a sync symbol occurs between two data symbols (severely degraded or not), the impulse noise sensor shall disregard it.

NOTE 2 – If a sync symbol occurs between two groups of, respectively, N1 and N2 consecutive severely degraded data symbols, the two groups will form a single group of consecutive severely degraded data symbols of length N1 + N2 data symbols.

The cluster indicator indicates short groups of severely degraded data symbols as clusters. The cluster can contain a single severely degraded data symbol, a group of consecutive severely degraded data symbols, or several groups of one or more consecutive severely degraded data symbols with gaps between the groups.

The cluster indicator shall use the following rule to identify the cluster. A gap is defined as a group of non-severely degraded data symbols in-between two severely degraded data symbols. A cluster is defined as the largest group of consecutive data symbols, starting and ending with a severely degraded data symbol, containing severely degraded data symbols, separated by gaps smaller than or equal to INMCC (the cluster continuation parameter, see clause 8.12.6.2.3).

As a consequence of the above definition of a cluster, each cluster starts with a severely degraded data symbol preceded by a gap larger than INMCC and ends with a severely degraded data symbol followed by a gap larger than INMCC, while gaps inside the cluster are all smaller than or equal to INMCC.

In the Eq INP generation block, the "equivalent INP" of the cluster is generated. For each cluster, the following characteristics shall be determined:

– The impulse noise cluster length (INCL), defined as the number of data symbols from the first to the last severely degraded data symbol in the cluster.

– The impulse noise cluster degraded (INCD) data symbols, defined as the number of severely degraded data symbols in the cluster.

– The impulse noise cluster number of gaps (INCG), defined as the number of gaps in the cluster, with gap as defined above.

Depending on the value of the control parameter INM_INPEQ_MODE, the equivalent INP is generated as:

– INM_INPEQ_MODE = 0: $INP\_eq = INCL$ with INMCC = 0 (see clause 8.12.6.2.3).

– INM_INPEQ_MODE = 1: $INP\_eq = INCL$ with INMCC as configured (see clause 8.12.6.2.3).

– INM_INPEQ_MODE = 2: $INP\_eq = INCD$ with INMCC as configured (see clause 8.12.6.2.3).

– INM_INPEQ_MODE = 3:

For INCG < (8*erasuregain): $INP\_eq = \min\left(INCL, ceil\left[INCD * \left(\dfrac{1}{1-\dfrac{INCG}{8*erasuregain}}\right)\right]\right)$

For INCG ≥ (8*erasuregain): $INP\_eq = INCL$

with INMCC configured as described in clause 8.12.6.2.3, and

where the erasuregain is defined as:

$erasuregain = \dfrac{INP}{INP\_no\_erasure}$ with INP, and INP_no_erasure as defined in clause 7.6.1.

NOTE 1 – In case the bit "INP_no_erasure_not_required" (as defined in Table K.2 and as exchanged during the G.994.1 phase) is set to ZERO, the erasuregain is equal to 1.

NOTE 2 – For the case of R = 16, the INM_INPEQ_MODE = 3 formula is a lower bound of the INP_min setting required to provide error-free operation for the measured clusters. It is a good approximation for R values close to 16. Optimal choice of framing parameters typically leads to R values close to 16, even more so for large INP_min values. Choice of values R < 16 may lead to lower performance for impulse noise clusters with gaps.

– INM_INPEQ_MODE = 4: In this mode, the value of *INP_eq* shall correspond with the ATU-R's own estimate in the downstream direction, of the INP_min setting required to provide error-free operation for the cluster, with INMCC as configured (see clause 8.12.6.2.3). The method of computation of the ATU-R's own estimate is vendor-discretionary. For INM_INPEQ_MODE = 4 only, if INMCC is set to 64, the ATU-R shall use its own method for cluster indication. If INMCC < 64, the ATU-R shall use the cluster indicator as described in this clause for the INM_INPEQ_MODE = 1, 2 and 3.

Anomalies are generated for several values of INP_eq, as defined in clause 8.12.6.3.1. The counters of these anomalies represent the INP_eq histogram.

In the IAT generation block, the inter arrival time (IAT) is generated as the number of data symbols from the start of a cluster to the start of the next cluster. If sync symbols occur between two clusters, they shall not be counted in the IAT. Anomalies are generated for several ranges of inter arrival time, as defined in clause 8.12.6.3.3. The counters of these anomalies represent the IAT histogram.

For every data symbol, the total measurement count INMAME is increased by 1.

8.12.6.2 Configuration parameters of the INM facility

8.12.6.2.1 Definition of configuration parameter INMIATO

Configuration parameter INMIATO defines the INM inter arrival time offset for the IAT anomaly generation in order to determine in which bin of the inter arrival time histogram the IAT is reported (see clause 8.12.6.3.3).

The CO MIB shall provide the value for the INMIATO parameter. The parameter in the downstream direction is INMIATOds, and the parameter in the upstream direction is INMIATOus.

