International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.993.2

Amendment 5

(04/2010)

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

Digital sections and digital line system – Access networks

Very high speed digital subscriber line transceivers 2 (VDSL2)

Amendment 5: Enhanced handling of noise and other improvements

Recommendation ITU-T G.993.2 (2006) – Amendment 5

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Recommendation ITU-T G.993.2

Very high speed digital subscriber line transceivers 2 (VDSL2)

Amendment 5

Enhanced handling of noise and other improvements

Summary

Amendment 5 to Recommendation ITU-T G.993.2 provides support for receiver-referred virtual noise, virtual noise scaling factors, and support for Recommendations ITU-T G.998.4 and G.993.5 by including variable length fields in the initialization messages. It also includes changes to the LATN definition to avoid interoperability issues.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.993.2	2006-02-17	15
1.1	ITU-T G.993.2 (2006) Cor. 1	2006-12-14	15
1.2	ITU-T G.993.2 (2006) Amend. 1	2007-04-06	15
1.3	ITU-T G.993.2 (2006) Amend. 1 Cor. 1	2007-07-29	15
1.3	ITU-T G.993.2 (2006) Cor. 2	2007-07-29	15
1.5	ITU-T G.993.2 (2006) Amend. 2	2008-02-06	15
1.6	ITU-T G.993.2 (2006) Amend. 3	2008-08-22	15
1.7	ITU-T G.993.2 (2006) Amend. 4	2009-01-13	15
1.8	ITU-T G.993.2 (2006) Cor. 3	2009-06-29	15
1.9	ITU-T G.993.2 (2006) Amend. 5	2010-04-22	15

FOREWORD

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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.

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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/.

Recommendation ITU-T G.993.2

Very high speed digital subscriber line transceivers 2 (VDSL2)

Amendment 5

Enhanced handling of noise and other improvements

Revise the following clauses:

11.4.1.1.2 Quiet line noise PSD per sub-carrier group (QLN-ps)

The quiet line noise PSD QLN(*f*) for a particular sub-carrier is the rms level of the noise present on the loop when no VDSL2 signals are present on the loop. The received virtual noise PSD as defined in SNRM_MODE=2, SNRM_MODE=3, and SNRM_MODE=4 shall not be taken into account in QLN(*f*).

…

11.4.1.1.3 Signal-to-noise ratio per sub-carrier group (SNR-ps)

The signal-to-noise ratio SNR(*f*) for a particular sub-carrier is a real value that shall represent the ratio between the received signal power and the received noise power for that sub-carrier. The received virtual noise PSD as defined in SNRM_MODE=2, SNRM_MODE=3, and SNRM_MODE=4 shall not be taken into account in SNR(*f*).

11.4.1.1.4 Loop attenuation per band (LATN-pb)

…

The loop attenuation of the *m*th downstream band (LATN_D(*m*)) is the squared magnitude of the channel characteristics function H(*f*) (as defined in clause 11.4.1.1.1) averaged over all sub-carriers of the *m*th downstream band converted to dB. LATN_D(*m*) shall be defined as:

$$LATN\_D(m) = -10 \times \log_{10}\left(\frac{\sum_{i=n1}^{n2}\left|H\left(i \times \Delta f\right)\right|^2}{N\_D(m)}\right)$$

with *N_D(m)* (the number of sub-carriers in the *m*th downstream band) = $n2-n1+1$ where $n1$ and $n2$ are the indices of the first and the last sub-carriers of this band, respectively, and H(*f*) is represented by Hlin(*f*) in Loop Diagnostic mode and by Hlog(*f*) in initialization (with conversion of $\log_{10}$ to linear values for use in the above equation).

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11.4.1.1.6.1.3 SNRM_MODE = 3

SNRM_MODE = 3 is an optional capability for upstream (i.e., VTU-O receiver) only.

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.

$$Received\_Virtual\_Noise\_PSD = \left|H_{RXfilter}(f)\right|^2 \times RXREFVN$$

where:

- $|H_{RXfilter}(f)|$ is the magnitude of the transfer function between the U-interface and the common internal reference point; and
- RXREFVN is the receiver-referred virtual noise PSD MIB parameter.

