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# ITU-T

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# G.993.2
**Amendment 2**
(12/2012)

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

Digital sections and digital line system – Access networks

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# Very high speed digital subscriber line transceivers 2 (VDSL2)

## Amendment 2

Recommendation ITU-T G.993.2 (2011) – Amendment 2

ITU-T

International Telecommunication Union

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# Recommendation ITU-T G.993.2

## Very high speed digital subscriber line transceivers 2 (VDSL2)

## Amendment 2


### Summary

Amendment 2 to Recommendation ITU-T G.993.2 (2011) covers the following functionalities:

1. Electrical length estimation method (corrigendum).
2. INPMIN-ROC (corrigendum).
3. Accuracy of test parameters (adding functionality).
4. INM facility (corrigendum).
5. O-SIGNATURE field for Upstream FDPS descriptor (new functionality).
6. SRA after SOS (corrigendum).
7. Annex B (Region B – Europe) (corrigendum and adding functionality).
8. Annex Y with optional "pilot sequence length multiple of 4" (corrigendum) and optional FDPS (new functionality).


### History

| Edition | Recommendation | Approval | Study Group |
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| 1.10 | ITU-T G.993.2 (2006) Amd. 6 | 2010-11-29 | 15 |
| 1.11 | ITU-T G.993.2 (2006) Cor. 4 | 2011-04-13 | 15 |
| 1.12 | ITU-T G.993.2 (2006) Amd. 7 | 2011-06-22 | 15 |
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| 2.1 | ITU-T G.993.2 (2011) Amd. 1 | 2012-04-06 | 15 |
| 2.2 | ITU-T G.993.2 (2011) Cor. 1 | 2012-06-13 | 15 |
| 2.3 | ITU-T G.993.2 (2011) Amd. 2 | 2012-12-07 | 15 |

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

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# Recommendation ITU-T G.993.2

## Very high speed digital subscriber line transceivers 2 (VDSL2)

## Amendment 2

### 1) Electrical length estimation method

### 1.1) Clause 7.2.1.3.2.1

*Change clause 7.2.1.3.2.1 as follows:*

**7.2.1.3.2.1 Electrical length estimation method**

Two methods are defined for deriving the electrical length autonomously:

ELE-M0 the default method

ELE-M1 the alternative method

Implementation of ELE-M0 is mandatory. Implementation of ELE-M1 is optional.

The ELE-M1 shall be used if the CO-MIB parameter "Alternative Electrical Length Estimation Mode" (AELE-MODE) is set to a value of 1 or higher, and the mode is supported by the VTU-O and by the VTU-R. Otherwise, the ELE-M0 shall be used.

The actual AELE-MODE used shall be reported in CO-MIB parameter "Actual Alternative Electrical Length Estimation Mode" (ACT-AELE-MODE). If the VTU-O supports the optional ELE-M1 and the ELE-M0 is used, then the ACT-AELE-MODE parameter shall be set to a value of 0.

### 2) INPMIN-ROC

### 2.1) Clause 10.4.4

*Change clause 10.4.4 as follows:*

**10.4.4 Cyclic extension and windowing**

…

For a given setting of the CE length and window length β, the DMT symbols will be transmitted at a symbol rate equal to:

$$f_{DMT} = \frac{2N \times \Delta f}{2N + L_{CP} + L_{CS} - \beta} = \frac{2N \times \Delta f}{2N + L_{CE}}$$

If the CE length corresponds to $m = 5$, this results in symbol rates of 4 ksymbols/s for $\Delta f = 4.3125$ kHz and 8 ksymbols/s for $\Delta f = 8.625$ kHz, independent of the sampling rate used.

The data symbol rate is equal to:

$$f_s = \frac{2N \times \Delta f}{2N + L_{CP} + L_{CS} - \beta} \times \frac{256}{257}$$

The equivalent 4k DMT symbol length (denoted as $T_{4k}$) is defined as:

$$T_{4k} = \frac{1}{f_{DMT}} \quad \text{for } \Delta f = 4.3125 \text{ kHz, and}$$

$$T_{4k} = \frac{2}{f_{DMT}} \quad \text{for } \Delta f = 8.625 \text{ kHz.}$$

If the CE length corresponds to $m$ = 5, this results in an equivalent 4k DMT symbol length of 250 µs, independent of the subcarrier spacing and sampling rate used.

**2.2) Clause 12.3.5.2.1.1**

*Change clause 12.3.5.2.1.1 as follows:*

**12.3.5.2.1.1 O-MSG 1**

…

Field #23 contains the value of INPMIN-ROC-ds as specified in the MIB. The parameter is defined as the required INP_no_erasure value for the ROC (see clause 9.6). INPMIN-ROC-ds is an integer in the range from 0 to 8 and is expressed in multiples of $T_{4k}$, with $T_{4k}$ defined in clause 10.4.4.

…

**2.3) Clause 9.6**

*Modify clause 9.6 as follows:*

## 9.6 Impulse noise protection ($INP_p$)

$INP_p$ (impulse noise protection for latency path $p$) 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.

NOTE 1 – This is equivalent to the number of consecutive errored octets within any block of $(I_p - 1)\cdot D_p + 1$ 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 interleaver block length, $I_p$, and interleaver depth, $D_p$, are defined in clause 9.4, and the number of bits from latency path $p$ loaded into a DMT symbol, $L_p$, is defined in clause 9.5.4.

NOTE 2 – The value of $INP_p$ is given in terms of DMT symbols. The time span of impulse noise protection, in ms, varies with subcarrier spacing as determined by the profile (see clause 6) and with the CE length (see clause 10.4.4).

The actual impulse noise protection $INP\_act_n$ of bearer channel #$n$ shall always be set to the value of the derived parameter $INP_p$ of the underlying PMS-TC path function (see Annex L). The receiver shall always ensure $INP\_act_n \geq INP\_min_n$ according to the definition of $INP_p$ regardless of any vendor-discretionary techniques including, for example, the use of erasure decoding. When the Reed-Solomon decoder in the receiver does not use erasure decoding, the $INP_p$ shall be computed as:

$$INP\_no\_erasure_p = \frac{8 \times D_p \times \left\lfloor \frac{R_p}{2 \times q_p} \right\rfloor}{L_p} = \frac{S_p \times D_p \times \left\lfloor \frac{R_p}{2 \times q_p} \right\rfloor}{N_{FECp}} \text{ DMT symbols}$$

where parameters $D_p$, $R_p$, $L_p$, and $q_p$ are defined in clauses 9.4 and 9.5.4. When erasure decoding is used, $INP_p$ might not equal $INP\_no\_erasure_p$.

For single latency with ROC mode, the value $INP\_no\_erasure_p$ for latency path #0 (the ROC) shall comply with:

$$INP\_no\_erasure_0 \geq \text{INPMIN-ROC (see clause 12.3.5.2.1.1)}$$

Within this equation, INPMIN-ROC is expressed in DMT symbols.

The VTU-O shall calculate INPMIN-ROCus (in DMT symbols) from the CO-MIB value INPMIN-ROC-us (defined in clause 7.3.1.10.12 of [ITU-T G.997.1] in multiples of $T_{4k}$), and the VTU-R shall calculate INPMIN-ROCds (in DMT symbols) from the O-MSG 1 parameter INPMIN-ROC-ds value (defined in field #23 in multiples of $T_{4k}$) as follows:

For 4.3125 kHz subcarrier spacing:

INPMIN-ROC in DMT symbols = INPMIN-ROC in multiples of $T_{4k}$.

For 8.625 kHz subcarrier spacing:

INPMIN-ROC in DMT symbols = 2 × (INPMIN-ROC in multiples of $T_{4k}$).

with $T_{4k}$ as defined in clause 10.4.4.

During initialization, the VTU-O, under direction from the CO-MIB, can set a bit in initialization to require that the VTU-R receiver select framing parameters so that $INP_p = INP\_no\_erasure_p$ on both latency paths. Regardless of whether this bit is set, the receiver shall always ensure $INP\_act_n \geq INP\_min_n$. This bit is referred to as "INP_no_erasure_required", bit 8 in the "Impulse noise protection" field in Table 12-51, clause 12.3.5.2.1.1.

During initialization, the VTU-R declares if it is using erasure decoding on either latency path. This field is referred to as "Erasure decoding used" in Table 12-64, clause 12.3.5.2.2.3.

Erasure decoding is vendor discretionary at both VTUs.

### 2.4) Clause 11.4.1.1.10

*Change clause 11.4.1.1.10 as follows:*

### 11.4.1.1.10 Actual impulse noise protection of the ROC (INP_act-ROC)

The INP_act-ROC is the actual impulse noise protection of the ROC, as defined in clause 9.1, Figure 9-2. It shall be computed as $INP\_act\text{-}ROC = INP\_no\_erasure_0$ (see clause 9.6).

~~The format shall be identical to that of the actual impulse noise protection INP_act of the bearer channels (see clause 11.4.1.1.9).~~

The parameter INP_act-ROC is expressed in DMT symbols.

The parameter ACTINP-ROC in the CO-MIB is expressed in multiples of $T_{4k}$. The value is coded in fractions of $T_{4k}$ periods with a granularity of 0.1 of a period. The range is from 0 to 25.4. At the Q-reference point, a special value indicates an ACTINP-ROC higher than 25.4. The $T_{4k}$ is defined in clause 10.4.4.

The VTU-O shall calculate ACTINP-ROC as follows:

For 4.3125 kHz subcarrier spacing:

$\text{ACTINP-ROC} = \text{MIN}(\lfloor 10 \times \text{INP\_act-ROC} \rfloor / 10;\ 25.5)$.

For 8.625 kHz subcarrier spacing:

$\text{ACTINP-ROC} = \text{MIN}(\lfloor 5 \times \text{INP\_act-ROC} \rfloor / 10;\ 25.5)$.

**2.5) Clause 12.3.5.2.1.1**

*Change text for field #23 in clause 12.3.5.2.1.1 as follows:*

**12.3.5.2.1.1 O-MSG 1**

…

Field #23 contains the value of INPMIN-ROCds expressed in multiples of $T_{4K}$ as specified in the MIB. The value of INPMIN-ROCds expressed in DMT symbols (as to be used by the VTU-R receiver as specified in clause 9.6), is calculated as follows:

For 4.3125 kHz subcarrier spacing:

INPMIN-ROCds in DMT symbols = INPMIN-ROCds in multiples of $T_{4k}$.

For 8.625 kHz subcarrier spacing:

INPMIN-ROCds in DMT symbols = 2 × (INPMIN-ROCds in multiples of $T_{4k}$).

with $T_{4k}$ as defined in clause 10.4.4.

The parameter INPMIN-ROCds (in DMT symbols) is defined as the required INP_no_erasure value for the ROC (see clause 9.6). ~~INPMIN-ROC~~ The value of field #23 is an integer in the range from 0 to 8.
If the CO does not support a robust overhead channel in the downstream direction, the fields #22 and #23 shall contain a value within the specified valid range for each of the parameters. These values shall be ignored at the receiver.

…

**3) Accuracy of test parameters**

**3.1) Clause 11.4.1.2**

*Change the following subclauses of clause 11.4.1.2 as indicated:*

**11.4.1.2 Accuracy of test parameters**

...

**11.4.1.2.1 Accuracy of channel characteristics function per sub-carrier group (CCF-ps)**

**11.4.1.2.1.1 Accuracy of Hlog($k \times G \times \Delta f$)**

…

~~Requirements for the Mean Absolute Error of the upstream Hlog($k \times G \times \Delta f$) is for further study.~~

…

**11.4.1.2.1.2 Accuracy of Hlin($k \times G \times \Delta f$)**

~~The Hlin($k \times G \times \Delta f$) reference values and Hlin($k \times G \times \Delta f$) accuracy requirements are for further study.~~

The accuracy requirements for the magnitude of Hlin($k \times G \times \Delta f$) are the same as those for Hlog($k \times G \times \Delta f$) in clause 11.4.1.2.1.1.

There is no accuracy requirement for the phase of Hlin($k \times G \times \Delta f$).

**11.4.1.2.2 Accuracy of quiet line noise PSD per sub-carrier group (QLN-ps)**

...