The valid values for INMIATO in both directions range from 3 to 511 DMT symbols in steps of 1 DMT symbol. If the ATU supports the INM facility, it shall support all valid values.

Upon entering the first showtime after power-up, the ATU-R shall use a default value of INMIATOds = 3. During showtime, this value may be overwritten by the ATU-C using an INM facility command defined in clause 9.4.1.11. A link state transition shall not affect the INMIATOds value (e.g., not reset the value to the default value).

The ATU-C shall use the current value of INMIATOus stored in the CO MIB.

8.12.6.2.2 Definition of configuration parameter INMIATS

Configuration parameter INMIATS defines the INM inter arrival time step for the IAT anomaly generation in order to determine in which bin of the inter arrival time histogram the IAT is reported (see clause 8.12.6.3.3).

The CO MIB shall provide the value for the INMIATS parameter. The parameter in the downstream direction is INMIATSds, and the parameter in the upstream direction is INMIATSus.

The valid values for INMIATS range from 0 to 7 in steps of 1. If the ATU supports the INM facility, it shall support all valid values.

Upon entering the first showtime after power-up, the ATU-R shall use a default value of INMIATSds = 0. During showtime, this value may be overwritten by the ATU-C using a INM facility command defined in clause 9.4.1.11. A link state transition shall not affect the INMIATSds value (e.g., not reset the value to the default value).

The ATU-C shall use the current value of INMIATSus stored in the CO MIB.

8.12.6.2.3 Definition of configuration parameter INMCC

Configuration parameter INMCC defines the INM cluster continuation value to be used in the cluster indication process described in clause 8.12.6.1. If INM_INPEQ_MODE = 0, INMCC is equal to zero, independent of the CO MIB setting. If INM_INPEQ_MODE > 0, the CO MIB shall provide the value for the INMCC parameter. The parameter in the downstream direction is INMCCds, and the parameter in the upstream direction is INMCCus.

The valid values for INMCC range from 0 to 64 DMT symbols in steps of 1 DMT symbol. If the ATU supports the INM facility, it shall support INMCC = 0. If the ATU supports the INM facility, and supports any INM_INPEQ_MODE > 0, it shall support all valid values.

Upon entering the first showtime after power-up, the ATU-R shall use a default value of INMCCds = 0. During showtime, this value may be overwritten by the ATU-C using a INM facility command defined in clause 9.4.1.11.

A link state transition shall not affect the INMCCds value (e.g., not reset the value to the default value).

The ATU-C shall use the current value of INMCCus stored in the CO MIB.

8.12.6.2.4 Definition of configuration parameter INM_INPEQ_MODE

Configuration parameter INM_INPEQ_MODE defines the means of computation of equivalent INP, as defined in clause 8.12.6.1. The CO MIB shall provide the value for the INM_INPEQ_MODE parameter. The parameter in the downstream direction is INM_INPEQ_MODEds, and the parameter in the upstream direction is INM_INPEQ_MODEus.

The valid values for INM_INPEQ_MODE are 0, 1, 2, 3 and 4. If the ATU supports the INM facility, it shall support INM_INPEQ_MODE = 0. All other modes are optional. If the ATU supports any INM_INPEQ_MODE > 0, it shall support at least INM_INPEQ_MODE = 1, 2 and 3.

Upon entering the first showtime after power-up, the ATU-R shall use a default value of INM_INPEQ_MODEds = 0. During showtime, this value may be overwritten by the ATU-C using a INM facility command defined in clause 9.4.1.11.

A link state transition shall not affect the INM_INPEQ_MODE value (e.g., not reset the value to the default value).

The ATU-C shall use the current value of INM_INPEQ_MODEus stored in the CO MIB.

8.12.6.3 Primitives of the INM facility

INM-related primitives represent anomalies related to PMD and PMS-TC sub-layers.

8.12.6.3.1 Definition of INM INPEQ histogram primitives

$INMAINPEQ_1$.$INMAINPEQ_{16}$: Every $INMAINPEQ_i$ is a primitive detected at the near end only. This anomaly occurs when the equivalent INP (as defined in clause 8.12.6.1) is exactly *i* DMT symbols.

$INMAINPEQ_{17}$ is a primitive detected at the near end only. This anomaly occurs when the equivalent INP (as defined in clause 8.12.6.1) is strictly more than 16 DMT symbols.

8.12.6.3.2 Definition of INM total measurement primitive

INMAME is a primitive detected at the near end only. This indication occurs every time a data symbol is processed by the impulse noise sensor.

8.12.6.3.3 Definition of INM inter arrival time histogram primitives

$INMAIAT_0$ is a primitive detected at the near end only. This anomaly occurs when the reported value of IAT falls in the range from 2 to INMIATO – 1, both boundaries inclusive.