  NOTE – A measurement of the current-condition external noise PSD could be overly optimistic, as it only represents a snapshot in time, not taking into account the future increase in noise PSD (e.g., due to additional VDSL2 lines being switched on). The SNRM_MODE = 3 is defined to prevent the VTU's bit loading algorithm from assigning an overly optimistic number of bits to a sub-carrier. This is achieved by defining (via the receiver-referred virtual noise PSD parameter RXREFVN) an anticipated noise PSD, which may be a function of frequency that can be used for bit loading.

This method can be used to avoid or reduce periods with excessive BER and retrains, in order to assure service quality and stability. It is expected that the configuration, via the MIB, is based on anticipated service penetration and noise environment.

11.4.1.1.6.1.3 SNRM_MODE = 4

SNRM_MODE = 4 is an optional capability for both upstream and downstream.

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.

In the downstream direction, the received virtual noise PSD shall be determined by the transceiver as defined in the following equation:

$$Received\_Virtual\_Noise\_PSD = \left|H(f)\right|^2 \times TXREFVNds$$

where:

- $\left|H(f)\right|^2$ is calculated as in SNRM_MODE=2; and
- TXREFVNds is the transmitter-referred virtual noise PSD control parameter as conveyed in O-SIGNATURE.

In SNRM_MODE= 4, the control parameter TXREFVNds is a combination of the configuration parameter TXREFVNds and the configuration parameter TXREFVNSFds, as described in clause 11.4.2.5.

In the upstream direction, the received virtual noise PSD shall be determined by the transceiver as defined in the following equation:

$$Received\_Virtual\_Noise\_PSD = \left|H_{RXfilter}(f)\right|^2 \times RXREFVNus$$

where:

- $|H_{RXfilter}(f)|$ is the magnitude of the transfer function between the U-interface and the common internal reference point; and
- RXREFVNus is the receiver-referred virtual noise PSD control parameter.

In SNRM_MODE=4, the control parameter RXREFVNus is a combination of the configuration parameter RXREFVNus and the configuration parameter RXREFVNSFus, as described in clause 11.4.2.4.

NOTE – A measurement of the current-condition external noise PSD could be overly optimistic, as it only represents a snapshot in time, not taking into account the future increase in noise PSD (e.g., due to additional VDSL2 lines being switched on). SNRM_MODE = 4 is defined to prevent the VTU's bit loading algorithm from assigning an overly optimistic number of bits to a sub-carrier. This is achieved by defining (via the virtual noise PSD parameter and the virtual noise scaling factor parameter) an anticipated noise PSD, which may be a function of frequency that can be used for bit loading. This method can be used to avoid or reduce periods with excessive BER and retrains, in order to assure service quality and stability. It is expected that the configuration, via the MIB, is based on anticipated service penetration and noise environment.

NOTE – SNRM_MODE=4 is similar to SNRM_MODE=3 in the upstream direction and SNRM_MODE=2 in the downstream direction. Per line configuration in SNRM_MODE=2, 3 and 4 may be accomplished by configuration of a different value for the configuration parameter Virtual Noise (VNus or VNds, see Recommendation ITU-T G.997.1 clauses 7.3.1.7.3 and 7.3.1.7.4) on a line-by-line basis. Per line configuration in SNRM_MODE=4 may also be accomplished by the configuration of a common value for the configuration parameter Virtual Noise (VNus or VNds) for a group of lines combined with the configuration of a scaling factor (TXREFVNSFds or RXREFVNSFus) on a line by line basis.

11.4.1.1.6.2 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 11.4.1.1.6.1) measured over all sub-carriers, except the sub-carriers assigned to the ROC, in a transmission direction for which $b_i > 0$. The received virtual noise PSD as defined in clauses 11.4.1.1.6.1.2 and 11.4.1.1.6.1.3 shall be taken into account, respectively, when configured in SNRM_MODE=2, SNRM_MODE=3, and SNRM_MODE=4.

…

11.4.1.1.6.3 Signal-to-noise ratio margin per band (SNRM-pb)

…

The signal-to-noise ratio margin per band parameter SNRM-pb is the signal-to-noise ratio margin (as defined in clause 11.4.1.1.6.1) measured over all sub-carriers in a particular band for which $b_i > 0$. The received virtual noise PSD as defined in clauses 11.4.1.1.6.1.2 and 11.4.1.1.6.1.3 shall be taken into account, respectively, when configured in SNRM_MODE=2, SNRM_MODE=3, and SNRM_MODE=4.