### 11.4.1.2.3 Accuracy of signal-to-noise ratio per sub-carrier group (SNR-ps)

...

### 11.4.1.2.4 Accuracy of loop attenuation per band (*LATN-pb*)

~~For further study.~~

The downstream LATN reference value shall be defined as follows:

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

In the equation above, *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_reference_ds($k \times \Delta f$) is define as:

$$|\text{H\_reference\_ds}(k \times \Delta f)|^2 = 10^{\text{HLOG\_reference\_ds}(k \times \Delta f)/10} = 10^{(\text{MREFPSDds}(k \times \Delta f) - \text{PSD\_UR2}(k \times \Delta f))/10},$$

where PSD_UR2($k \times \Delta f$) is the PSD measured at the U-R2 reference point with the VTU-O connected to the loop and frozen in the O-P-MEDLEY stage of initialization with the SOC in the O-IDLE state, and with the VTU-R replaced by an $R_N$=100 Ohm resistance terminating the loop.

If one or more H_reference_ds($f$) values could not be measured because they are out of the transmitter SUPPORTEDCARRIERS set (see clause 11.4.1.1.1), then the LATN_D($m$) shall be calculated as an average of H($f$) values over the number of sub-carriers for which valid values of H($f$) are available. Also,

The upstream LATN reference value shall be defined as follows:

$$\text{LATN\_reference\_us}(m) = -10 \times \log_{10}\left( \frac{\sum_{k=n1}^{n2} \left|\text{H\_reference\_us}(k \times \Delta f)\right|^2}{N\_U(m)} \right)$$

with *N_U(m)* (the number of sub-carriers in the $m^{th}$ upstream band) = $n2-n1+1$ where $n1$ and $n2$ are the indices of the first and the last sub-carriers of this band, respectively. The value of H_reference_ds($k \times \Delta f$) is defined as:

$$|\text{H\_reference\_us}(k \times \Delta f)|^2 = 10^{\text{HLOG\_reference\_us}(k \times \Delta f)/10} = 10^{(\text{MREFPSDus}(k \times \Delta f) - \text{PSD\_UO2}(k \times \Delta f))/10},$$

where PSD_UO2($k \times \Delta f$) is the PSD measured at the U-O2 reference point with the VTU-R connected to the loop and frozen in the R-P-MEDLEY stage of initialization with the SOC in the R-IDLE state, and with the VTU-O replaced by an $R_N$=100 Ohm resistance terminating the loop.

If one or more H_reference_us($f$) values could not be measured because they are out of the transmitter SUPPORTEDCARRIERS set (see clause 11.4.1.1.1), then the LATN_U($m$) shall be calculated as an average of H($f$) values over the number of sub-carriers for which valid values of H($f$) are available.

NOTE – The feature to freeze a VTU in the MEDLEY stage of initialization exists solely to allow a test bed to be constructed for the purpose of measuring the H($f$) reference values. It applies only to specific transceivers serving as the 'transmit transceiver' of the test environment, and is not a requirement for compliance with this Recommendation.

The receiving VTU shall measure the LATN values under the same loop, noise, temperature, and configuration settings that are used for measuring the LATN reference values.

For all downstream bands, $m$, that are active during loop diagnostics or initialization, the absolute error between LATN_D($m$) and LATN_reference_ds($m$) shall be equal to or smaller than 3 dB.

The accuracy requirements for downstream LATN_D($m$) shall apply to its measurement either during Initialization or in Loop Diagnostic mode.

For all upstream bands, $m$, that are active during loop diagnostics or initialization, the absolute error between LATN_U($m$) and LATN_reference_us($m$) shall be equal to or smaller than 3 dB.

The accuracy requirements for upstream LATN_U($m$) shall apply to its measurement either during Initialization or in Loop Diagnostic mode.

### 11.4.1.2.5 Accuracy of signal attenuation (*SATN*)

~~For further study.~~

The downstream SATN reference value shall be defined as follows:

$$\text{SATN\_reference\_ds}(m) = \text{TXpower\_dBm\_reference\_ds}(m) - \text{RXpower\_dBm\_reference\_ds}(m)$$

The TXpower_dBm_reference_ds($m$) is defined as:

$$\text{TXpower\_dBm\_reference\_ds}(m) = 10 \times \log_{10} \Delta f + 10 \times \log_{10}\left( \sum_{i \in \text{MEDLEYds} \cap \text{DS}(m)} \left( 10^{\frac{\text{MREFPSD}[i]}{10}} \times g_i^2 \right) \right),$$

where MEDLEYds ∩ DS($m$) denotes all sub-carriers of the MEDLEYds set that fall into the $m$th downstream band, MREFPSD[$i$] is the value of MREFPSDds for sub-carrier $i$ in dBm/Hz, $g_i$ is as defined in clause 11.4.1.1.5, and $\Delta f$ is the sub-carrier spacing in Hz.

The RXpower_dBm_reference_ds ($m$) is defined as:

$$\text{RXpower\_dBm\_reference\_ds}(m) = 10 \times \log_{10}\left( \sum_{i \in \text{MEDLEYds} \cap \text{DS}(m)} \left( 10^{\frac{\text{PSD\_UR2}(i \times \Delta f)}{10}} \times g_i^2 \right) \right),$$

where PSD_UR2($i \times \Delta f$) is the PSD measured at the U-R2 reference point with the VTU-O connected to the loop and frozen in the O-P-MEDLEY stage of initialization with the SOC in the O-IDLE state, and with the VTU-R replaced by an $R_N$=100 Ohm resistance terminating the loop.

The upstream SATN reference value shall be defined as follows:

$$\text{SATN\_reference\_us}(m) = \text{TXpower\_dBm\_reference\_us}(m) - \text{RXpower\_dBm\_reference\_us}(m)$$

The TXpower_dBm_reference_us($m$) is defined as:

$$\text{TXpower\_dBm\_reference\_us}(m) = 10 \times \log_{10} \Delta f + 10 \times \log_{10}\left( \sum_{i \in \text{MEDLEYus} \cap \text{US}(m)} \left( 10^{\frac{\text{MREFPSD}[i]}{10}} \times g_i^2 \right) \right),$$

where MEDLEYus ∩ US($m$) denotes all sub-carriers of the MEDLEYus set that fall into the $m$th upstream band, MREFPSD[$i$] is the value of MREFPSDus for sub-carrier $i$ in dBm/Hz, $g_i$ is as defined in clause 11.4.1.1.5, and $\Delta f$ is the sub-carrier spacing in Hz.

The RXpower_dBm_reference_us ($m$) is defined as:

$$\text{RXpower\_dBm\_reference\_us}(m) = 10 \times \log_{10}\left( \sum_{i \in \text{MEDLEYus} \cap \text{US}(m)} \left( 10^{\frac{\text{PSD\_UO2}(i \times \Delta f)}{10}} \times g_i^2 \right) \right),$$

where PSD_UO2($i \times \Delta f$) is the PSD measured at the U-O2 reference point with the VTU-R connected to the loop and frozen in the R-P-MEDLEY stage of initialization with the SOC in the R-IDLE state, and with the VTU-O replaced by an $R_N$=100 Ohm resistance terminating the loop.

NOTE – The feature to freeze a VTU in the MEDLEY stage of initialization exists solely to allow a test bed to be constructed for the purpose of measuring the H(*f*) reference values. It applies only to specific transceivers serving as the 'transmit transceiver' of the test environment, and is not a requirement for compliance with this Recommendation.

The receiving VTU shall measure the SATN values under the same loop, noise, temperature, and configuration settings that are used for measuring the SATN reference values.

For all downstream bands, *m*, that are active during loop diagnostics or initialization, the absolute error between SATN_D(*m*) and SATN_reference_ds(*m*) shall be equal to or smaller than 3 dB.

The accuracy requirements for downstream SATN_D(*m*) shall apply to its measurement after Initialization during showtime.

For all upstream bands, *m*, that are active during loop diagnostics or initialization, the absolute error between SATN_U(*m*) and SATN_reference_us(*m*) shall be equal to or smaller than 3 dB.

The accuracy requirements for upstream SATN_U(*m*) shall apply to its measurement after Initialization during showtime.

**11.4.1.2.6 Accuracy of signal-to-noise ratio margin (*SNRM*)**

...

## 4) INM facility

### 4.1) Clause 11.2.3.13

*Modify clause 11.2.3.13 as follows:*

**11.2.3.13 INM facility commands and responses**

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

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

The INM facility commands are described in Table 11-32, and may only be initiated by the VTU-O. The VTU-R shall reply using one of the responses shown in Table 11-33. 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 11-5. The remaining octets shall be as specified in Table 11-32 and Table 11-33 for commands and responses, respectively. The octets shall be sent using the format described in clause 11.2.3.1.

**Table 11-32 – INM facility commands sent by the VTU-O**

| Name | Length (Octets) | Octet number | Content |
|---|---|---|---|
| Read INM counters | 2 | 2 | $02_{16}$ |
| Set INM parameters | 6 or 7 | 2 | $03_{16}$ |
| | | 3 to 6 or 7 | 4 or 5 octets of INM parameters: see Table 11-36 |
| Read INM parameters | 2 | 2 | $04_{16}$ |
| All other values for octet number 2 are reserved by ITU-T. | | | |

**Table 11-33 – INM facility responses sent by the VTU-R**

| Name | Length (Octets) | Octet number | Content |
|---|---|---|---|
| ACK | 3 | 2 | $80_{16}$ |
| | | 3 | 1 octet INM acceptance code: see Table 11-34 |
| 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 11-35 |
| | | 107 | 1 octet INMDF |
| INM parameters | 6 or 7 | 2 | $84_{16}$ |
| | | 3 to 6 or 7 | 4 or 5 octets of INM parameters: see Table 11-36 |
| All other values for octet number 2 are reserved by ITU-T. | | | |

Upon reception of any INM facility command, the VTU-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 VTU-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 VTU-R, the VTU-R shall accept all of the INM parameters contained in the command. The INM acceptance code (see Table 11-34) 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 VTU-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 values listed in the set INM parameters command is valid but not supported by the VTU-R, the VTU-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 VTU-R shall send the INM parameters response that includes the current value of the VTU-R INM parameters.

**Table 11-34 – VTU-R INM acceptance code**

| Name | Octet No. | 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 VTU shall send the INM counters response, which includes the INMDF. Any function of either the requesting or the responding VTU shall not be affected by this command.

The INM counter values shall be derived according to [ITU-T G.997.1] from locally generated defects and anomalies defined in clause 11.3. The parameters shall be transferred in the order (top to bottom) defined in Table 11-35. 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 VTU-O 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 11-35 – VTU-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 INMAIAT0 anomalies |
| Counter of the INMAIAT1 anomalies |
| ... |
| Counter of the $INMAIAT_6$ anomalies |
| Counter of the $INMAIAT_7$ anomalies |
| Counter of the INMAME anomalies |

The VTU-R shall set the INM default flag (INMDF) to ONE whenever all active INM parameters are equal to the default values. The VTU-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 11-36 and mapped in order of most significant to least significant octet.

**Table 11-36 – VTU-R INM parameters**

| Octet No. | INM parameter |
|---|---|
| 3-4 | 2 octets:<br>• The 9 LSBs are INMIATO<br>• The 4 MSBs are INMIATS |
| 5 | 1 octet: INMCC |
| 6 | 1 octet: INM_INPEQ_MODE |
| 7 | 1 octet: INM_INPEQ_FORMAT<br>This octet is present only if supported by both VTU-C and VTU-R (see Tables 12-49 and 12-60). |

### 4.2) Clause 11.3.4.1

*Modify clause 11.3.4.1 as follows:*

### 11.3.4.1 INM INPEQ histogram primitives

If INM_INPEQ_FORMAT=0, then the INM INPEQ histogram shall be configured with a linear scale as follows:

- $INMAINPEQ_1..INMAINPEQ_{16}$: every $INMAINPEQ_i$ is a primitive detected at the near end only. This anomaly occurs when the equivalent INP (as defined in clause 11.4.2.2.1) 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 11.4.2.2.1) is strictly more than 16 DMT symbols.