$INMAIAT_1$..$INMAIAT_6$: Every $INMAIAT_i$ is a primitive detected at the near end only. This anomaly occurs when the reported value of IAT falls in the range from $INMIATO + (i - 1)*(2^{INMIATS})$ to $(INMIATO - 1) + i*(2^{INMIATS})$, both boundaries inclusive.

$INMAIAT_7$ is a primitive detected at the near end only. This anomaly occurs when the reported value of IAT, falls in the range from $INMIATO + 6*(2^{INMIATS})$ to infinity.

Change clause 9.4.1 as follows.

All commands received from Tables 9-2, 9-3 and 9-4 are mandatory, except when noted otherwise. All mandatory commands shall have a response, noting that the PMS-TC function will discard improperly framed or formatted messages. The responder shall respond within the timeout period displayed in Table 7-17 (dependent on the overhead command priority) less than 50 ms to prevent protocol glare interaction between the ATUs. Shorter responses are allowed and may be required in some application-specific situations outside the scope of this Recommendation.

The ATU should reply with unable-to-comply (UTC) response on the optional commands for which the ATU does not recognize the assigned message designator value. The UTC response shall include 2 octets: the first octet of the UTC shall be the same as the first octet of the received command, and the second octet shall be FF_{16}. The UTC response shall be sent as a high priority overhead message.

NOTE – If the UTC response is not supported, the command will time out. This would reduce the efficiency of the eoc.

Table 9-2 – Highest priority overhead messages

Message and designator	Direction	Command content	Response content
On-line Reconfiguration (OLR) Command 0000 0001_b	From a receiver to the transmitter	New configuration including all necessary PMS-TC and PMD control values.	Followed by either a line signal corresponding to the PMD.Synchflag primitive (not a OLR command) or an OLR command for defer or reject.
NOTE – The UTC response shall be sent as a high priority overhead message.			

Table 9-4 – Low priority overhead messages

Message and designator	Direction	Comment content	Response content
PMD Test Parameter Read Command 1000 0001_b	From either ATU to the other	Parameter number for single read, parameter number and subcarrier id for multiple read, null for next multiple read.	Followed by a PMD test parameter read command response including the requested test parameters or a negative acknowledge.
INM facility 1000 1001_2 (optional)	From ATU-C to ATU-R	Set or read out the INM data.	An acknowledgment of the INM facility set command, or a response including the INM data.
Non-Standard Facility Low Priority Command 1011 1111_b	From one ATU to the other	Non-standard identification field followed by message content.	Followed by a non-standard facility command for either acknowledge or negative acknowledge to indicate if the non-standard identification field is recognized.

Add new clause 9.4.1.11

9.4.1.11 INM facility commands and responses

Support of the INM facility commands and responses is optional.

An ATU-R that supports the INM functionality shall maintain INM counters to measure the impulse noise, as described in ITU-T Rec. G.997.1 [4]. The INM facility commands shall be used to update and read the INM parameters at the ATU-R.

The INM facility command shall be used also to retrieve the current value of the INM counters maintained by the far-end ATU in accordance with ITU-T Rec. G.997.1 [4].

The INM facility commands are described in Table 9-30a, and may only be initiated by the ATU-C. The ATU-R shall reply using one of the responses shown in Table 9-30b. The first octet of all INM facility commands and responses shall be the assigned value for the INM facility command type, as shown in Table 9-4. The remaining octets shall be as specified in Tables 9-30a and 9-30b for commands and responses, respectively.

Table 9-30a – INM facility commands sent by the ATU-C

Name	Length (Octets)	Octet number	Content
Read INM counters	2	2	02_{16}
Set INM parameters	6	2	03_{16}
		3 to 6	4 octets of INM parameters: see Table 9-30e.
Read INM parameters	2	2	04_{16}
NOTE – All other values for octet number 2 are reserved by ITU-T.			

Table 9-30b – INM facility responses sent by the ATU-R

Name	Length (Octets)	Octet number	Content
ACK	3	2	80_{16}
		3	1 octet INM acceptance code: see Table 9-30c.
NACK	2	2	81_{16}
INM counters	107	2	82_{16}
		3 to 2 + 4 × (17 + 1 + 8)	Octets for all of the INM counter values: see Table 9-30d.
		107	1 octet INMDF
INM parameters	6	2	84_{16}
		3 to 6	4 octets of INM parameters: see Table 9-30e.
NOTE – All other values for octet number 2 are reserved by ITU-T.			

Upon reception of any INM facility command, the ATU-R shall send NACK in response, if it does not support the INM procedure or the INM command is invalid. Upon reception of an INM facility set INM parameters command, the ATU-R shall send the ACK in response if it does support the INM procedure.

In case all INM parameter values listed in the set INM parameters command are valid and supported by the ATU-R, the ATU-R shall accept all of the INM parameters contained in the command. The INM acceptance code (see Table 9-30c) will indicate that the parameters are accepted. If, for any of the INM parameters, the value in the command is different from the value in active use by the INM, the ATU-R shall activate the new INM parameter values and reset the counters less than 1 second after sending the ACK.