…

11.4.1.1.7 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 bearer channel and single latency operation;
- Target SNR margin equal to the configured TARSNRMds/TARSNRMus downstream and upstream, respectively;
- 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, FEC) within the latency bound;
- Accounting for the channel characteristics at the instant of measurement; and
- Accounting for the received virtual noise PSD when configured in SNRM_MODE=2, SNRM_MODE=3, or SNRM_MODE=4.

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 loop diagnostic mode, the ATTNDR value for upstream and downstream shall be calculated as:

$$\text{ATTNDR} = \sum_{i=0}^{MSI} \min\left\{\text{round}\left[\log_2\left(1+10^{(SNR(i\times\Delta f)-\text{SNRGAP}-\text{TARSNRM})/10}\right)\right], 15\right\}\times 4 \text{ kbit/s}$$

with SNR($i \times \Delta f$) in dB as defined in clause 11.4.1.1.3, but accounting for the received virtual noise PSD when configured in SNRM_MODE=2, SNRM_MODE=3, or SNRM_MODE=4, and SNRGAP = 9.75 dB (see Note 1).

…

11.4.2.1 Transmitter-referred virtual noise PSD

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

11.4.2.1.1 Definition of parameter TXREFVN

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

For SNRM_MODE = 2 and SNRM_MODE = 4, the CO-MIB shall provide a TXREFVN parameter set for each utilized band.

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

Each breakpoint shall consist of a sub-carrier 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 band edge frequencies of the band.

The sub-carrier indices t_i shall be coded in the CO-MIB as unsigned integers in the range from $t_1 = roundup(f_x/Df)$ to $t_{NBP} = rounddown(f_{x+1}/Df)$, where f_x, f_{x+1} are the low and the high band separating frequencies determined by the applied band plan and specified in clause 7.1, and Df = 4.3125 kHz. 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: $f_n = t_n \times Df$. The value of Df is independent of the sub-carrier spacing Δf used for DMT modulation. When the VTU operates with 8.625 kHz sub-carrier spacing, all odd values of t_i shall be converted by the VTU, by rounding down to the next lower even value, and values t_1 and t_{NBP} shall be rounded (up and down, respectively) to even values.

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 32, in the downstream, and 16, in the upstream.

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

NOTE – TXREFVN is configured via the ITU-T G.997.1 parameter VN, whose interpretation depends on the value of SNRM_MODE.

11.4.2.1.2 Use of parameter TXREFVN

The transmitter-referred virtual noise PSD to be used by the transceiver for calculation of the SNR margin for each sub-carrier i shall be obtained by linear interpolation in dB on a linear frequency scale as follows:

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

where Δf is the actual sub-carrier spacing used by the DMT modulation.

In downstream, the breakpoints (t_i, PSD_i) are those communicated to the VTU-R in O-SIGNATURE and are a combination of the configuration parameter TXREFVNds and the configuration parameter TXRFVNSFds, as described in clause 11.4.2.5.

In upstream, the breakpoints (t_i, PSD_i) are equal to the breakpoints of the configuration parameter TXREFVNus as in the CO-MIB.

The near-end transceiver should apply the Received_Virtual_Noise_PSD (see clause 11.4.1.1.6.1.2) at the constellation decoder point (i.e., the transceiver does not need to account for DFT leakage effects from one sub-carrier to another sub-carrier). All effects are to be taken into account in the setting of the TXREFVN in the CO-MIB.

NOTE 1 – The above method is equivalent to the near-end transceiver calculating its bit loading using the following Virtual_Noise_SNR for the sub-carrier with index i, at the constellation decoder (all terms are expressed in dB):

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

where:

S_tx(i) = MREFPSD(i)

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

and MREFPSD(i) is the MEDLEY reference PSD value at the far-end transmitter for the sub-carrier with index i, obtained by interpolation of the breakpoints of the MEDLEY reference PSD (MREFPSD) information exchanged in the O-PRM and R-PRM messages during initialization.

TX_referred_Virtual_Noise_PSD(i) is the transmitter-referred virtual noise PSD value for sub-carrier with index i, obtained by interpolation of the breakpoints of TXREFVN sent in the O-SIGNATURE message during initialization.

g_i is the gain adjuster for the sub-carrier with index i as defined in clause 10.3.4.

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.

11.4.2.3 Receiver-referred virtual noise PSD

This subclause describes the receiver-referred virtual noise PSD parameter RXREFVN, used only in the optional SNR margin mode SNRM_MODE = 3 and SNRM_MODE=4.