If INM_INPEQ_FORMAT=1 then the INM INPEQ histogram shall be configured with a logarithmic scale as follows ( $\lfloor x \rfloor$ denotes rounding to the lower integer ):

$INMAINPEQ_1..INMAINPEQ_{16}$: every $INMAINPEQ_i$ is a primitive detected at the near end only. This anomaly occurs when the equivalent INP (as defined in clause 11.4.2.2.1) falls in the range from $\lfloor 1.33^{i+1} \rfloor$ to $\lfloor 1.33^{i+2} \rfloor - 1$ DMT symbols, both boundaries inclusive.

$INMAINPEQ_{17}$ is a primitive detected at the near end only. This anomaly occurs when the equivalent INP (as defined in clause 11.4.2.2.1) is at least $\lfloor 1.33^{17+1} \rfloor = 169$ DMT symbols.

NOTE – The logarithmic scale gives rise to the following possible INMAINPEQ histogram ranges (in DMT symbols). It gives a finer granularity for the higher probability short duration impulses, whilst still capturing some information about the longer duration events.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | 2-2 | 3-3 | 4-4 | 5-6 | 7-8 | 9-12 | 13-16 | 17-22 | 23-29 | 30-39 | 40-53 | 54-71 | 72-94 | 95-126 | 127-168 | ≥ 169 |

### 4.3) Clause 11.4.2.2.6

*Modify clause 11.4.2.2.6 as follows:*

### 11.4.2.2.6 Definition of parameter INM_INPEQ_FORMAT

Configuration parameter INM_INPEQ_FORMAT defines the way the scale is configured for the INM_INPEQ histogram, as defined in clause 11.3.4.1. The CO MIB shall provide the value for the INM_INPEQ_FORMAT parameter. The parameter in the downstream direction is INM_INPEQ_FORMATds, and the parameter in the upstream direction is INM_INPEQ_FORMATus.

The valid values for INM_INPEQ_FORMAT are 0 and 1. If the VTU supports the INM facility, it shall support INM_INPEQ_FORMAT = 0 and may support INM_INPEQ_FORMAT = 1.

Upon entering the first showtime after power-up, the VTU-R shall use a default value of INM_INPEQ_FORMAT = 0. During showtime, this value may be overwritten by the VTU-O using an INM facility command defined in clause 11.2.3.13 if the VTU-R supports INM_INPEQ_FORMAT = 1.

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

The VTU-O shall use the current value of INM_INPEQ_FORMATus stored in the CO-MIB.

**4.4) Clause 12.3.5.2.1.1**

*Modify clause 12.3.5.2.1.1 as follows:*

**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 12-49.

**Table 12-49 – Description of message O-MSG 1**

| | Field name | Format |
|---|---|---|
| 1 | Message descriptor | Message code |
| 2 | Downstream target SNR margin (TARSNRMds) | 2 bytes |
| 3 | Downstream minimum SNR margin (MINSNRMds) | 2 bytes |
| 4 | Downstream maximum SNR margin (MAXSNRMds) | 2 bytes |
| 5 | RA-MODE | 1 byte |
| 6 | NTR | 1 byte |
| 7 | TPS-TC capabilities | See Table 12-50 |
| 8 | PMS-TC capabilities | See Table 12-52 |
| 9 | Downstream Rate adaptation downshift SNR margin (RA-DSNRMds) | 2 bytes |
| 10 | Downstream Rate adaptation downshift time interval (RA-DTIMEds) | 2 bytes |
| 11 | Downstream Rate adaptation upshift SNR margin (RA-USNRMds) | 2 bytes |
| 12 | Downstream Rate adaptation upshift time interval (RA-UTIMEds) | 2 bytes |
| 13 | Support of "Flexible OH frame type 2" downstream and INM_INPEQ_FORMATds | 1 byte |
| 14 | SOS Multi-step activation downstream | 1 byte |
| 15 | SOS Multi-step activation upstream | 1 byte |
| 16 | MIN-SOS-BR-ds0 | 2 bytes |
| 17 | MIN-SOS-BR-ds1 | 2 bytes |
| 18 | SOS-TIME-ds | 1 byte |
| 19 | SOS-NTONES-ds | 1 byte |
| 20 | SOS-CRC-ds | 2 bytes |
| 21 | MAX-SOS-ds | 1 byte |
| 22 | SNRMOFFSET-ROC-ds | 2 bytes |
| 23 | INPMIN-ROC-ds | 1 byte |

**Table 12-49 – Description of message O-MSG 1**

| | Field name | Format |
|---|---|---|
| 24 | G.998.4 parameter field | Variable length |
| 25 | G.993.5 parameter field | Variable length |
| 26 | REINIT_TIME_THRESHOLDds | 1 byte |
| 27 | Time synchronization capability | 1 byte |

Field #1 "Message descriptor" is a unique one-byte code that identifies the message. See Table 12-6 for a complete list of codes.

Field #2 "Downstream target SNR margin (TARSNRMds)" indicates the target SNR margin of the VTU-R receiver. The definition and use of this parameter shall be the same as for the parameter "Downstream Target Noise Margin (TARSNRMds)" specified in [ITU-T G.997.1]. The value and format of this parameter shall be the same as that in Field #12 of O-SIGNATURE (see clause 12.3.3.2.1.1).

Field #3 "Downstream minimum SNR margin (MINSNRMds)" is the minimum SNR margin the VTU-R shall tolerate. The definition and use of this parameter shall be the same as for the parameter "Downstream Minimum Noise Margin (MINSNRMds)" specified in [ITU-T G.997.1]. The field shall be formatted as a 16-bit unsigned integer with LSB weight of 0.1 dB and a valid range between 0 and 31 dB.

Field #4 "Downstream maximum SNR margin (MAXSNRMds)". The value and format for this parameter shall be the same as in Field #11 of O-SIGNATURE (see clause 12.3.3.2.1.1).

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), and TXREFVN (in SNRM_MODE=2) – 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) are of concern.

Field #5 "RA-MODE" specifies the mode of operation of a rate-adaptive VTU-O in the downstream direction as defined in [ITU-T G.997.1]. This field shall be coded as an 8-bit integer with valid values $01_{16}$, $02_{16}$, $03_{16}$ and $04_{16}$ for RA-MODE 1, 2, 3 and 4, respectively.

Field #6 "NTR" shall be set to $01_{16}$ if the VTU-O is transporting the NTR signal in the downstream direction, otherwise it shall be set to $00_{16}$.

Field #7 "TPS-TC capabilities" indicates the TPS-TC capabilities of the VTU-O as shown in Table 12-50.

Field #8 "PMS-TC capabilities" indicates the PMS-TC capabilities of the VTU-O. This includes the supported latency paths at the VTU-O (DS and US) and the capabilities per path (such as supported coding and interleaver parameters), as shown in Table 12-52.

Field #9 "Downstream Rate adaptation downshift SNR margin (RA-DSNRMds)": The definition and use of this parameter is specified in clause 13.4. The field shall be formatted as a 16-bit unsigned integer with LSB weight of 0.1 dB and has a valid range between 0 and 31.0 dB.

Field #10 "Downstream Rate adaptation downshift time interval (RA-DTIMEds)": The definition and use of this parameter is specified in clause 13.4. The field shall be formatted as a 16-bit unsigned integer with LSB weight of 1 s and has a valid range between 0 to 16 383 s.

Field #11 "Downstream Rate adaptation upshift SNR margin (RA-USNRMds)": The definition and use of this parameter is specified in clause 13.4. The field shall be formatted as a 16-bit unsigned integer with LSB weight of 0.1 dB and has a valid range between 0 and 31.0 dB.

Field #12 "Downstream Rate adaptation upshift time interval (RA-UTIMEds)": The definition and use of this parameter is specified in clause 13.4. The field shall be formatted as a 16-bit unsigned integer with LSB weight of 1 s and has a valid range between 0 to 16 383 s.

Field #13 indicates the support by the VTU-O of the "Flexible OH Frame Type 2" and the INM_INPEQ_FORMATds in the downstream direction. The field shall be formatted as [0000 000~~0~~ba]. The VTU-O shall indicate support by setting, respectively, a=1 and b=1 in this field~~the LSB of the field to 1~~. Other bits shall be set to 0 and are reserved by ITU-T.

...

## 4.5) Clause 12.3.5.2.2.1

*Modify clause 12.3.5.2.2.1 as follows:*

### 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 12-60.

**Table 12-60 – Description of message R-MSG 2**

| | Field name | Format |
|---|---|---|
| 1 | Message descriptor | Message code |
| 2 | TPS-TC capabilities | See Table 12-61 |
| 3 | PMS-TC capabilities | See Table 12-62 |
| 4 | Support of "Flexible OH frame type 2" upstream and INM_INPEQ_FORMATds | 1 byte |
| 5 | SOS Multi-step activation downstream | 1 byte |
| 6 | SOS Multi-step activation upstream | 1 byte |
| 7 | G.998.4 parameter field | Variable length |
| 8 | G.993.5 parameter field | Variable length |
| 9 | Time Synchronization capability | 1 byte |
| 10 | Time Synchronization Period (TSP) | 1 byte |

Field #1 "Message descriptor" is a unique one-byte code that identifies the message. See Table 12-6 for a complete list of codes.

Field #2 "TPS-TC capabilities" indicates the TPS-TC capabilities of the VTU-R, as shown in Table 12-61.

Field #3 "PMS-TC capabilities" indicates the PMS-TC capabilities of the VTU-R. This includes the supported latency paths at the VTU-R (DS and US) and the capabilities per path (such as supported coding and interleaver parameters), as shown in Table 12-62.

Field #4 indicates the support by the VTU-R of the "Flexible OH Frame Type 2" in the upstream~~downstream~~ direction and the INM_INPEQ_FORMATds in the downstream direction. The field shall be formatted as [0000 000~~0~~ba]. The VTU-R shall indicate support by setting, respectively, a=1 and b=1 in this field~~the LSB of the field to 1~~. Other bits shall be set to 0 and are reserved by ITU-T.

## 5) O-SIGNATURE field for Upstream FDPS descriptor

### 5.1) Table 12-21, Fields #23 and #24

*Add new fields #23 and #24 to Table 12-21 as follows:*

#### 12.3.3.2.1.1 O-SIGNATURE

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

**Table 12-21 – Description of message O-SIGNATURE**

| | Field name | Format |
|---|---|---|
| 1 | Message descriptor | Message code |
| 2 | Supported subcarriers in the downstream direction (SUPPORTEDCARRIERSds set) | Bands descriptor |
| 3 | Supported subcarriers 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 ($\beta_{ds}$) | 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 | ITU-T G.998.4 parameter field | Variable length |
| 21 | ITU-T G.993.5 parameter field A | Variable length |
| 22 | Alternative Electrical Length Estimation Mode Control | 2 bytes AELE-MODE Control descriptor |
| 23 | Reserved for operation according to Annex X | 1 byte |
| 24 | ITU-T G.993.5 parameter field B | Variable length |

### 5.2) Table 12-21, Fields #20 and #21

*Modify the description for field #20 and field #21 as follows:*

Field #20 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-26.

Field #21 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-26.

**Table 12-26 – Format of variable length fields #20 and #21**

| Octet | Name | Format | Description |
|---|---|---|---|
| 1 | ~~Field~~ Data length | 1 byte | Number of ~~data~~ bytes in the ~~parameter~~Data field (i.e., N-1). This is the number of bytes following this octet (see Note 1~~Note~~). |
| 2-N | Data | N-1 bytes | N-1 data bytes, with N-1 being equal to the number contained in Octet #1 (see Note 2). |
| NOTE 1 – The number of ~~data~~ bytes in the Data field could be zero. In that case, the variable length field consists of a single byte (i.e., N=1) with value $00_{16}$.<br>NOTE 2 – The N represents the length of the variable length field in bytes. | | | |

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 [ITU-T G.998.4] or [ITU-T G.993.5] or both is required. However, support of those Recommendations is not implied or required for compliance with [ITU-T G.993.2].

If the VTU-O does not support [ITU-T G.998.4], the ITU-T G.998.4 parameter field shall be a single byte with value $00_{16}$.

If the VTU-O does not support [ITU-T G.993.5], the ITU-T G.993.5 parameter field A shall be a single byte with value $00_{16}$.