In case any INM parameter value listed in the set INM parameters command is valid but not supported by the ATU-R, the ATU-R shall not accept any of the INM parameters and shall not reset the counters.

Upon reception of the INM facility read INM parameters command, the ATU-R shall send the INM parameters response that includes the current value of the ATU-R INM parameters.

Table 9-30c – ATU-R INM acceptance code

Name	Octet #	Content
ACC-INM_INPEQ_MODE	3	80_{16}: value for INM_INPEQ_MODE accepted
NACC-INM_INPEQ_MODE	3	81_{16}: value for INM_INPEQ_MODE not supported

Upon reception of the INM facility read INM counters command, the ATU-R shall send the INM counters response, which includes the INMDF. Any function of either the requesting ATU-C or the responding ATU-R shall not be affected by this command.

The INM counter values shall be derived according to ITU-T Rec. G.997.1 [4] from locally generated defects and anomalies defined within clause 8.12.6.3. The parameters shall be transferred in the order (top to bottom) defined in Table 9-30d. All counter values are defined as 32-bit counters and shall be mapped to the response in order of most significant to least significant octet.

The INM counters shall be reset at power-up, and shall not be reset upon any link state transition, and shall not be reset upon read. They shall be reset at activation of the new INM parameter values. The reset value is zero. The INM counters and the procedure to update the counters shall work continuously and independently of other (proprietary or non-proprietary) features, e.g., the INM shall work in the presence of OLR and without interruption.

NOTE – The ATU-C should respond to the request from the NMS to read the values of INM counters. It is left to the implementations to store and update the counters as necessary for accurate monitoring and reporting.

Table 9-30d – ATU-R INM counters

INM counters
Counter of the $INMAINPEQ_1$ anomalies
Counter of the $INMAINPEQ_2$ anomalies
..
Counter of the $INMAINPEQ_{16}$ anomalies
Counter of the $INMAINPEQ_{17}$ anomalies
Counter of the $INMAIAT_0$ anomalies
Counter of the $INMAIAT_1$ anomalies
..
Counter of the $INMAIAT_6$ anomalies
Counter of the $INMAIAT_7$ anomalies
Counter of the INMAME anomalies

The ATU-R shall set the INM default flag (INMDF) to ONE, whenever all active INM parameters are equal to the default values. The ATU-R shall set the INM default flag (INMDF) to ZERO, whenever any active INM parameter is different from the default value.

The INM parameter values shall be transferred in the order defined in Table 9-30e, and mapped in order of most significant to least significant octet.

Table 9-30e – ATU-R INM parameters

Octet #	INM parameter
3-4	2 octets: – The 9 LSBs are INMIATO. – The 4 MSBs are INMIATS.
5	1 octets: INMCC
6	1 octets: INM_INPEQ_MODE

3 C-REVERB PRBS

Change the equation in clause 8.13.4.1.1 (C-REVERB1) as follows (i.e., insert minus sign between "2" and "n" in sub-index of d in 4th line of equation):

The data pattern modulated on a C-REVERB symbol shall be the pseudo-random binary sequence (PRBS), d_n for $n = 1$ to $4 \times NSCds$, defined as follows:

$$
\begin{aligned}
&= 1 && \text{for } n = 1 \text{ to } 9;\\
&= d_{n-4} \oplus d_{n-9} && \text{for } n = 10 \text{ to } 2 \times NSCds;\\
d_n &= d_{n-2\times NSCds} && \text{for } n = 2\times NSCds + 1 \text{ to } 2\times NSCds + 2;\\
&= d_{4\times NSCds+2\underline{-}n} && \text{for } n = 2\times NSCds + 3 \text{ to } 4\times NSCds\ (n \text{ odd});\\
&= 1 \oplus d_{4\times NSCds+4-n} && \text{for } n = 2\times NSCds + 3 \text{ to } 4\times NSCds\ (n \text{ even});
\end{aligned}
$$

4 Virtual noise

Add rows at end of Table 8-6 as follows:

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 is enabled.
TXREFVN	The transmitter-referred virtual noise PSD to be used in determining the SNR margin (see clause 8.5.1.1). The parameter can be different for ATU-C (TXREFVNus) and ATU-R (TXREFVNds), and is configured through the CO-MIB. The TXREFVNds is exchanged during the initialization channel discovery phase.

Add new clause 8.5.1.1.

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 mode SNRM_MODE = 2.

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 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 $t_{NBP} = rounddown(f_H/\Delta f)$, 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: $f_n = t_n \times \Delta f$.

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 W/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.

8.5.1.1.2 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 in-band 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(i) = REFPSD + log_tssi(i)

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

g_i = 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 a 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, with the value of *NBPds* set during the 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 *NSCds* – 1, and bits 7 to 0 representing an 8-bit PSD value as defined in clause 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). 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. 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) are of concern.