11.4.2.3.1 Definition of parameter RXREFVN

Configuration parameter RXREFVN defines the receiver-referred virtual noise PSD to be used in determining the SNR margin.

For SNRM_MODE=3 and SNRM_MODE=4, the CO-MIB shall provide a RXREFVN parameter set for each utilized band.

The receiver-referred virtual noise PSD in the CO-MIB shall be specified by a set of breakpoints. Each breakpoint shall consist of a sub-carrier index t_n and a noise PSD value (expressed in *dBm*/*Hz*). The RXREFVN parameter for each 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 band edge frequencies of the band. The modem shall ignore any frequency information that does not belong to the utilized (upstream) bands.

The sub-carrier indices t_i shall be coded in the CO-MIB as unsigned integers in the range from $t_1 = roundup(f_x/Df)$ to $t_{NBP} = rounddown(f_{x+1}/Df)$, where f_x, f_{x+1} are the low and the high band separating frequencies determined by the applied band plan and specified in clause 7.1, and $Df = 4.3125$ kHz. 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: $f_n = t_n \times Df$. The value of Df is independent of the sub-carrier spacing Δf used for DMT modulation. When the VTU operates with 8.625 kHz sub-carrier spacing, all odd values of t_i shall be converted by the VTU, by rounding down to the next lower even value, and values t_1 and t_{NBP} shall be rounded (up and down, respectively) to even values.

The values for the virtual noise PSD shall be coded as 8-bit unsigned integers representing virtual noise PSD values 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.

The parameter in the upstream direction is RXREFVNus.

NOTE – RXREFVN is configured via the ITU-T G.997.1 parameter VN, whose interpretation depends on the value of SNRM_MODE.

11.4.2.3.2 Use of parameter RXREFVN

For each frequency band, the receiver-referred virtual noise PSD, for each sub-carrier i, shall be obtained by linear interpolation in *dB* on a linear frequency scale as follows:

$$RX\_referred\_Virtual\_Noise\_PSD(i) = PSD_n + \left(PSD_{n+1} - PSD_n\right) \times \frac{\left(\frac{i*\Delta f}{Df}\right) - t_n}{t_{n+1} - t_n} \qquad t_n < \left(\frac{i*\Delta f}{Df}\right) \le t_{n+1}$$

where Δf is the actual sub-carrier spacing used by the DMT modulation.

In SNRM_MODE=3, the breakpoints (t_i, PSD_i) are equal to the breakpoints of the configuration parameter RXREFVNus as in the CO-MIB.

In SNRM_MODE=4, the breakpoints (t_i, PSD_i) are a combination of the configuration parameter RXREFVNus and the configuration parameter RXRFVNSFus as described in clause 11.4.2.4.

The near-end transceiver should apply the Received_Virtual_Noise_PSD (see clause 11.4.1.1.6.1.3) over the upstream frequencies at the constellation decoder point (i.e., the transceiver does not need to account for DFT leakage effects from one sub-carrier to another sub-carrier). All effects are to be taken into account in the setting of the RXREFVN in the CO-MIB.

NOTE 1 – The above method is equivalent to the near-end transceiver calculating its bit loading using the following Virtual_Noise_SNR for the sub-carrier with index i, at the constellation decoder (all terms are expressed in dB):

$$Virtual\_Noise\_SNR(i) = S\_rx(i) - N\_rx(i)$$

where:

$$S\_tx(\mathrm{i}) = \mathrm{Actual\_Received\_Signal\_PSD} = |\mathrm{H_{RXfilter}}(f)|^2 + \mathrm{Actual\_Received\_Signal\_at\_U\_interface}$$

$$N\_tx(i) = \mathrm{Received\_Virtual\_Noise\_PSD} = |\mathrm{H_{RXfilter}}(f)|^2 + \mathrm{RXREFVN + RXREFVNSF.}$$

NOTE 2 – Improper setting of RXREFVN and RXREFVNSF 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.

11.4.2.4 Receiver-referred virtual noise scaling factor

This subclause describes the receiver-referred virtual noise scaling factor parameter RXREFVNSF, used only in the optional SNR margin mode SNRM_MODE = 4.

Configuration parameter RXREFVNSF defines the receiver-referred virtual noise scaling factor to be used together with the receiver-referred virtual noise PSD in determining the SNR margin.

The CO-MIB shall provide an upstream RXREFVNSF parameter when SNRM_MODE = 4.