### 5.3) Table 12-21, Field #24

*Add new Field #24 at the end of clause 12.3.3.2.1.1 as follows:*

Field #24 is a variable length field consisting of an integer number of bytes. It is formatted as shown in Table 12-26a.

**Table 12-26a – Format of variable length field #24**

| Octet | Name | Format | Description |
|---|---|---|---|
| 1-2 | Data length | 2 bytes | Number of bytes in the Data field (i.e., N-2). This is the number of bytes following these 2 octets (see Note 1). |
| 3-N | Data | N-2 bytes | N-2 data bytes, with N-2 being equal to the number contained in Octets #1-2 (see Note 2). |
| NOTE 1 – The number of bytes in the Data field could be zero. In that case, the variable length field consists of 2 bytes long (i.e., N=2) with value $0000_{16}$.<br>NOTE 2 – The N represents the length of the variable length field in bytes. | | | |

The actual data in the variable length field #24 is beyond the scope of this Recommendation. For a correct interpretation at the receiver, support of [ITU-T G.993.5] is required. However, support of [ITU-T G.993.5] is not implied or required for compliance with this Recommendation.

If the VTU-O does not support [ITU-T G.993.5], the ITU-T G.993.5 parameter field B shall be 2 bytes long with value $0000_{16}$.

## 6) SRA following SOS

### 6.1) Clause 13.4.4

*Change clause 13.4.4 as follows:*

### 13.4.4 Receiver Initiated SRA following an SOS procedure

A VTU shall send one or more SRA requests following an SOS procedure to remediate the situation in which the current rate is less than Minimum Net Data Rate, or the actual noise margin greater than the target noise margin. As long as the current bit rate is less than Minimum Net Data Rate, or the actual noise margin greater than the target noise margin, these SRA requests are not required to respect either RA-UTIME or RA-USNRM.

NOTE – Although these SRA requests can be issued at the discretion of the VTU, the Note in clause 13.1 defines a goal for the overall duration of the SOS procedure.

## 7) Annex B

*Change Annex B as follows:*

# Annex B

# Region B (Europe)

(This annex forms an integral part of this Recommendation.)

## B.1 Band plans

This annex defines the various band plans required for European deployment of VDSL2 systems operating at a maximum frequency of 30 MHz. These are based on [ITU-T G.993.1] band plans A and B (also referred to as plan 998 and plan 997, respectively). The various band plans are defined in Table B.1 below and can be summarized as follows:

**Plan 997** The original plan 997 ($f_{max}$ = 12 MHz).

**Plan 997E17** Plan 997 directly extended to $f_{max}$ = 17.664 MHz.

**Plan 997E30** Plan 997 directly extended to $f_{max}$ = 30 MHz.

NOTE – Plan 997E17 and plan 997 are truncated versions of plan 997E30.

**Plan 998** The original plan 998 ($f_{max}$ = 12 MHz).

**Plan 998E17** Plan 998 directly extended to $f_{max}$ = 17.664 MHz.

**Plan 998E30** Plan 998 directly extended to $f_{max}$ = 30 MHz.

NOTE – Plan 998E17 and plan 998 are truncated versions of plan 998E30.

**Plan 998ADE17** Plan 998 extended to $f_{max}$ = 17.664 MHz (downstream transmission only above 12 MHz)

**Plan 998ADE30** Plan 998 extended to $f_{max}$ = 30 MHz.

NOTE – Plan 998ADE17 and plan 998 are truncated versions of plan 998ADE30.

**Plan HPE17** Band plan for operation between 7.05 MHz and 17.664 MHz.

**Plan HPE30** Band plan for operation between 7.05 MHz and 30 MHz.

NOTE – Plan HPE17 is a truncated version of plan HPE30.

**Plan HPE1230** Band plan for operation between 12 MHz and 30 MHz.

NOTE – Plan HPE1230 is a truncated version of plan HPE30.

**Plan HPE1730** Band plan for operation between 17.664 MHz and 30 MHz.

NOTE – Plan HPE1730 is a truncated version of plan HPE30.

**Plan HPEADE1230** Band plan for operation between 12 MHz and 30 MHz.

NOTE – Plan HPEADE1230 is a truncated version of plan 998ADE30.

**Plan HPEADE1730** Band plan for operation between 17.664 MHz and 30 MHz.

NOTE – Plan HPEADE1730 is a truncated version of plan 998ADE30.

Different variants are defined for band plans 997, 998, 998E17, 998E30, 998ADE17 and 998ADE30 to accommodate different underlying services (POTS and ISDN), and different US0 bandwidths.

**Table B.1 – Band-edge frequencies for European VDSL2 band plans**

| Band plan | Band-edge frequencies (as defined in the generic band plan in clause 7.1.2) $f_{0L}$ kHz | $f_{0H}$ kHz | $f_1$ kHz | $f_2$ kHz | $f_3$ kHz | $f_4$ kHz | $f_5$ kHz | $f_6$ kHz | $f_7$ kHz | $f_8$ kHz | $f_9$ kHz |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | US0 | | DS1 | US1 | DS2 | US2 | DS3 | US3 | DS4 | US4 | |
| 997 | 25 | 138 | 138 | 3 000 | 5 100 | 7 050 | 12 000 | N/A | N/A | N/A | N/A |
| | 25 | 276 | 276 | | | | | | | | |
| 997E17 | 25 | 138 | 138 | 3 000 | 5 100 | 7 050 | 12 000 | 14 000 | 17 664 | N/A | N/A |
| 997E30 | N/A | N/A | 138 | 3 000 | 5 100 | 7 050 | 12 000 | 14 000 | 19 500 | 27 000 | 30 000 |
| | US0 | | DS1 | US1 | DS2 | US2 | US3 | DS3 | US4 | DS4 | |
| 998 | 25 | 138 | 138 | 3 750 | 5 200 | 8 500 | 12 000 | N/A | N/A | N/A | N/A |
| | 25 | 276 | 276 | | | | | | | | |
| | 120 | 276 | 276 | | | | | | | | |
| | N/A | N/A | 138 | | | | | | | | |
| 998E17 | N/A | N/A | 138 | 3 750 | 5 200 | 8 500 | 12 000 | 14 000 | 17 664 | N/A | N/A |
| | N/A | N/A | 276 | 3 750 | 5 200 | 8 500 | 12 000 | 14 000 | 17 664 | N/A | N/A |
| 998E30 | N/A | N/A | 138 | 3 750 | 5 200 | 8 500 | 12 000 | 14 000 | 21 450 | 24 890 | 30 000 |
| | N/A | N/A | 276 | 3 750 | 5 200 | 8 500 | 12 000 | 14 000 | 21 450 | 24 890 | 30 000 |
| | US0 | | DS1 | US1 | DS2 | US2 | DS3 | US3 | | | |
| 998ADE17 | 25 | 138 | 138 | 3 750 | 5 200 | 8 500 | 12 000 | 17 664 | N/A | | |
| | 120 | 276 | 276 | | | | | | | | |
| | 25 | 276 | 276 | | | | | | | | |
| | N/A | N/A | 276 | | | | | | | | |

**Table B.1 – Band-edge frequencies for European VDSL2 band plans**

| Band plan | Band-edge frequencies (as defined in the generic band plan in clause 7.1.2) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $f_{0L}$ kHz | $f_{0H}$ kHz | $f_1$ kHz | $f_2$ kHz | $f_3$ kHz | $f_4$ kHz | $f_5$ kHz | $f_6$ kHz | $f_7$ kHz | $f_8$ kHz | $f_9$ kHz |
| 998ADE30 | N/A | N/A | 138 | 3 750 | 5 200 | 8 500 | 12 000 | 24 890 | 30 000 | | |
| | N/A | N/A | 276 | | | | | | | | |
| | | | | | DS2 | US2 | US3 | DS3 | US4 | DS4 | |
| HPE17 | N/A | N/A | N/A | N/A | 7 050 | 10 125 | 12 000 | 14 000 | 17 664 | N/A | N/A |
| HPE30 | N/A | N/A | N/A | N/A | 7 050 | 10 125 | 12 000 | 14 000 | 21 450 | 24 890 | 30 000 |
| HPE1230 | N/A | N/A | N/A | N/A | N/A | N/A | 12 000 | 14 000 | 21 450 | 24 890 | 30 000 |
| HPE1730 | N/A | N/A | N/A | N/A | N/A | N/A | NA | 17 664 | 21 450 | 24 980 | 30 000 |
| | US0 | | DS1 | US1 | DS2 | US2 | DS3 | US3 | | | |
| HPEADE1230 | N/A | N/A | N/A | N/A | N/A | N/A | 12 000 | 24 890 | 30 000 | | |
| HPEADE1730 | N/A | N/A | N/A | N/A | N/A | N/A | 17 664 | 24 890 | 30 000 | | |

NOTE 1 – N/A in the columns $f_{0L}$ and $f_{0H}$ designates a band plan variant that does not use US0.
NOTE 2 – The capability to support US0 together with profile 17a is required for European VDSL2.

The $f_i$ in Table B.1 are defined as follows:

- $f_{0L}$ and $f_{0H}$: define lower and upper frequency of US0;
- $f_1$ to $f_5$ are the boundary frequencies of the bands DS1, US1, DS2, US2 as defined for VDSL1 for 997 and 998;
- $f_5$ to $f_9$ are the boundary frequencies for the bands US3, DS3, US4 and DS4 (extended bands);
- the extension of an existing band is considered as a separate band (e.g., 998E17: US3 12 MHz-14 MHz).

## B.2 Limit PSD mask options

The Limit PSD mask options defined in this annex are shown in Tables B.2, and B.3 and B4, for various band plans.

**Table B.2 – European Limit PSD mask options for band plans 997 (and its extensions), HPE17 and HPE30**

| Short name | Limit PSD mask (Long name) | Frequency | |
|---|---|---|---|
| | | US0 type A/B/M (Note) | Highest used upstream or downstream frequency (kHz) |
| B7-1 | 997-M1c-A-7 | A | 7 050 |
| B7-3 | 997-M1x-M | M | 12 000 |
| B7-7 | HPE17-M1-NUS0 | N/A | 17 664 |
| B7-8 | HPE30-M1-NUS0 | N/A | 30 000 |
| B7-9 | 997E17-M2x-A | A | 17 664 |
| B7-10 | 997E30-M2x-NUS0 | N/A | 30 000 |
| B7-11 | HPE1230-M1-NUS0 | N/A | 30 000 |
| B7-12 | HPE1730-M1-NUS0 | N/A | 30 000 |
| NOTE – The US0 types stand for:<br>• US0 type A corresponds to Annex A of [ITU-T G.992.5];<br>• US0 type B corresponds to Annex B of [ITU-T G.992.5];<br>• US0 type M corresponds to Annex M of [ITU-T G.992.3] or of [ITU-T G.992.5];<br>• US0 type N/A designates a band plan variant that does not use US0. | | | |

**Table B.3 – European limit PSD mask options for band plan 998 (and its extensions)**

| Short name | Limit PSD mask (Long name) | Frequency | |
|---|---|---|---|
| | | US0 type A/B/M (Note) | Highest used upstream or downstream frequency (kHz) |
| B8-1 | 998-M1x-A | A | 12 000 |
| B8-2 | 998-M1x-B | B | 12 000 |
| B8-3 | 998-M1x-NUS0 | N/A | 12 000 |
| B8-4 | 998-M2x-A | A | 12 000 |
| B8-5 | 998-M2x-M | M | 12 000 |
| B8-6 | 998-M2x-B | B | 12 000 |
| B8-7 | 998-M2x-NUS0 | N/A | 12 000 |
| B8-8 | 998E17-M2x-NUS0 | N/A | 17 664 |
| B8-9 | 998E17-M2x-NUS0-M | N/A | 17 664 |
| B8-10 | 998ADE17-M2x-NUS0-M | N/A | 17 664 |
| B8-11 | 998ADE17-M2x-A | A | 17 664 |
| B8-12 | 998ADE17-M2x-B | B | 17 664 |

**Table B.3 – European limit PSD mask options for band plan 998 (and its extensions)**

| Short name | Limit PSD mask (Long name) | Frequency | |
|---|---|---|---|
| | | US0 type A/B/M (Note) | Highest used upstream or downstream frequency (kHz) |
| B8-13 | 998E30-M2x-NUS0 | N/A | 30 000 |
| B8-14 | 998E30-M2x-NUS0-M | N/A | 30 000 |
| B8-15 | 998ADE30-M2x-NUS0-M | N/A | 30 000 |
| B8-16 | 998ADE30-M2x-NUS0-A | N/A | 30 000 |
| B8-17 | 998ADE17-M2x-M | M | 17 664 |

NOTE – The US0 types stand for:
- US0 type A corresponds to Annex A of [ITU-T G.992.5];
- US0 type B corresponds to Annex B of [ITU-T G.992.5];
- US0 type M corresponds to Annex M of [ITU-T G.992.3]or of [ITU-T G.992.5];
- US0 type N/A designates a band plan variant that does not use US0;
- 998ADExx-M2x-NUS0-M designate the variants in which DS1 starts at 276 kHz instead of 138 kHz.