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

8.12.3.2 Quiet line noise PSD per subcarrier (QLN-ps)

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. <u>The received virtual noise PSD as defined in SNRM_MODE = 2 shall not be taken into account in QLN(*f*).</u>

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

8.12.3.3 Signal-to-noise ratio per subcarrier (SNR-ps)

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. <u>The received virtual noise PSD as defined in SNRM_MODE = 2 shall not be taken into account in SNR(*f*).</u>

Replace clause 8.12.3.6 with the following:

8.12.3.6 Signal-to-noise ratio margin ~~(*SNRM*)~~

8.12.3.6.1 General definition of signal-to-noise ratio margin

The signal-to-noise ratio margin is the maximum increase (scalar gain, in dB) of the reference noise PSD (at all relevant frequencies), such that the BER of each TPS-TC stream does not exceed the maximum BER specified for the corresponding TPS-TC stream, without any change of PMD parameters (e.g., bits and gains) and PMS-TC parameters (e.g., L_p, FEC parameters). The BER is referenced to the output of the PMS-TC function (i.e., the α/β interface).

The definition of the reference noise PSD depends on the control parameter SNRM_MODE.

8.12.3.6.1.1 SNRM_MODE = 1

SNRM_MODE = 1 is a mandatory capability for both ATUs.

The reference noise PSD equals the received current-condition external noise PSD only, as measured by the near-end transceiver (i.e., equal to the PSD of the noise measured by the near-end transceiver at the constellation decoder or other relevant internal reference point when the only noise source is the external stationary noise applied to the U interface and no internal noise sources are present).

NOTE – Mathematically this can be illustrated by:

$$\text{Received\_External\_Noise\_PSD} = |\,H_{\text{RXfilter}}(f)\,|^2 \times \text{External\_Noise\_PSD\_at\_U\_interface}$$

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.

$$\text{Received\_Virtual\_Noise\_PSD} = |\,H(f)\,|^2 \times \text{TXREFVN}$$

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

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.

The signal-to-noise ratio margin shall be measured by the receive PMD function during initialization and diagnostics mode. The measurement may be updated autonomously and shall be updated on request during showtime. The signal-to-noise ratio margin shall be sent to the far-end transmit PMD function during initialization and diagnostics mode (see clause 8.15.1) and shall be sent on request to the near-end management entity. The near-end management entity shall send the *SNRM* to the far-end management entity on request during showtime (see clause 9.4.1.10).

To determine the signal-to-noise ratio margin (*SNRM*), the receive PMD function must be able to first determine the bits and gains table. During diagnostics mode, the receive PMD function may measure the *SNRM* value or, alternatively, may use the special value to indicate that the *SNRM* value was not measured.

The signal-to-noise ratio margin shall be represented as an 10-bit 2s complement signed integer ***snrm***, with the value of *SNRM* defined as *SNRM* = ***snrm***/10 dB. This data format supports an *SNRM* granularity of 0.1 dB and an *SNRM* dynamic range of –51.1 to +51.1 dB.

An *SNRM* value indicated as ***snrm*** = –512 is a special value. It indicates that the signal-to-noise ratio margin is out of range to be represented. During diagnostics mode, the special value may also be used to indicate that the *SNRM* value was not measured.

Change clause 8.12.3.7 as follows (add item to bullet list in first paragraph):

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.

To accurately determine the attainable net data rate (*ATTNDR*), the receive PMD function must be able to first determine the bits and gains table. Therefore, during diagnostics mode, the *ATTNDR* value shall be defined as an estimate of the line rate (without coding), calculated as:

$$ATTNDR = \left(\sum_{i=0}^{NSC-1} \left[\log_2 \left(1 + 10^{(SNR(i) - snrgap - TARSNRM)/10} \right) \right] \right) \times 4 \text{ kbit/s}$$

with *SNR*(i × Δf) in dB as defined in clause 8.12.3.3, but accounting for the received virtual noise PSD when configured in SNRM_MODE = 2, and *snrgap* = 9.75 dB (see Note). The function [x] is equal to 0 for x < 0, is equal to *BIMAX* for x > *BIMAX* and rounding to the nearest integer for 0 ≤ x ≤ *BIMAX*. The values of *BIMAX* and *TARSNRM* are defined in Table 8-48.