The values for the receiver-referred virtual noise PSD scaling factor 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 parameter in the upstream direction is RXREFVNSFus.

The VTU-O shall combine the value of the configuration parameter RXREFVNSFus as in the CO-MIB with the value of the configuration parameter RXREFVNus as in the CO-MIB to a control parameter RXREFVNus as follows:

Control parameter RXREFVNus in *dBm*/*Hz* = configuration parameter RXREFVNus in *dBm*/*Hz* + configuration parameter RXREFVNSFus in *dB*.

11.4.2.5 Transmitter-referred virtual noise scaling factor

This subclause describes the transmitter-referred virtual noise scaling factor parameter TXREFVNSF, used only in the optional SNR margin mode SNRM_MODE = 4.

Configuration parameter TXREFVNSF defines the transmitter-referred virtual noise scaling factor to be used together with the transmitter-referred virtual noise PSD in determining the SNR margin.

The CO-MIB shall provide a TXREFVNSF parameter for downstream when SNRM_MODE = 4.

The values for the receiver-referred virtual noise PSD scaling factor 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 parameter in the downstream direction is TXREFVNSFds.

The VTU-O shall combine the value of the configuration parameter TXREFVNSFds as in the CO-MIB with the value of the configuration parameter TXREFVNds as in the CO-MIB to a control parameter TXREFVNds as communicated to the VTU-R in O-SIGNATURE as follows:

Control parameter TXREFVNds in *dBm*/*Hz* = *min*(*max*((configuration parameter TXREFVNds in *dBm*/*Hz* + configuration parameter TXREFVNSFds in *dB*), –140 *dBm*/*Hz*), –40 *dBm*/*Hz*).

12.3.3.2.1.1 O-SIGNATURE

The full list of parameters carried by the O-SIGNATURE message is shown in Table 12-17.

Table 12-17 – Description of message O-SIGNATURE

	Field name	Format
1	Message descriptor	Message code
2	Supported sub-carriers in the downstream direction (SUPPORTEDCARRIERSds set)	Bands descriptor
3	Supported sub-carriers in the upstream direction (SUPPORTEDCARRIERSus set)	
4	Downstream transmit PSD mask (PSDMASKds)	PSD descriptor
5	Upstream transmit PSD mask (PSDMASKus)	
6	Channel Discovery downstream PSD (CDPSDds)	
7	Initial downstream PSD ceiling (CDMAXMASKds)	2 bytes
8	Downstream nominal maximum aggregate transmit power (MAXNOMATPds)	2 bytes
9	Parameters for UPBO reference PSD (UPBOPSD)	UPBOPSD descriptor
10	Maximum target total data rate	2 bytes
11	Downstream maximum SNR margin (MAXSNRMds)	2 bytes
12	Downstream target SNR margin (TARSNRMds)	2 bytes
13	Downstream transmit window length (β_{ds})	1 byte
14	Downstream cyclic prefix	2 bytes
15	Initial value of timing advance	2 bytes
16	Downstream transmitter-referred virtual noise PSD (TXREFVNds)	PSD descriptor
17	SNRM_MODE	1 byte
18	Upstream transmitter-referred virtual noise PSD (TXREFVNus)	PSD descriptor
19	UPBO Reference electrical length (UPBOREFEL)	UPBOREFEL descriptor
20	G.998.4 parameter field	Variable length
21	G.993.5 parameter field	Variable length

…

Field #16 "Downstream transmitter-referred virtual noise PSD (TXREFVNds)" indicates the PSD of the virtual noise in the downstream direction. This information shall be taken into account when determining the SNR margin (for optional SNRM_MODE = 2, optional SNRM_MODE = 3, and optional SNRM_MODE = 4), which in turn shall be taken into account in determining the possible power cutback during the channel discovery phase, and for performing the bit loading later in initialization. The "PSD descriptor" format specified in Table 12-19 shall be used, and the number of sub-carriers being described shall be limited to ≤ 32. When SNRM_MODE = 1, the PSD descriptor field shall contain zero breakpoints (only 1 byte with a value of zero).