**Table B.4 – European limit PSD mask options for HPE band plans**

| Short name | Limit PSD mask (Long name) | Frequency | |
|---|---|---|---|
| | | US0 type A/B/M (Note) | Highest used upstream or downstream frequency (kHz) |
| BH-1 | HPE17-M1-NUS0 | N/A | 17 664 |
| BH-2 | HPE30-M1-NUS0 | N/A | 30 000 |
| BH-3 | HPE1230-NUS0 | N/A | 30 000 |
| BH-4 | HPE1730-NUS0 | N/A | 30 000 |
| BH-5 | HPEADE1230-NUS0 | N/A | 30 000 |
| BH-6 | HPEADE1730-NUS0 | N/A | 30 000 |

NOTE 1 – US0 type N/A designates a band plan variant that does not use US0.

NOTE 2 – Band plans BH-1 and BH-2 were referred to as band plans B7-7 and B7-8 respectively in previous versions of ITU-T G.993.2.

### B.2.1 General requirements in the band below 4 kHz

The noise in the voice band measured with psophometric weighting according to [ITU-T O.41] clause 3.3 shall not exceed –68 dBm. The psophometer shall be used in bridging mode and shall be calibrated for 600 ohm termination.

### B.2.2 VTU-R limit PSD masks for band plans 997 (and its extensions)~~, HPE17 and HPE30~~

The VTU-R limit PSD masks for band plan 997 (and its extensions) are shown in Table B.5.

**Table B.54 – VTU-R limit PSD masks for band plans 997 (and its extensions)~~, HPE17 and HPE30~~**

| Name | B7-1 | B7-3 | B7-9 | B7-10 |
|---|---|---|---|---|
| Long name | 997-M1-c-A-7 | 997-M1-x-M | 997E17-M2x-A | 997E30-M2x-NUS0 |
| kHz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz |
| 0 | –97.5 | –97.5 | –97.5 | –100 |
| 4 | –97.5 | –97.5 | –97.5 | –100 |
| 4 | –92.5 | –92.5 | –97.5 | –100 |
| 25.875 | –34.5 | –37.5 | –34.5 | –100 |
| 50 | –34.5 | –37.5 | –34.5 | –100 |
| 80 | –34.5 | –37.5 | –34.5 | –100 |
| 120 | –34.5 | –37.5 | –34.5 | –100 |
| 138 | –34.5 | –37.5 | –34.5 | –100 |
| 225 | Interp | –37.5 | Interp | –100 |
| 243 | –93.2 | –37.5 | –93.2 | –100 |
| 276 | Interp | –37.5 | Interp | –100 |
| 493.41 | Interp | –97.9 | Interp | –100 |
| 686 | –100 | –100 | –100 | –100 |
| 2 825 | –100 | –100 | –100 | –100 |
| 3 000 | –80 | –80 | –80 | –80 |
| 3 000 | –56.5 | –56.5 | –50.3 | –50.3 |
| 3 575 | –56.5 | –56.5 | Interp | Interp |
| 3 750 | –56.5 | –56.5 | Interp | Interp |
| 5 100 | –56.5 | –56.5 | –52.6 | –52.6 |
| 5 100 | –80 | –80 | –80 | –80 |
| 5 275 | –100 | –100 | –100 | –100 |
| 6 875 | –100 | –100 | –100 | –100 |
| 7 050 | –100 | –80 | –80 | –80 |
| 7 050 | –100 | –56.5 | –54 | –54 |
| 8 325 | –100 | –56.5 | Interp | Interp |
| 9 950 | –100 | –56.5 | Interp | Interp |
| 10 125 | –100 | –56.5 | –55.5 | –55.5 |
| 10 125 | –100 | –56.5 | –55.5 | –55.5 |
| 11 825 | –100 | –56.5 | –55.5 | –55.5 |
| 12 000 | –100 | –56.5 | –55.5 | –55.5 |
| 12 000 | –100 | –80 | –80 | –80 |

**Table B.54 – VTU-R limit PSD masks for band plans 997 (and its extensions), HPE17 and HPE30**

| Name | B7-1 | B7-3 | B7-9 | B7-10 |
|---|---|---|---|---|
| Long name | 997-<br>M1-c-A-7 | 997-<br>M1-x-M | 997E17-<br>M2x-A | 997E30-<br>M2x-NUS0 |
| kHz | dBm/<br>Hz | dBm/<br>Hz | dBm/<br>Hz | dBm/<br>Hz |
| 12 175 | –100 | –100 | –100 | –100 |
| 13 825 | –100 | –100 | –100 | –100 |
| 14 000 | –100 | –100 | –80 | –80 |
| 14 000 | –100 | –100 | –56.5 | –56.5 |
| 14 175 | –100 | –100 | Interp | Interp |
| 17 664 | –100 | –100 | –56.5 | –56.5 |
| 19 500 | –100 | –100 | –80 | –56.5 |
| 19 500 | –100 | –100 | –80 | –80 |
| 19 675 | –100 | –100 | –100 | –100 |
| 21 275 | –100 | –100 | –100 | –100 |
| 21 450 | –100 | –100 | –100 | –100 |
| 21 450 | –100 | –100 | –100 | –100 |
| 24 890 | –100 | –100 | –100 | –100 |
| 24 890 | –100 | –100 | –100 | –100 |
| 25 065 | –100 | –100 | –100 | –100 |
| 26 825 | –100 | –100 | –100 | –100 |
| 27 000 | –100 | –100 | –100 | –80 |
| 27 000 | –100 | –100 | –100 | –56.5 |
| 30 000 | –100 | –100 | –100 | –56.5 |
| 30 000 | –110 | –110 | –110 | –80 |
| 30 175 | –110 | –110 | –110 | –110 |
| ≥ 30 175 | –110 | –110 | –110 | –110 |

NOTE – The PSD values between breakpoints including the values marked by "Interp" shall be obtained by interpolation between adjacent breakpoints as follows:
- below 2 825 kHz on a dB/log(*f*) basis; and
- above 2 825 kHz on a dB/*f* basis.

### B.2.3 VTU-O limit PSD masks for band plans 997 (and its extensions), ~~HPE17 and HPE30~~

The VTU-O limit PSD masks for band plan 997 (and its extensions) are shown in Table B.6.

**Table B.65 – VTU-O limit PSD masks for band plans 997 (and its extensions), ~~HPE17 and HPE30~~**

| Name | B7-1 | B7-3 | B7-9 | B7-10 |
|---|---|---|---|---|
| Long name | 997-M1c-A-7 | 997-M1x-M | 997E17-M2x-A | 997E30-M2x-NUS0 |
| kHz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz |
| 0 | –97.5 | –97.5 | –97.5 | –97.5 |
| 4 | –97.5 | –97.5 | –97.5 | –97.5 |
| 4 | –92.5 | –92.5 | –92.5 | –92.5 |
| 80 | –72.5 | –92.5 | –72.5 | –72.5 |
| 101.2 | Interp | –92.5 | Interp | Interp |
| 138 | –49.5 | Interp | –44.2 | –44.2 |
| 138 | –49.5 | Interp | –36.5 | –36.5 |
| 227.11 | –49.5 | –62 | –36.5 | –36.5 |
| 276 | –49.5 | –48.5 | –36.5 | –36.5 |
| 276 | –49.5 | –36.5 | –36.5 | –36.5 |
| 1 104 | –49.5 | –36.5 | –36.5 | –36.5 |
| 1 622 | –49.5 | –46.5 | –46.5 | –46.5 |
| 2 208 | –49.5 | –48 | Interp | Interp |
| 2 236 | –49.5 | Interp | Interp | Interp |
| 2 249 | –49.5 | –49.5 | Interp | Interp |
| 2 423 | –56.5 | Interp | Interp | Interp |
| 2 500 | –56.5 | –56.5 | Interp | Interp |
| 3 000 | –56.5 | –56.5 | –49.6 | –49.6 |
| 3 000 | –80 | –80 | –80 | –80 |
| 3 175 | –100 | –100 | –100 | –100 |
| 4 925 | –100 | –100 | –100 | –100 |
| 5 100 | –80 | –80 | –80 | –80 |
| 5 100 | –56.5 | –56.5 | –52.6 | –52.6 |
| 5 200 | –56.5 | –56.5 | Interp | Interp |
| 6 875 | –56.5 | –56.5 | Interp | Interp |
| 7 050 | –56.5 | –56.5 | –54 | –54 |
| 7 050 | –80 | –80 | –80 | –80 |
| 7 225 | –100 | –100 | –100 | –100 |
| 10 125 | –100 | –100 | –100 | –100 |
| 10 125 | –100 | –100 | –100 | –100 |
| 10 300 | –100 | –100 | –100 | –100 |

**Table B.6~~5~~ – VTU-O limit PSD masks for band plan~~s~~ 997 (and its extensions)~~, HPE17 and HPE30~~**

| Name | B7-1 | B7-3 | B7-9 | B7-10 |
|---|---|---|---|---|
| Long name | 997-M1c-A-7 | 997-M1x-M | 997E17-M2x-A | 997E30-M2x-NUS0 |
| kHz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz |
| 11 825 | –100 | –100 | –100 | –100 |
| 12 000 | –100 | –100 | –80 | –80 |
| 12 000 | –100 | –100 | –56.5 | –56.5 |
| 13 825 | –100 | –100 | –56.5 | –56.5 |
| 14 000 | –100 | –100 | –56.5 | –56.5 |
| 14 000 | –100 | –100 | –80 | –80 |
| 14 175 | –100 | –100 | –100 | –100 |
| 17 489 | ~~14 175~~–100 | –100 | ~~–56.5~~–100 | –100 |
| 17 664 | –100 | –100 | –100 | –100 |
| 17 664 | –100 | –100 | –100 | –100 |
| 19 325 | –100 | –100 | –100 | –100 |
| 19 500 | –100 | –100 | –100 | –80 |
| 19 500 | –100 | –100 | –100 | –56.5 |
| 21 000 | –100 | –100 | –100 | –56.5 |
| 21 450 | –100 | –100 | –100 | –56.5 |
| 21 450 | –100 | –100 | –100 | –56.5 |
| 21 625 | –100 | –100 | –100 | –56.5 |
| 24 715 | –100 | –100 | –100 | –56.5 |
| 24 890 | –100 | –100 | –100 | –56.5 |
| 24 890 | –100 | –100 | –100 | –56.5 |
| 27 000 | –100 | –100 | –100 | –56.5 |
| 27 000 | –100 | –100 | –100 | –80 |
| 27 175 | –100 | –100 | –100 | –100 |
| 30 000 | –100 | –100 | –100 | –100 |
| 30 000 | –110 | –110 | –110 | –110 |

**Table B.65 – VTU-O limit PSD masks for band plans 997 (and its extensions), HPE17 and HPE30**

| Name | B7-1 | B7-3 | B7-9 | B7-10 |
|---|---|---|---|---|
| Long name | 997-M1c-A-7 | 997-M1x-M | 997E17-M2x-A | 997E30-M2x-NUS0 |
| kHz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz |
| 30 175 | –110 | –110 | –110 | –110 |
| ≥ 30 175 | –110 | –110 | –110 | –110 |

NOTE – The PSD values between breakpoints including the values marked by "Interp" shall be obtained by interpolation between adjacent breakpoints as follows:
– below $f_1$ on a dB/log($f$) basis; and
– above $f_1$ on a dB/$f$ basis,
where f1 is defined in Table B.1 as either 138 or 276 kHz.
For Limit PSD masks B7-7 and B7-8, where $f_1$ is N/A, the PSD values between breakpoints including the values marked by "Interp" shall be obtained by interpolation between adjacent breakpoints as follows:
– below 138 kHz on a dB/log($f$) basis; and
– above 138 kHz on a dB/f basis.