Change Table 8-20 as follows (add row to Par(2) part):

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

NPar(2) bit	**Definition**
Tones 1 to 32	Applies to ISDN-related service options only (see annexes).
Diagnostics Mode	When set to 1, indicates the ATU-C wants to enter diagnostics mode (see 8.15). When set to 0, indicates the ATU-C wants to enter initialization (see 8.13).
Short Initialization	When set to 1, indicates the ATU-C supports the Short Initialization (see 8.14). When set to 0, indicates the ATU-C does not support the Short Initialization.
Support of downstream virtual noise	When set to 1, indicates that the ATU-C supports the use of the downstream virtual noise mechanism, and SNRM_MODEds = 2. When set to 0, indicates that the ATU-C does not support the use of the downstream virtual noise mechanism, or SNRM_MODEds = 1.
Spar(2) bit	**Definition of related Npar(3) bits**
Number of breakpoints for downstream virtual noise PSD	A one octet parameter block indicating the number of breakpoints for the downstream virtual noise PSD (range 2 to 16, coded in 5 bits, see clause 8.5.1.1.2). This Spar(2) bit shall be set to the same value as the NPar(2) 'support of downstream virtual noise' bit.

Change Table 8-21 as follows (add row at end of Par(2) part):

Table 8-21 – ATU-C MS message Par(2) PMD bit definitions

NPar(2) bit	Definition
Tones 1 to 32	Applies to ISDN related service options only (see annexes).
Diagnostics Mode	Set to 1 if the CL or the CLR message have this bit set to 1. When set to 1, indicates both ATUs shall enter diagnostics mode (see 8.15). When set to 0, indicates both ATUs shall enter initialization (see 8.13).
Short Initialization	Set to 1 if and only if this bit was set to 1 in both the last previous CL message and the last previous CLR message. When set to 1, indicates the ATUs may use the Short Initialization (see 8.14). When set to 0, indicates the ATUs shall not use the Short Initialization.
Support of downstream virtual noise	Set to 1 if and only if this bit was set to 1 in both the last previous CL and the last previous CLR message. When set to 1, indicates that the downstream virtual noise mechanism shall be used (see clause 8.5.1.1) and that the *NBPds* value shall be as indicated in the CL message. When set to 0, indicates that the downstream virtual noise mechanism shall not be used and that the *NBPds* value shall be set to 0.
Spar(2) bit	**Definition of related Npar(3) bits**
Number of breakpoints for downstream virtual noise PSD	Parameter block shall not be included. This SPar(2) bit shall be set to 0.

Change Table 8-22 as follows (add row to Par(2) part):

Table 8-22 – ATU-R CLR message Par(2) PMD bit definitions

NPar(2) bit	Definition
Tones 1 to 32	Applies to ISDN related service options only (see annexes).
Diagnostics Mode	When set to 1, indicates the ATU-R wants to enter diagnostics mode (see 8.15). When set to 0, indicates the ATU-R wants to enter initialization (see 8.13).
Short Initialization	When set to 1, indicates the ATU-R supports the Short Initialization (see 8.14). When set to 0, indicates the ATU-R does not support the Short Initialization.
Support of downstream virtual noise	When set to 1, indicates that the ATU-R supports the use of the downstream virtual noise mechanism. When set to 0, indicates that the ATU-R does not support the use of the downstream virtual noise mechanism.
Spar(2) bit	**Definition of related Npar(3) bits**
Number of breakpoints for downstream virtual noise PSD	Parameter block shall not be included. This SPar(2) bit shall be set to 0.

Change Table 8-23 as follows (add row to Par(2) part):

Table 8-23 – ATU-R MS message Par(2) PMD bit definitions

NPar(2) bit	**Definition**
Tones 1 to 32	Applies to ISDN related service options only (see annexes).
Diagnostics Mode	Set to 1 if the CL or the CLR message have this bit set to 1. When set to 1, indicates both ATUs shall enter diagnostics mode (see 8.15). When set to 0, indicates both ATUs shall enter initialization (see 8.13).
Short Initialization	Set to 1 if, and only if, this bit was set to 1 in both the last previous CL message and the last previous CLR message. When set to 1, indicates the ATUs may use the Short Initialization (see 8.14). When set to 0, indicates the ATUs shall not use the Short Initialization.
Support of downstream virtual noise	Set to 1 if and only if this bit was set to 1 in both the last previous CL and the last previous CLR message. When set to 1, indicates that the downstream virtual noise mechanism shall be used (see clause 8.5.1.1) and that the *NBPds* value shall be as indicated in the CL message. When set to 0, indicates that the downstream virtual noise mechanism shall not be used and that the *NBPds* value shall be set to 0.
Spar(2) bit	**Definition of related Npar(3) bits**
Number of breakpoints for downstream virtual noise PSD	Parameter block shall not be included. This SPar(2) bit shall be set to 0.

Change clause 8.13.3.1.11 as follows:

8.13.3.1.11 C-MSG-PCB

In each direction, the transmit power will be reduced by a power cutback which is the highest of the power cutback values determined by the ATU-R and the ATU-C. The ATU-C can consider its receiver dynamic range as determined by observing R-COMB2, the local line conditions determined by the optional C-LINEPROBE, and policy matters such as spectral limits when determining its cutback levels.