Field #17 "SNRM_MODE" indicates the mode of downstream and upstream SNRM computation as described in clause 11.4.1.1.6. Bits 0 to 3 of the field shall be used to indicate the downstream SNR mode with valid values of 0_{16} (Downstream SNRM_MODE = 1, mandatory), 1_{16} (Downstream SNRM_MODE = 2, optional), 2_{16} (Downstream SNRM_MODE = 3, optional), and 3_{16} (Downstream SNRM_MODE = 4, optional). All other values are reserved. Bits 4 to 7 of the field shall be used to indicate the upstream SNR mode with valid values of 0_{16} (Upstream

SNRM_MODE = 1, mandatory), 1_{16} (Upstream SNRM_MODE = 2, optional) , and 2_{16} (Upstream SNRM_MODE = 3, optional). All other values are reserved.

Field #18 "Upstream transmitter-referred virtual noise PSD (TXREFVNus)" indicates the PSD of the virtual noise in the upstream direction. The "PSD descriptor" format specified in Table 12-19 shall be used, and the number of sub-carriers being described shall be limited to ≤ 16. When SNRM_MODE = 1, 3 or 4, the PSD descriptor field shall contain zero breakpoints (only 1 byte with a value of zero).

NOTE – Improper setting of TXREFVN or RXREFVN 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.

…

Field #20 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field #21 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Table 12-17.1 – Format of variable length field

Octet	Name	Format	Description
1	Field length	1 byte	Number of data bytes in the parameter field. This is the number of bytes following this octet (Note).
2-N	Data	N-1 bytes	N-1 data byes, with N-1 being equal to the number contained in Octet #1.
NOTE – The number of data bytes could be zero. In that case, the variable length field consists of a single byte with value 0.			

The actual data in the variable length fields 20 and 21 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-O does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-O does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

...

Table 12-19 – PSD descriptor

Octet	Content of field
1	Number of sub-carriers (or breakpoints) being described
2-4	Bits 0-11: Index of first sub-carrier being described Bits 12-23: PSD level in steps of 0.1 dB with an offset of −140 dBm/Hz
5-7 (if applicable)	Bits 0-11: Index of second sub-carrier being described Bits 12-23: PSD level in steps of 0.1 dB with an offset of −140 dBm/Hz
etc.	etc.

The first octet of the descriptor shall contain the number of breakpoints being specified. This number can be zero. In that case, there shall be no additional octets in the descriptor. If the number of breakpoints is not equal to zero, each group of three consecutive octets shall describe one breakpoint as a PSD value at a certain sub-carrier index.

The first 12 bits (0-11) in the group of three octets shall contain the index of the sub-carrier. The last 12 bits (12-23) shall contain the PSD level. The PSD level shall be an integer multiple of 0.1 dB with an offset of −140 dBm/Hz. For example, a field value of 320400_{16} means a PSD of $320_{16} \times 0.1 - 140 = -60$ dBm/Hz on sub-carrier index $400_{16} = 1024$. The PSD level of intermediate unspecified sub-carriers shall be obtained using a linear interpolation between the given PSD points (in dBm/Hz) with the frequency axis expressed in a linear scale. The sub-carrier indices of the specified breakpoints may be either determined by the CO-MIB or vendor discretionary.

NOTE 1 – Breakpoints should be selected such that the PSD between the breakpoints obtained using linear interpolation is sufficiently close to the PSD that is being described.

12.3.3.2.1.2 O-UPDATE

The full list of parameters carried by the O-UPDATE message is shown in Table 12-21.

Table 12-21 – Description of message O-UPDATE

	Field name	Format
1 to 7	As in Recommendation ITU-T G.993.2	
8	ITU-T G.998.4 parameter field	Variable length
9	ITU-T G.993.5 parameter field	Variable length

…

Field 8 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 9 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 8 and 9 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-O does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-O does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

12.3.3.2.1.3 O-PRM

O-PRM contains the downstream MEDLEY reference PSD following the modifications proposed in the R-UPDATE message. It also contains the modulation parameters that shall be used in the downstream direction from the beginning of the training phase and requests for the durations of training periods in the training phase. The full list of parameters carried by the O-PRM message is shown in Table 12-22.

Table 12-22 – Description of message O-PRM

	Field name	Format
1 to 12	As in Recommendation ITU-T G.993.2	
13	ITU-T G.998.4 parameter field	Variable length
14	ITU-T G.993.5 parameter field	Variable length

…

Field 13 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 14 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 13 and 14 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-O does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-O does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

12.3.3.2.1.4 O-ACK

O-ACK is a one-byte message that acknowledges correct reception of the R-PRM message. The format of the message shall be as specified in clause 12.2.1, and the payload shall be as specified in Table 12-2.