### B.2.4 VTU-R limit PSD masks for band plan 998 (and its extensions)

The VTU-R limit PSD masks for band plan 998 (and its extensions) are shown in Table B.7.

**Table B.7~~6~~ – VTU-R limit PSD masks for band plan 998 (and its extensions)**

| Name | B8-4 | B8-5 | B8-6 | B8-7 | B8-8 | B8-9 | B8-10 | B8-11 | B8-12 | B8-13 | B8-14 | B8-15 | B8-16 | B8-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Long name** | **998-M2x-A** | **998-M2x-M** | **998-M2x-B** | **998-M2x-NUS0** | **998 E17-M2x-NUS0** | **998 E17-M2x-NUS0-M** | **998 ADE17-M2x-NUS0-M** | **998 ADE17-M2x-A** | **998 ADE17-M2x-B** | **998 E30-M2x-NUS0** | **998 E30-M2x-NUS0-M** | **998 ADE30-M2x-NUS0-M** | **998 ADE30-M2x-NUS0-A** | **998 ADE17-M2x-M** |
| **kHz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** |
| 0 | –97.5 | –97.5 | –97.5 | –100 | –100 | –100 | –100 | –97.5 | –97.5 | –100 | –100 | –100 | –100 | –97.5 |
| 4 | –97.5 | –97.5 | –97.5 | –100 | –100 | –100 | –100 | –97.5 | –97.5 | –100 | –100 | –100 | –100 | –97.5 |
| 4 | –92.5 | –92.5 | –92.5 | –100 | –100 | –100 | –100 | –92.5 | –92.5 | –100 | –100 | –100 | –100 | –92.5 |
| 25.875 | –34.5 | –37.5 | –92.5 | –100 | –100 | –100 | –100 | –34.5 | –92.5 | –100 | –100 | –100 | –100 | –37.5 |
| 50 | –34.5 | –37.5 | –90 | –100 | –100 | –100 | –100 | –34.5 | –90 | –100 | –100 | –100 | –100 | –37.5 |
| 80 | –34.5 | –37.5 | –81.8 | –100 | –100 | –100 | –100 | –34.5 | –81.8 | –100 | –100 | –100 | –100 | –37.5 |
| 120 | –34.5 | –37.5 | –34.5 | –100 | –100 | –100 | –100 | –34.5 | –34.5 | –100 | –100 | –100 | –100 | –37.5 |
| 138 | –34.5 | –37.5 | –34.5 | –100 | –100 | –100 | –100 | –34.5 | –34.5 | –100 | –100 | –100 | –100 | –37.5 |
| 225 | Interp | –37.5 | –34.5 | –100 | –100 | –100 | –100 | Interp | –34.5 | –100 | –100 | –100 | –100 | –37.5 |
| 243 | –93.2 | –37.5 | –34.5 | –100 | –100 | –100 | –100 | –93.2 | –34.5 | –100 | –100 | –100 | –100 | –37.5 |
| 276 | Interp | –37.5 | –34.5 | –100 | –100 | –100 | –100 | Interp | –34.5 | –100 | –100 | –100 | –100 | –37.5 |
| 307 | Interp | Interp | Interp | –100 | –100 | –100 | –100 | Interp | Interp | –100 | –100 | –100 | –100 | Interp |
| 493.41 | Interp | –97.9 | Interp | –100 | –100 | –100 | –100 | Interp | Interp | –100 | –100 | –100 | –100 | –97.9 |
| 508.8 | Interp | Interp | –98 | –100 | –100 | –100 | –100 | Interp | –98 | –100 | –100 | –100 | –100 | Interp |
| 686 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 |
| 3 575 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 |
| 3 750 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 |
| 3 750 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 |
| 5 100 | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp |
| 5 200 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 |
| 5 200 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 |
| 5 375 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 |
| 8 325 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 |

## Table B.76 – VTU-R limit PSD masks for band plan 998 (and its extensions)

| Name | B8-4 | B8-5 | B8-6 | B8-7 | B8-8 | B8-9 | B8-10 | B8-11 | B8-12 | B8-13 | B8-14 | B8-15 | B8-16 | B8-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Long name** | **998-M2x-A** | **998-M2x-M** | **998-M2x-B** | **998-M2x-NUS0** | **998 E17-M2x-NUS0** | **998 E17-M2x-NUS0-M** | **998 ADE17-M2x-NUS0-M** | **998 ADE17-M2x-A** | **998 ADE17-M2x-B** | **998 E30-M2x-NUS0** | **998 E30-M2x-NUS0-M** | **998 ADE30-M2x-NUS0-M** | **998 ADE30-M2x-NUS0-A** | **998 ADE17-M2x-M** |
| **kHz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** |
| 8 500 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 |
| 8 500 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 |
| 10 000 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 |
| 12 000 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 | –55.5 |
| 12 000 | –80 | –80 | –80 | –80 | –56.5 | –56.5 | –80 | –80 | –80 | –56.5 | –56.5 | –80 | –80 | –80 |
| 12 175 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –100 | –100 | –100 | –56.5 | –56.5 | –100 | –100 | –100 |
| 14 000 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –100 | –100 | –100 | –56.5 | –56.5 | –100 | –100 | –100 |
| 14 000 | –100 | –100 | –100 | –100 | –80 | –80 | –100 | –100 | –100 | –80 | –80 | –100 | –100 | –100 |
| 14 175 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 |
| 21 275 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 |
| 21 450 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –80 | –80 | –100 | –100 | –100 |
| 21 450 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –100 | –100 | –100 |
| 24 715 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –100 | –100 | –100 |
| 24 890 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –80 | –80 | –100 |
| 24 890 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –80 | –80 | –56.5 | –56.5 | –100 |
| 25 065 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –100 |
| 30 000 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –100 |
| 30 000 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –80 | –80 | –110 |
| 30 175 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 |
| ≥ 30 175 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 |

NOTE – The PSD values between breakpoints including the values marked by "Interp" shall be obtained by interpolation between adjacent breakpoints as follows:

– below 3 575 kHz on a dB/log(*f*) basis; and
– above 3 575 kHz on a dB/*f* basis.

### B.2.5 VTU-O limit PSD masks for band plan 998 (and its extensions)

The VTU-O limit PSD masks for band plan 998 (and its extensions) are shown in Table B.8.

**Table B.8~~7~~ – VTU-O limit PSD masks for band plan 998 (and its extensions)**

| Name | B8-4 | B8-5 | B8-6 | B8-7 | B8-8 | B8-9 | B8-10 | B8-11 | B8-12 | B8-13 | B8-14 | B8-15 | B8-16 | B8-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Long name | 998-M2x-A | 998-M2x-M | 998-M2x-B | 998-M2x-NUS0 | 998 E17-M2x-NUS0 | 998 E17-M2x-NUS0-M | 998 ADE17-M2x-NUS0-M | 998 ADE17-M2x-A | 998 ADE17-M2x-B | 998 E30-M2x-NUS0 | 998 E30-M2x-NUS0-M | 998 ADE30-M2x-NUS0-M | 998 ADE30-M2x-NUS0-A | 998 ADE17-M2x-M |
| kHz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz |
| 0 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 |
| 4 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 |
| 4 | –92.5 | –92.5 | –92.5 | –92.5 | –92.5 | –92.5 | –92.5 | –92.5 | –92.5 | –92.5 | –92.5 | –92.5 | –92.5 | –92.5 |
| 80 | –72.5 | –92.5 | –92.5 | –72.5 | –72.5 | –92.5 | –92.5 | –72.5 | –92.5 | –72.5 | –92.5 | –92.5 | –72.5 | –92.5 |
| 101.2 | Interp | –92.5 | –92.5 | Interp | Interp | –92.5 | –92.5 | Interp | –92.5 | Interp | –92.5 | –92.5 | Interp | –92.5 |
| 138 | –44.2 | Interp | Interp | –44.2 | –44.2 | Interp | Interp | –44.2 | Interp | –44.2 | Interp | Interp | –44.2 | Interp |
| 138 | –36.5 | Interp | Interp | –36.5 | –36.5 | Interp | Interp | –36.5 | Interp | –36.5 | Interp | Interp | –36.5 | Interp |
| 227.11 | –36.5 | –62 | –62 | –36.5 | –36.5 | –62 | –62 | –36.5 | –62 | –36.5 | –62 | –62 | –36.5 | –62 |
| 276 | –36.5 | –48.5 | –48.5 | –36.5 | –36.5 | –48.5 | –48.5 | –36.5 | –48.5 | –36.5 | –48.5 | –48.5 | –36.5 | –48.5 |
| 276 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 |
| 1 104 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 | –36.5 |
| 1 622 | –46.5 | –46.5 | –46.5 | –46.5 | –46.5 | –46.5 | –46.5 | –46.5 | –46.5 | –46.5 | –46.5 | –46.5 | –46.5 | –46.5 |
| 2 208 | –48 | –48 | –48 | –48 | –48 | –48 | –48 | –48 | –48 | –48 | –48 | –48 | –48 | –48 |
| 2 249 | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp |
| 2 500 | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp |
| 3 750 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 | –51.2 |
| 3 750 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 |
| 3 925 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 |
| 5 025 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 |
| 5 200 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 |

**Table B.87 – VTU-O limit PSD masks for band plan 998 (and its extensions)**

| Name | B8-4 | B8-5 | B8-6 | B8-7 | B8-8 | B8-9 | B8-10 | B8-11 | B8-12 | B8-13 | B8-14 | B8-15 | B8-16 | B8-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Long name** | **998-M2x-A** | **998-M2x-M** | **998-M2x-B** | **998-M2x-NUS0** | **998 E17-M2x-NUS0** | **998 E17-M2x-NUS0-M** | **998 ADE17-M2x-NUS0-M** | **998 ADE17-M2x-A** | **998 ADE17-M2x-B** | **998 E30-M2x-NUS0** | **998 E30-M2x-NUS0-M** | **998 ADE30-M2x-NUS0-M** | **998 ADE30-M2x-NUS0-A** | **998 ADE17-M2x-M** |
| **kHz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** |
| 5 200 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 | –52.7 |
| 7 050 | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp |
| 7 225 | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp | Interp |
| 8 500 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 | –54.8 |
| 8 500 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 | –80 |
| 8 675 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 |
| 11 825 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 |
| 12 000 | –100 | –100 | –100 | –100 | –100 | –100 | –80 | –80 | –80 | –100 | –100 | –80 | –80 | –80 |
| 12 000 | –100 | –100 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –56.5 | –100 | –100 | –56.5 | –56.5 | –56.5 |
| 13 825 | –100 | –100 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –56.5 | –100 | –100 | –56.5 | –56.5 | –56.5 |
| 14 000 | –100 | –100 | –100 | –100 | –80 | –80 | –56.5 | –56.5 | –56.5 | –80 | –80 | –56.5 | –56.5 | –56.5 |
| 14 000 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 |
| 17 664 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 |
| 21 000 | –100 | –100 | –100 | –100 | –80 | –80 | –80 | –80 | –80 | –56.5 | –56.5 | –56.5 | –56.5 | –80 |
| 21 450 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –56.5 | –56.5 | –100 |
| 21 450 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –80 | –80 | –56.5 | –56.5 | –100 |
| 21 625 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –100 |
| 24 715 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –100 |
| 24 890 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –80 | –80 | –56.5 | –56.5 | –100 |
| 24 890 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –80 | –80 | –100 |
| 25 065 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –100 | –100 | –100 |
| 30 000 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –100 | –56.5 | –56.5 | –100 | –100 | –100 |

### Table B.87 – VTU-O limit PSD masks for band plan 998 (and its extensions)

| Name | B8-4 | B8-5 | B8-6 | B8-7 | B8-8 | B8-9 | B8-10 | B8-11 | B8-12 | B8-13 | B8-14 | B8-15 | B8-16 | B8-17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Long name** | **998-M2x-A** | **998-M2x-M** | **998-M2x-B** | **998-M2x-NUS0** | **998 E17-M2x-NUS0** | **998 E17-M2x-NUS0-M** | **998 ADE17-M2x-NUS0-M** | **998 ADE17-M2x-A** | **998 ADE17-M2x-B** | **998 E30-M2x-NUS0** | **998 E30-M2x-NUS0-M** | **998 ADE30-M2x-NUS0-M** | **998 ADE30-M2x-NUS0-A** | **998 ADE17-M2x-M** |
| **kHz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** | **dBm/Hz** |
| 30 000 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –80 | –80 | –110 | –110 | –110 |
| 30 175 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 |
| ≥ 30 175 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 | –110 |

NOTE – The PSD values between breakpoints including the values marked by "Interp" shall be obtained by interpolation between adjacent breakpoints as follows:

– below $f_1$ on a dB/log($f$) basis; and

– above $f_1$ on a dB/$f$ basis,

where $f_1$ is defined in Table B.1 as either 138 kHz or 276 kHz.