In order to provide non-reciprocal FEXT control, the ATU-C shall request an upstream transmit power cutback in the C-MSG-PCB message, such that the power received at the ATU-C is no higher than the maximum level indicated by MAXRXPWR as specified in the CO-MIB (see 8.5.1). The power received at the ATU-C shall be measured over three subcarriers: subcarriers 12, 18 and 24 for Annexes A and I and subcarriers 36, 42 and 48 for Annexes B and J.

NOTE 1 – The ATU-C should take into account the spectrum shaping on these subcarriers when determining the required upstream power cutback (PCBus) value.

The C-MSG-PCB state is of fixed length. In the C-MSG-PCB state, the ATU-C shall transmit 96 $+ 72 \times NBPds$ or $96 + 3 \times NSCus + 72 \times NBPds$ symbols of C-COMB or C-ICOMB to modulate the C-MSG-PCB message and CRC, depending on whether the C-BLACKOUT bits are included or not. The C-MSG-PCB message conveys the ATU-C determined power cutback levels for both the upstream and downstream directions, the hook status as known by the ATU-C, ~~and~~ the upstream BLACKOUT bits and the *NBPds* breakpoints for the downstream virtual noise PSD (see clause 8.5.1.1.2).

The ATU-C shall indicate in the C-MSG-FMT message whether the C-MSG-PCB message includes the C-BLACKOUT bits or not. If the C-MSG-PCB does not include the C-BLACKOUT bits, the C-MSG-PCB message, *m*, is defined by:

$$m = \{m_{15+24\times NBPds}, \ \dots \ , m_0\},$$

and bits shall be defined as shown in Table 8-27a.

Table 8-27a – Bit definition for the C-MSG-PCB message without BLACKOUT

Bit index	Parameter	Definition
5…0	*C-MIN_PCB_DS*	ATU-C Minimum Downstream Power Cutback (6 bit value with MSB in bit 5 and LSB in bit 0)
11…6	*C-MIN_PCB_US*	ATU-C Minimum Upstream Power Cutback (6 bit value with MSB in bit 11 and LSB in bit 6)
13…12	*HOOK_STATUS*	Hook Status (2 bit value with MSB in bit 13 and LSB in bit 12)
15…14		Reserved, set to 0.
15+24×*NBPds*...16	*TXREFVNds*	*NBPds* breakpoints for downstream virtual noise PSD (24 bits per breakpoint, as defined in clause 8.5.1.1.2)

If the C-MSG-PCB includes the C-BLACKOUT bits, the C-MSG-PCB message, *m*, is defined by:

$$m = \{m_{15+NSCus+24\times NBPds}, \ \dots \ , m_0\},$$

~~B~~and bits shall be defined as shown in Table 8-27b.

Table 8-27b – Bit definition for the C-MSG-PCB message

Bit index	Parameter	Definition
5…0	*C-MIN_PCB_DS*	ATU-C Minimum Downstream Power Cutback (6 bit value with MSB in bit 5 and LSB in bit 0)
11…6	*C-MIN_PCB_US*	ATU-C Minimum Upstream Power Cutback (6 bit value with MSB in bit 11 and LSB in bit 6)
13…12	*HOOK_STATUS*	Hook Status (2 bit value with MSB in bit 13 and LSB in bit 12)
15…14		Reserved, set to 0.
15 + *NSCus*...16	*C-BLACKOUT*	Blackout indication per subcarrier (subcarrier *NSCus* – 1 in bit 15 + *NSCus*, subcarrier 0 in bit 16). Bit 16 shall be set to 0 (i.e., no blackout of DC subcarrier).
15+*NSCus*+24×*NBPds* ... 16 + *NSCus*	*TXREFVNds*	*NBPds* breakpoints for downstream virtual noise PSD (24 bits per breakpoint, as defined in clause 8.5.1.1.2)

The ATU-C Minimum Downstream Power Cutback level shall be coded as defined in Table 8-28.

Table 8-28 – ATU-C minimum downstream power cutback

Value (6 bits)	ATU-C minimum downstream power cutback (dB)
0	0
1	1
...	...
40	40
41-63	Reserved

The ATU-C Minimum Upstream Power Cutback level shall be coded as defined in Table 8-29.

Table 8-29 – ATU-C minimum upstream power cutback

Value (6 bits)	ATU-C minimum upstream power cutback (dB)
0	0
1	1
...	...
40	40
41-63	Reserved

The POTS hook status shall be coded as defined in Table 8-30. The hook state "Unknown" is intended to be indicated by a device that normally indicates the on- or off-hook state. The state "Not capable to detect" is intended to be indicated by a device that never indicates the on- or off-hook state (e.g., is not capable or disabled to detect the hook state).

Table 8-30 – Hook status

Value (2 bits)	Hook status
0	Unknown
1	On-hook
2	Off-hook
3	Not capable to detect

The POTS Hook Status shall be coded as Unknown when operating without underlying service (i.e., Annexes I and J).