12.3.3.2.2 VTU-R messages sent during the Channel Discovery phase

12.3.3.2.2.1 R-MSG 1

The full list of parameters carried by the R-MSG 1 message is shown in Table 12-24.

Table 12-24 – Description of message R-MSG 1

	Field name	Format
1 to 9	As in Recommendation ITU-T G.993.2	
10	ITU-T G.998.4 parameter field	Variable length
11	ITU-T G.993.5 parameter field	Variable length

…

Field 10 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 11 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 10 and 11 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-R does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-R does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

12.3.3.2.2.2 R-UPDATE

The R-UPDATE message is a request to modify the downstream PSD. The full list of parameters carried by the R-UPDATE message is shown in Table 12-26.

Table 12-26 – Description of message R-UPDATE

	Field name	Format
1 to 6		
7	ITU-T G.998.4 parameter field	Variable length
8	ITU-T G.993.5 parameter field	Variable length

…

Field 7 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 8 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 7 and 8 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-R does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-R does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

12.3.3.2.2.3 R-PRM

The R-PRM message is sent in response to the O-PRM message. It contains the upstream MEDLEY reference PSD following the modifications proposed in the O-UPDATE message. It also contains the modulation parameters that shall be used in the upstream direction from the beginning of the Training phase and requests for the durations of training periods in the Training phase. The full list of parameters carried by the R-PRM message is shown in Table 12-27.

Table 12-27 – Description of message R-PRM

	Field name	Format
1 to 12	As in Recommendation ITU-T G.993.2	
13	ITU-T G.998.4 parameter field	Variable length
14	ITU-T G.993.5 parameter field	Variable length

…

Field 13 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 14 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 13 and 14 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-R does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-R does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

12.3.4.2.1.1 O-TA_UPDATE

The full list of parameters carried by the O-TA_UPDATE message is shown in Table 12-32.

Table 12-32 – Description of message O-TA_UPDATE

	Field name	Format
1 to 4	As in Recommendation ITU-T G.993.2	
5	ITU-T G.998.4 parameter field	Variable length
6	ITU-T G.993.5 parameter field	Variable length

…

Field 5 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 6 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 5 and 6 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-O does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-O does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

12.3.4.2.2 VTU-R messages sent during the Training phase

12.3.4.2.2.1 R-TA_UPDATE

The full list of parameters carried by the R-TA_UPDATE message is shown in Table 12-33.

Table 12-33 – Description of message R-TA_UPDATE

	Field name	Format
1 to 6	As in Recommendation ITU-T G.993.2	
7	ITU-T G.998.4 parameter field	Variable length
8	ITU-T G.993.5 parameter field	Variable length

…

Field 7 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 8 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 7 and 8 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-R does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-R does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

12.3.4.2.2.2 R-ACK

R-ACK is a one-byte message that acknowledges correct reception of the O-TA_UPDATE message. The format of the message shall be as specified in clause 12.2.1, and the payload shall be as specified in Table 12-2.

12.3.5.2.1.1 O-MSG 1

The O-MSG 1 message contains the capabilities of the VTU-O and the requirements for downstream transmission (such as margin). The full list of parameters carried by the O-MSG 1 message is shown in Table 12-40.

Table 12-40 – Description of message O-MSG 1

	Field name	Format
1 to 23	As in Recommendation ITU-T G.993.2, including its Amendments 1 and 3	
24	ITU-T G.998.4 parameter field	Variable length
25	ITU-T G.993.5 parameter field	Variable length

Field 24 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 25 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 24 and 25 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-O does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-O does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

12.3.5.2.1.2 O-TPS

The O-TPS message conveys the TPS-TC configuration for both the upstream and the downstream directions. It is based on the capabilities that were indicated in O-MSG 1 and R-MSG 2. The full list of parameters carried by the O-TPS message is shown in Table 12-44.

Table 12-44 – Description of message O-TPS

	Field name	Format
1 to 4	As in Recommendation ITU-T G.993.2, including its Amendments 1 and 3	
5	ITU-T G.998.4 parameter field	Variable length
6	ITU-T G.993.5 parameter field	Variable length

…

Field 5 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 6 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 5 and 6 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-O does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-O does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

…

NOTE – Improper setting of one or more of the following parameters – maximum net data rate, downstream maximum SNR margin, impulse noise protection, maximum interleaving delay (in SNRM_MODE=1), TXREFVN (in SNRM_MODE= 2 and SNRM_MODE=4), RXREFVN (in SNRM_MODE=3 and SNRM_MODE=4), and TXREFVNSF and RXREFVNSF (in 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, downstream 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), RXREFVN (in SNRM_MODE=3 and SNRM_MODE=4), and TXREFVNSF and RXREFVNSF (in SNRM_MODE=4) are of concern.