### B.2.6 VTU-R limit PSD masks for HPE band plans

The VTU-R limit PSD masks for HPE band plans are shown in Table B.9.

**Table B.9 – VTU-R limit PSD masks for HPE band plans**

| Name | ~~B7-7~~BH-1 | ~~B7-8~~BH-2 | ~~B7-11~~BH-3 | ~~B7-12~~BH-4 | BH-5 | BH-6 |
|---|---|---|---|---|---|---|
| Long name | HPE17-M1-NUS0 | HPE30-M1-NUS0 | HPE12-30-M1-NUS0~~U~~ | HPE17~~2~~-30-M1-NUS0~~U~~ | HPEADE1230-NUS0 | HPEADE1730-NUS0 |
| kHz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz |
| 0 | –100 | –100 | –100 | –100 | –100 | –100 |
| 4 | –100 | –100 | –100 | –100 | –100 | –100 |
| 4 | –100 | –100 | –100 | –100 | –100 | –100 |
| 25.875 | –100 | –100 | –100 | –100 | –100 | –100 |
| 50 | –100 | –100 | –100 | –100 | –100 | –100 |
| 80 | –100 | –100 | –100 | –100 | –100 | –100 |
| 120 | –100 | –100 | –100 | –100 | –100 | –100 |
| 138 | –100 | –100 | –100 | –100 | –100 | –100 |
| 225 | –100 | –100 | –100 | –100 | –100 | –100 |
| 243 | –100 | –100 | –100 | –100 | –100 | –100 |
| 276 | –100 | –100 | –100 | –100 | –100 | –100 |
| 493.41 | –100 | –100 | –100 | –100 | –100 | –100 |
| 686 | –100 | –100 | –100 | –100 | –100 | –100 |
| 2 825 | –100 | –100 | –100 | –100 | –100 | –100 |
| 3 000 | –100 | –100 | –100 | –100 | –100 | –100 |
| 3 000 | –100 | –100 | –100 | –100 | –100 | –100 |
| 3 575 | –100 | –100 | –100 | –100 | –100 | –100 |
| 3 750 | –100 | –100 | –100 | –100 | –100 | –100 |
| 5 100 | –100 | –100 | –100 | –100 | –100 | –100 |
| 5 100 | –100 | –100 | –100 | –100 | –100 | –100 |
| 5 275 | –100 | –100 | –100 | –100 | –100 | –100 |
| 6 875 | –100 | –100 | –100 | –100 | –100 | –100 |
| 7 050 | –100 | –100 | –100 | –100 | –100 | –100 |
| 7 050 | –100 | –100 | –100 | –100 | –100 | –100 |
| 8 325 | –100 | –100 | –100 | –100 | –100 | –100 |
| 9 950 | –100 | –100 | –100 | –100 | –100 | –100 |
| 10 125 | –80 | –80 | –100~~–80~~ | –100~~–80~~ | –100 | –100 |
| 10 125 | –56.5 | –56.5 | –100~~–56.5~~ | –100~~–56.5~~ | –100 | –100 |
| 11 825 | –56.5 | –56.5 | –100~~–56.5~~ | –100 | –100 | –100 |
| 12 000 | –56.5 | –56.5 | –80~~–56.5~~ | –100~~–80~~ | –100 | –100 |
| 12 000 | –56.5 | –56.5 | –56.5 | –100~~–56.5~~ | –100 | –100 |
| 12 175 | –56.5 | –56.5 | –56.5 | –100~~–56.5~~ | –100 | –100 |
| 13 825 | –56.5 | –56.5 | –56.5 | –100~~–56.5~~ | –100 | –100 |
| 14 000 | –56.5 | –56.5 | –56.5 | –100~~–56.5~~ | –100 | –100 |
| 14 000 | –80 | –80 | –80 | –100~~–80~~ | –100 | –100 |

**Table B.9 – VTU-R limit PSD masks for HPE band plans**

| Name | ~~B7-7~~BH-1 | ~~B7-8~~BH-2 | ~~B7-11~~BH-3 | ~~B7-12~~BH-4 | BH-5 | BH-6 |
|---|---|---|---|---|---|---|
| Long name | HPE17-M1-NUS0 | HPE30-M1-NUS0 | HPE12-30-M1-NUS0~~U~~ | HPE17~~2~~-30-M1-NUS0~~U~~ | HPEADE1230-NUS0 | HPEADE1730-NUS0 |
| kHz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz |
| 14 175 | –100 | –100 | –100 | –100 | –100 | –100 |
| 17 664 | –100 | –100 | –100 | –100 | –100 | –100 |
| 19 500 | –100 | –100 | –100 | –100 | –100 | –100 |
| 19 500 | –100 | –100 | –100 | –100 | –100 | –100 |
| 19 675 | –100 | –100 | –100 | –100 | –100 | –100 |
| 21 275 | –100 | –100 | –100 | –100 | –100 | –100 |
| 21 450 | –100 | –80 | –80 | –80 | –100 | –100 |
| 21 450 | –100 | –56.5 | –56.5 | –56.5 | –100 | –100 |
| 24 715 | –100 | –56.5 | –56.5 | –56.5 | –100 | –100 |
| 24 890 | –100 | –56.5 | –56.5 | –56.5 | –80 | –80 |
| 24 890 | –100 | –80 | –80 | –80 | –56.5 | –56.5 |
| 25 065 | –100 | –100 | –100 | –100 | –56.5 | –56.5 |
| 26 825 | –100 | –100 | –100 | –100 | –56.5 | –56.5 |
| 27 000 | –100 | –100 | –100 | –100 | –56.5 | –56.5 |
| 27 000 | –100 | –100 | –100 | –100 | –56.5 | –56.5 |
| 30 000 | –100 | –100 | –100 | –100 | –56.5 | –56.5 |
| 30 000 | –110 | –110 | –110 | –110 | –80 | –80 |
| 30 175 | –110 | –110 | –110 | –110 | –110 | –110 |
| ≥ 30 175 | –110 | –110 | –110 | –110 | –110 | –110 |

NOTE – The PSD values between breakpoints ~~including the values marked by "Interp"~~ shall be obtained by interpolation between adjacent breakpoints on a dB/*f* basis.~~as follows:~~
~~– below 2 825 kHz on a dB/log(*f*) basis; and~~
~~– above 2 825 kHz on a dB/*f* basis.~~

## B.2.7 VTU-O limit PSD masks for HPE band plans

The VTU-O limit PSD masks for HPE band plans are shown in Table B.10.

**Table B.10 – VTU-O limit PSD masks for HPE band plans**

| Name | ~~B7-7~~BH-1 | ~~B7-8~~BH-2 | ~~B7-11~~BH-3 | ~~B7-12~~BH-4 | BH-5 | BH-6 |
|---|---|---|---|---|---|---|
| Long name | HPE17-M1-NUS0 | HPE30-M1-NUS0 | HPE1230-M1-NUS0 | HPE1730-M1-NUS0 | HPEADE1230-NUS0 | HPEADE1730-NUS0 |
| kHz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz |
| 0 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 |
| 4 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 | –97.5 |
| 4 | –97.5 | –97.5 | –97.5 | –97.5 | –92.5 | –92.5 |
| 80 | –97.5 | –97.5 | –97.5 | –97.5 | –92.5 | –92.5 |

## Table B.10 – VTU-O limit PSD masks for HPE band plans

| Name | ~~B7-7~~BH-1 | ~~B7-8~~BH-2 | ~~B7-11~~BH-3 | ~~B7-12~~BH-4 | BH-5 | BH-6 |
|---|---|---|---|---|---|---|
| Long name | HPE17-M1-NUS0 | HPE30-M1-NUS0 | HPE1230-M1-NUS0 | HPE1730-M1-NUS0 | HPEADE1230-NUS0 | HPEADE1730-NUS0 |
| kHz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz |
| 101.2 | –97.5 | –97.5 | –97.5 | –97.5 | –92.5 | –92.5 |
| 138 | –100 | –100 | –100 | –100 | –100 | –100 |
| 138 | –100 | –100 | –100 | –100 | –100 | –100 |
| 227.11 | –100 | –100 | –100 | –100 | –100 | –100 |
| 276 | –100 | –100 | –100 | –100 | –100 | –100 |
| 276 | –100 | –100 | –100 | –100 | –100 | –100 |
| 1 104 | –100 | –100 | –100 | –100 | –100 | –100 |
| 1 622 | –100 | –100 | –100 | –100 | –100 | –100 |
| 2 208 | –100 | –100 | –100 | –100 | –100 | –100 |
| 2 236 | –100 | –100 | –100 | –100 | –100 | –100 |
| 2 249 | –100 | –100 | –100 | –100 | –100 | –100 |
| 2 423 | –100 | –100 | –100 | –100 | –100 | –100 |
| 2 500 | –100 | –100 | –100 | –100 | –100 | –100 |
| 3 000 | –100 | –100 | –100 | –100 | –100 | –100 |
| 3 000 | –100 | –100 | –100 | –100 | –100 | –100 |
| 3 175 | –100 | –100 | –100 | –100 | –100 | –100 |
| 4 925 | –100 | –100 | –100 | –100 | –100 | –100 |
| 5 100 | –100 | –100 | –100 | –100 | –100 | –100 |
| 5 100 | –100 | –100 | –100 | –100 | –100 | –100 |
| 5 200 | –100 | –100 | –100 | –100 | –100 | –100 |
| 6 875 | –100 | –100 | –100 | –100 | –100 | –100 |
| 7 050 | –80 | –80 | –100 | –100 | –100 | –100 |
| 7 050 | –56.5 | –56.5 | –100 | –100 | –100 | –100 |
| 7 225 | –56.5 | –56.5 | –100 | –100 | –100 | –100 |
| 10 125 | –56.5 | –56.5 | –100 | –100 | –100 | –100 |
| 10 125 | –80 | –80 | –100 | –100 | –100 | –100 |
| 10 300 | –100 | –100 | –100 | –100 | –100 | –100 |
| 11 825 | –100 | –100 | –100 | –100 | –100 | –100 |
| 12 000 | –100 | –100 | –100 | –100 | –80 | –100 |
| 12 000 | –100 | –100 | –100 | –100 | –56.5 | –100 |
| 13 825 | –100 | –100 | –100 | –100 | –56.5 | –100 |
| 14 000 | –80 | –80 | –80 | –100 | –56.5 | –100 |
| 14 000 | –56.5 | –56.5 | –56.5 | –100 | –56.5 | –100 |
| 14 175 | –56.5 | –56.5 | –56.5 | –100 | –56.5 | –100 |
| 17 489 | –56.5 | –56.5 | –56.5 | –100 | –56.5 | –100 |
| 17 664 | –56.5 | –56.5 | –56.5 | –80 | –56.5 | –80 |
| 17 664 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 |