NOTE 2 – The POTS Hook Status may be indicated when operating with underlying service (i.e., Annexes A and B). In the case of Annex B, the ADSL signal allows for an underlying ISDN service, however, it may actually be operated with an underlying POTS service.

The C-BLACKOUT bits shall contain the C-BLACKOUT bit settings for each of the subcarriers 1 to *NSCus* – 1. The C-BLACKOUT bit set to 0 for a particular subcarrier indicates that the ATU-R shall transmit that subcarrier at the ATU-R reference transmit PSD level (*REFPDSus*) level, and including spectral shaping, for the remainder of initialization, starting from the Transceiver Training Phase. The C-BLACKOUT bit be set to 1 indicates that the ATU-R shall transmit no power ("blackout") on that subcarrier, for the remainder of initialization, starting from the Transceiver Training Phase.

A C-MSG-PCB message containing $16\underline{+ 24 \times NBPds}$ bits $m_{15\underline{+ 24 \times NBPds}} – m_0$ shall be transmitted in

$48 \underline{+ 72 \times NBPds}$ symbol periods (m_0 first and $m_{15 \underline{+ 24 \times NBPds}}$ last). A C-MSG-PCB message containing $16 + NSCus \underline{+ 24 \times NBPds}$ bits $m_{15 + NSCus \underline{+ 24 \times NBPds}} - m_0$ shall be transmitted in $48 + 3 \times NSCus \underline{+ 72 \times NBPds}$ symbol periods (m_0 first and $m_{15 + NSCus \underline{+ 24 \times NBPds}}$ last). A zero bit shall be transmitted as three consecutive C-COMB symbols. A one bit shall be transmitted as three consecutive C-ICOMB symbols.

After the C-MSG-PCB message has been transmitted, a CRC shall be appended to the message. The 16 CRC bits shall be computed in the same way as for the C-MSG-FMT message.

The 16 bits c_0-c_{15} shall be transmitted in 48 symbol periods (c_0 first and c_{15} last) using the same modulation as used to transmit the message m.

The C-MSG-PCB state shall be followed by the C-QUIET4 state.

Add new Annex P. Annex O is intentionally left blank so Annex P stands for power.

Annex O

This annex is intentionally left blank.

Annex P

Reduced downstream aggregate transmit power requirements

P.1 Scope

This annex defines reduced downstream aggregate transmit power (ATP) requirements for implementations of this Recommendation, e.g., from the cabinet where high transmit power is not required and would be inefficient.

An ATU-C compliant with the reduced downstream ATP requirements listed in this annex is not required to comply to the performance requirements defined in Annex F and Annex G. Instead, it is expected that such ATU-C implementation has a significantly lower power consumption than an ATU-C compliant with Annex F or Annex G.

P.2 Downstream ATP requirements

The downstream maximum nominal aggregate transmit power (MAXNOMATPds) is a transmit PMD function control parameter defined in Table 8-4. It configures the maximum value for the derived NOMATPds parameter defined in Table 8-5. The MAXNOMATPds value depends on CO-MIB element settings and local capabilities and is exchanged in the G.994.1 phase in the downstream spectrum bounds parameter block (see Table 8-20). The value is coded relative to a default setting, which is defined for each operating mode separately (e.g., in Table A.1 for operation according to Annex A).

Annexes F and G define regional performance requirements for region A (North America) and region B (Europe), respectively. These performance requirements are set assuming (but not requiring) that the ATU-C is capable of transmitting an aggregate power related to the MAXNOMATPds default setting. Hence, this Recommendation does not define minimum downstream ATP requirements as such, but only indirectly via the Annexes F and G performance requirements.

P.3 Reduced downstream ATP requirements

An ATU-C compliant with this annex shall indicate in the G.994.1 phase a MAXNOMATPds parameter value that shall not exceed the value listed in Table P.1, even the Table P.1 value is lower than the related setting for the CO-MIB element MAXNOMATPds (see clause 7.3.1.2.3 of ITU-T Rec. G.997.1 [4]).

An ATU-C compliant with this annex shall comply with one of the ATP limits defined in Table P.1. Multiple ATP limits are defined, each corresponding with a different maximum G.994.1 MAXNOMATPds value.

Table P.1 – Maximum G.994.1 MAXNOMATPds values

ATP limit	Maximum G.994.1 MAXNOMATPds value
ATPlimit14	14.5 dBm
ATPlimit11	11.5 dBm

The ATU-C ATP limit is independent of the ATU-C operating mode. The values listed in Table P.1 apply to all of the operating modes defined in various annexes of this Recommendation.

This Recommendation does not define performance requirements for an ATU-C compliant with this annex.

Add the following to the bibliography:

[B21] ITU-T Recommendation G.993.2 (2006), *Very high speed digital subscriber line tranceivers 2 (VDSL2)*.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	**Transmission systems and media, digital systems and networks**
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Terminals and subjective and objective assessment methods
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	Global information infrastructure, Internet protocol aspects and next-generation networks
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2009