…

12.3.5.2.1.3 O-PMS

The O-PMS message conveys the initial PMS-TC parameter settings that shall be used in the upstream direction during Showtime. It also specifies the portion of shared interleaver memory that the VTU-R can use to de-interleave the downstream data stream. The full list of parameters carried by the O-PMS message is shown in Table 12-46.

Table 12-46 – Description of message O-PMS

	Field name	Format
1 to 13	As in Recommendation ITU-T G.993.2, including its Amendments 1 and 3	
14	ITU-T G.998.4 parameter field	Variable length
15	ITU-T G.993.5 parameter field	Variable length

…

Field 14 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 15 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 14 and 15 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-O does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-O does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

12.3.5.2.1.4 O-PMD

The O-PMD message conveys the initial PMD parameter settings that shall be used in the upstream direction during Showtime. The full list of parameters carried by the O-PMD message is shown in Table 12-48.

Table 12-48 – Description of message O-PMD

	Field name	Format
1 to 5	As in Recommendation ITU-T G.993.2, including its Amendment 1	
6	ITU-T G.998.4 parameter field	Variable length
7	ITU-T G.993.5 parameter field	Variable length

…

Field 6 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 7 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 6 and 7 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-O does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-O does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

12.3.5.2.2.1 R-MSG 2

The R-MSG 2 message conveys VTU-R information to the VTU-O. The full list of parameters carried by the R-MSG 2 message is shown in Table 12-49.

Table 12-49 – Description of message R-MSG 2

	Field name	Format
1 to 6	As in Recommendation ITU-T G.993.2, including its Amendment 3	
7	ITU-T G.998.4 parameter field	Variable length
8	ITU-T G.993.5 parameter field	Variable length

…

Field 7 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 8 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 7 and 8 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-R does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-R does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

12.3.5.2.2.2 R-TPS-ACK

R-TPS-ACK is a message that acknowledges correct reception of the O-TPS message. The content shall be as specified in Table 12-52.

Table 12-52 – Description of message R-TPS-ACK

	Field name	Format
1	As in Recommendation ITU-T G.993.2	
2	ITU-T G.998.4 parameter field	Variable length
3	ITU-T G.993.5 parameter field	Variable length

…

Field 2 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 3 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 2 and 3 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-R does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-R does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

12.3.5.2.2.3 R-PMS

The R-PMS message conveys the initial PMS-TC parameter settings that shall be used in the downstream direction during Showtime. The full list of parameters carried by the R-PMS message is shown in Table 12-53.

Table 12-53 – Description of message R-PMS

	Field name	Format
1 to 10	As in Recommendation ITU-T G.993.2, including its Amendment 3	
11	ITU-T G.998.4 parameter field	Variable length
12	ITU-T G.993.5 parameter field	Variable length

…

Field 11 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 12 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 11 and 12 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-R does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-R does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

12.3.5.2.2.4 R-PMD

The R-PMD message conveys the initial PMD parameter settings that shall be used in the downstream direction during Showtime. The content of R-PMD is shown in Table 12-54.

Table 12-54 – Description of message R-PMD

	Field name	Format
1 to 4	As in Recommendation ITU-T G.993.2, including its Amendment 1	
5	ITU-T G.998.4 parameter field	Variable length
6	ITU-T G.993.5 parameter field	Variable length

…

Field 5 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

Field 6 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-17.1.

The actual data in the variable length fields 5 and 6 are beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of either Recommendation ITU-T G.998.4 or Recommendation ITU-T G.993.5 or both is required. However, support of those Recommendations is not implied or required for compliance with Recommendation ITU-T G.993.2.

If the VTU-R does not support Recommendation ITU-T G.998.4, the ITU-T G.998.4 parameter field shall be a single byte with value 0.

If the VTU-R does not support Recommendation ITU-T G.993.5, the ITU-T G.993.5 parameter field shall be a single byte with value 0.

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Printed in Switzerland
Geneva, 2010