**Table B.10 – VTU-O limit PSD masks for HPE band plans**

| Name | ~~B7-7~~BH-1 | ~~B7-8~~BH-2 | ~~B7-11~~BH-3 | ~~B7-12~~BH-4 | BH-5 | BH-6 |
|---|---|---|---|---|---|---|
| Long name | HPE17-M1-NUS0 | HPE30-M1-NUS0 | HPE1230-M1-NUS0 | HPE1730-M1-NUS0 | HPEADE1230-NUS0 | HPEADE1730-NUS0 |
| kHz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz | dBm/Hz |
| 19 325 | Interp | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 |
| 19 500 | Interp | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 |
| 19 500 | Interp | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 |
| 21 000 | –80 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 |
| 21 450 | –100 | –56.5 | –56.5 | –56.5 | –56.5 | –56.5 |
| 21 450 | –100 | –80 | –80 | –80 | –56.5 | –56.5 |
| 21 625 | –100 | –100 | –100 | –100 | –56.5 | –56.5 |
| 24 715 | –100 | –100 | –100 | –100 | –56.5 | –56.5 |
| 24 890 | –100 | –80 | –80 | –80 | –56.5 | –56.5 |
| 24 890 | –100 | –56.5 | –56.5 | –56.5 | –80 | –80 |
| 25 065 | –100 | –56.5 | –56.5 | –56.5 | –100 | –100 |
| 27 000 | –100 | –56.5 | –56.5 | –56.5 | –100 | –100 |
| 27 000 | –100 | –56.5 | –56.5 | –56.5 | –100 | –100 |
| 27 175 | –100 | –56.5 | –56.5 | –56.5 | –100 | –100 |
| 30 000 | –100 | –56.5 | –56.5 | –56.5 | –100 | –100 |
| 30 000 | –110 | –80 | –80 | –80 | –110 | –110o |
| 30 175 | –110 | –110 | –110 | –110 | –110 | –110 |
| ≥ 30 175 | –110 | –110 | –110 | –110 | –110 | –110 |

NOTE – ~~The PSD values between breakpoints including the values marked by "Interp" shall be obtained by interpolation between adjacent breakpoints as follows:~~

~~– below $f_1$ on a dB/log($f$) basis; and~~

~~– above $f_1$ on a dB/$f$ basis,~~

~~where $f_1$ is defined in Table B.1 as either 138 or 276 kHz.~~

~~For Limit PSD masks B7-7 and B7-8, where $f_1$ is N/A, t~~The PSD values between breakpoints including the values marked by "Interp" shall be obtained by interpolation between adjacent breakpoints as follows:

– below 138 kHz on a dB/log($f$) basis; and

– above 138 kHz on a dB/$f$ basis.

## B.3 UPBO reference PSDs

UPBO parameters '$a$' and '$b$' are set by network management.

NOTE – The parameters '$a$' and '$b$' are expected to be uniform across all lines sharing a section of cable plant.

## B.4 Template PSD

### B.4.1 Definition

The Template PSD is set to 3.5 dB below the PSD mask in frequency bands in which the PSD is at or above −96.5 dBm/Hz. Elsewhere the template is set to −100 dBm/Hz below 4 MHz, −110 dBm/Hz between 4 MHz and $f_3$, or −112 dBm/Hz between $f_3$ and 30 MHz, where $f_3$ is defined in Table B.1. These values are chosen to satisfy the requirements of clause 7.2.2.

### B.4.2 Narrow-band PSD verification

Narrow-band compliance with the PSD masks in this annex shall be verified by power measurements using a 10-kHz measurement bandwidth centred on the frequency in question above 4 kHz, and in a 100-Hz measurement bandwidth in the band up to 4 kHz.

### B.4.3 Use in simulation (Informative)

The Template PSD may be used in simulations of VDSL2 performance as representative of an average transmitter conformant with the associated limit PSD mask.

### B.5 Compliance

Compliance requires conformance with at least one limit PSD mask.

**8) Annex O**

# Annex O

# Full ITU-T G.993.5-friendly ITU-T G.993.2 operation

(This annex forms an integral part of this Recommendation.)

**8.1) Clause O.1**

*Change clause O.1 as follows:*

### O.1 Initialization procedure (supplements clause 12.3 of ITU-T G.993.2)

If and only if the ITU-T G.994.1 VTU-O MS message or VTU-R MS message the NPar(2) bit "Full ITU-T G.993.5-friendly ITU-T G.993.2 operation" is set to ONE, the VTU-O and VTU-R shall use the a modified ITU-T G.993.5 initialization procedure, as defined in this annex. If, in addition, NPar(2) bit "Upstream FDPS in full ITU-T G.993.5-friendly ITU-T G.993.2 operation" is set to ONE, the VTU-O and VTU-R shall also support upstream frequency dependent pilot sequences (FDPS) as defined in ITU-T G.993.5.

This initialization procedure is identical to an ITU-T G.993.5 initialization procedure, except for the initialization messages R-MSG 1, O_TA-UPDATE, and O-PMS and for the initialization signal R-P-VECTOR 2 (during which the message R-ERROR-FEEDBACK is not transmitted).

### O.1.1 ITU-T G.994.1 Handshake phase

#### O.1.1.1 Handshake – VTU-O

##### O.1.1.1.1 CL messages (supplements clause 12.3.2.1.1 of ITU-T G.993.2)

Table 12-7 shall be extended with Table O.1 as follows:

**Table O.1 – VTU-O CL message NPar(2) bit definitions**

| ITU-T G.994.1 NPar(2) Bit | Definition of NPar(2) bit |
|---|---|
| Full ITU-T G.993.5-friendly ITU-T G.993.2 operation | If set to ONE, indicates that the VTU-O supports compliance with this annex (full ITU-T G.993.5-friendly ITU-T G.993.2 operation).<br>If set to ONE, both the ITU-T G.993.5 SPar(2) bit and the related "Upstream vectoring" NPar(3) bit shall also be set to ONE. |
| Pilot sequence length multiple of 4 in full ITU-T G.993.5-friendly ITU-T G.993.2 operation | If set to ONE, this bit indicates the VTU-O supports pilot sequence lengths that are a multiple of 4. If set to ZERO, this bit indicates the VTU-O only supports pilot sequence lengths that are a power of 2.<br>If set to ONE, the "Full ITU-T G.993.5-friendly ITU-T G.993.2 operation" bit shall also be set to ONE. |
| Upstream FDPS in full ITU-T G.993.5-friendly ITU-T G.993.2 operation | If set to ONE, indicates that the VTU-O supports upstream FDPS as defined in ITU-T G.993.5 when in full ITU-T G.993.5-friendly ITU-T G.993.2 operation.<br>If set to ONE, the "Full ITU-T G.993.5-friendly ITU-T G.993.2 operation" bit shall also be set to ONE. |

##### O.1.1.1.2 MS messages (supplements clause 12.3.2.1.2 of ITU-T G.993.2)

Table 12-10 shall be extended with Table O.2 as follows:

**Table O.2 – VTU-O MS message NPar(2) bit definitions**

| ITU-T G.994.1 NPar(2) Bit | Definition of NPar(2) bit |
|---|---|
| Full ITU-T G.993.5-friendly ITU-T G.993.2 operation | Set to ONE if and only if both the last previous CLR and the last previous CL messages have set this bit to ONE.<br>If set to ONE, both the VTU-O and VTU-R shall operate as defined in this annex.<br>NOTE – If set to ONE, the bit "G.993.5-friendly ITU-T G.993.2 operation in the downstream direction" (see Annex X) and the bit "ITU-T G.993.5" are both set to ZERO in the VTU-O MS message. |
| Pilot sequence length multiple of 4 in full ITU-T G.993.5-friendly ITU-T G.993.2 operation | This bit shall be set to ONE if and only if set to ONE in both the last previous CL message and the last previous CLR message. If set to ONE, this bit indicates that "pilot sequence length multiple of 4" is enabled. If set to ZERO, this bit indicates only pilot sequence lengths that are a power of 2 are enabled.<br>If the "Full ITU-T G.993.5-friendly ITU-T G.993.2 operation" bit is set to ZERO in the VTU-O MS message, then this bit shall be ignored by the VTU-R. |

**Table O.2 – VTU-O MS message NPar(2) bit definitions**

| ITU-T G.994.1 NPar(2) Bit | Definition of NPar(2) bit |
|---|---|
| Upstream FDPS in full ITU-T G.993.5-friendly ITU-T G.993.2 operation | Set to ONE if and only if both the last previous CLR and the last previous CL messages have set this bit to ONE.<br>If set to ONE, both the VTU-O and VTU-R shall operate as defined in this annex and support upstream FDPS.<br>If the "Full ITU-T G.993.5-friendly ITU-T G.993.2 operation" bit is set to ZERO in the VTU-O MS message, then this bit shall be ignored by the VTU-R. |

### O.1.1.2 Handshake – VTU-R

#### O.1.1.2.1 CLR messages (supplements clause 12.3.2.2.1 of ITU-T G.993.2)

Table 12-13 shall be extended with Table O.3 as follows:

**Table O.3 – VTU-R CLR message NPar(2) bit definitions**

| ITU-T G.994.1 NPar(2) Bit | Definition of NPar(2) bit |
|---|---|
| Full ITU-T G.993.5-friendly ITU-T G.993.2 operation | If set to ONE, indicates that the VTU-R supports full compliance with this annex (ITU-T G.993.5-friendly ITU-T G.993.2 operation).<br>If set to ONE, the ITU-T G.993.5 SPar(2) bit shall be set to ZERO (see Note). |
| Pilot sequence length multiple of 4 in full ITU-T G.993.5-friendly ITU-T G.993.2 operation | If set to ONE, this bit indicates the VTU-R supports pilot sequence lengths that are a multiple of 4. If set to ZERO, this bit indicates the VTU-R only supports pilot sequence lengths that are a power of 2.<br>If set to ONE, the "Full ITU-T G.993.5-friendly ITU-T G.993.2 operation" bit shall also be set to ONE. |
| Upstream FDPS in full ITU-T G.993.5-friendly ITU-T G.993.2 operation | If set to ONE, indicates that the VTU-R supports upstream FDPS as defined in ITU-T G.993.5 when in full ITU-T G.993.5-friendly ITU-T G.993.2 operation.<br>If set to ONE, the "Full ITU-T G.993.5-friendly ITU-T G.993.2 operation" bit shall also be set to ONE. |
| NOTE – A VTU-R that has ITU-T G.993.5 capability enabled, sets this NPAR(2) bit to 0. | |

### O.1.1.2.2 MS messages (supplements clause 12.3.2.2.2 of ITU-T G.993.2)

Table 12-16 shall be extended with Table O.4 as follows:

**Table O.4 – VTU-R MS message NPar(2) bit definitions**

| ITU-T G.994.1 NPar(2) Bit | Definition of NPar(2) bit |
|---|---|
| Full ITU-T G.993.5 friendly ITU-T G.993.2 operation | Set to ONE if and only if both the last previous CLR and the last previous CL messages have set this bit to ONE.<br>If set to ONE, both the VTU-O and VTU-R shall operate as defined in this annex.<br>NOTE – If set to ONE, the bit "ITU-T G.993.5-friendly ITU-T G.993.2 operation in the downstream direction" (see Annex X) and the bit "ITU-T G.993" are both set to ZERO in the VTU-R MS message. |
| Pilot sequence length multiple of 4 in full ITU-TG.993.5-friendly ITU-T G.993.2 operation | This bit shall be set to ONE if and only if set to ONE in both the last previous CL message and the last previous CLR message. If set to ONE, this bit indicates that "pilot sequence length multiple of 4" is enabled. If set to ZERO, this bit indicates only pilot sequence lengths that are a power of 2 are enabled.<br>If the "Full ITU-T G.993.5-friendly ITU-T G.993.2 operation" bit is set to ZERO in the VTU-R MS message, then this bit shall be ignored by the VTU-O. |
| Upstream FDPS in full ITU-T G.993.5-friendly ITU-T G.993.2 operation | Set to ONE if and only if both the last previous CLR and the last previous CL messages have set this bit to ONE.<br>If set to ONE, both the VTU-O and VTU-R shall operate as defined in this annex and support upstream FDPS.<br>If the "Full ITU-T G.993.5-friendly ITU-T G.993.2 operation" bit is set to ZERO in the VTU-R MS message, then this bit shall be ignored by the VTU-O. |

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