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

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.993.2
Corrigendum 1
(12/2006)

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)

Corrigendum 1

ITU-T Recommendation G.993.2 (2006) – Corrigendum 1

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ITU-T G-SERIES RECOMMENDATIONS

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ITU-T Recommendation G.993.2

Very high speed digital subscriber line transceivers 2 (VDSL2)

Corrigendum 1

Source

Corrigendum 1 to ITU-T Recommendation G.993.2 (2006) was approved on 14 December 2006 by ITU-T Study Group 15 (2005-2008) under the ITU-T Recommendation A.8 procedure.

FOREWORD

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

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

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

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

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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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ITU-T Recommendation G.993.2

Very high speed digital subscriber line transceivers 2 (VDSL2)

Corrigendum 1

1) Clause 11.2.3.8

Modify 11.2.3.8 as follows:

11.2.3.8 Clear eoc commands and responses

The Clear eoc Request command may be used by the G.997.1 function to transfer management octets between the EIA and the VTU-R and from one VTU to another (see 6/G.997.1 [4]). The Clear eoc Request command is shown in Table 11-18 and may be initiated by either VTU. The responses shall be as shown in Table 11-19. The first octet of either the command or a response shall be the assigned value for the Clear eoc command type shown in Table 11-3. The subsequent octets of the command shall be as shown in Table 11-18. The subsequent octets of the responses shall be as shown in Table 11-19. The octets shall be sent using the format described in 11.2.3.1.

NOTE – In accordance with ITU-T Rec. G.997.1 [4], the ~~length~~ information payload of the clear eoc message does not exceed 510~~6~~ octets. Therefore, the length of either a clear eoc Request command or a response does not exceed 516~~8~~ octets.

Table 11-18/G.993.2 – Clear eoc commands sent by the initiating VTU

Name	Length (Octets)	Octet number	Content
Request	variable	2	01_{16} (Note)
		3 +	the ~~entire~~ information payload of the clear eoc message to be delivered to the far end
NOTE – All other values for octet number 2 are reserved by the ITU-T.			

Table 11-19/G.993.2 – Clear eoc responses sent by the responding VTU

Name	Length (Octets)	Octet number	Content
ACK	2	2	80_{16} (Note)
NACK	3	2	81_{16} (Note)
		3	04_{16} (Note)
NOTE – All other values for octet numbers 2 & 3 are reserved by the ITU-T.			

Upon reception of the Clear eoc Request command, the VTU shall respond with an acknowledgement (ACK) and deliver the received clear eoc message to the local G.997.1 management function transparently, with the original formatting used by the G.997.1 management function of the initiating VTU. The VTU may instead respond with a negative acknowledge (NACK) including the Not Supported (value 04_{16}) reason code, indicating that the received clear eoc message cannot be delivered to the G.997.1 management function (because the G.997.1 management function may not support clear eoc messages; see 6/G.997.1 [4]). Other reason codes are for further study.

2) Clause 11.2.3.11

Add the following note after Table 11-27:

NOTE – Since the number of sub-carriers, *G*, in the sub-carrier group (see 11.4.1) may be different for QLN, HLOG, and SNR, the values of QLN, HLOG and SNR communicated by Multiple Read or Block Read for the same group index may correspond to different sub-carrier indices. The sub-carrier index for each parameter equals *G*×group_index, where the value of *G* is as defined in Table 11-30 of 11.4.1 (for Showtime).

3) Clauses 11.4.1 and 11.4.1.1.1

Revise 11.4.1 and 11.4.1.1.1 as follows:

11.4.1 Test parameters

The test parameters are measured by the PMD transmit or receive function and shall be reported on request to the near-end VME. Test parameters can be used to identify possible issues with the physical loop and to check for adequate physical media performance margin at acceptance and after repair verification, or at any other time following the initialization of the VDSL2 system.

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

- Channel characteristics function H(*f*) per sub-carrier (CCF-ps);
- Quiet line noise PSD QLN(*f*) per sub-carrier (QLN-ps);
- Signal-to-noise Ratio SNR(*f*) per sub-carrier (SNR-ps);
- Loop attenuation per band (LATN-pb);
- Signal attenuation per band (SATN-pb);
- Signal-to-noise ratio margin per band (SNRM-pb);
- Attainable net data rate (ATTNDR); and
- Far-end actual aggregate transmit power (ACTATP).

The following test parameter shall be passed on request from the transmit PMD transmit function to the near-end VME:

- Near-end actual aggregate transmit power (ACTATP).

The purposes of making the above information available are:

- H(*f*) can be used to analyze the physical copper loop condition;
- QLN(*f*) can be used to analyze the crosstalk;
- SNR(*f*) can be used to analyze time-dependent changes in crosstalk levels and loop attenuation (such as due to moisture and temperature variations); and
- The combination of H(*f*), QLN(*f*) and SNR(*f*) can be used to help determine why the data rate is not equal to the maximum data rate for a given loop.

The detailed diagnostic information H(*f*) and QLN(*f*) would be most useful during Showtime. However, requesting this would place an undue computational burden on the VDSL2 modems. Thus, the combination of complete information on the channel (H(*f*) and QLN(*f*)) during initialization combined with initialization and Showtime SNR(*f*) is provided as a reasonable compromise. This combination of data will allow greater analysis of the loop conditions than traditional methods and will reduce interruptions to both VDSL2 and the underlying service that traditional diagnostic methods require.

The quiet line noise (QLN), signal-to-noise ratio (SNR), and channel characteristics in format (Hlin, Hlog) shall be represented by sub-carrier group. The number of sub-carriers, *G*, in one sub-carrier group shall be equal to:

$$G = pow2(\Theta / 512)$$

where the function *pow*2(x) takes the nearest power of 2 greater than or equal to x and Θ is the highest sub-carrier index of the transmitter SUPPORTEDCARRIERS set if the parameter is measured during the Channel Discovery phase; or the last sub-carrier index of the transmitter MEDLEY set in other cases.

Specific carrier sets to be used during Showtime and Loop Diagnostic mode are summarized in Table 11-30 (N/A indicates that a parameter is not applicable).

Table 11-30/G.993.2 – Value of *G* for various phases of operation

Test parameter	**Normal operation**	**Loop Diagnostic mode**	
	Showtime	**Channel Discovery**	**Channel Analysis and Exchange**
QLN	SUPPORTEDCARRIERS	SUPPORTEDCARRIERS	N/A
HLOG	SUPPORTEDCARRIERS	SUPPORTEDCARRIERS	N/A
HLIN	N/A	N/A	MEDLEY
SNR	MEDLEY	N/A	MEDLEY

Valid values of *G* are 1, 2, 4 and 8.

11.4.1.1.1 Channel characteristics function per sub-carrier group (CCF-ps)

The channel characteristics function H(*f*) is a quantity that is related to the values of the (complex) source and load impedances. A simplified definition is used in which the source and load impedances are the same and equal to a real value R_N. The channel characteristics function H(*f*) is associated with a two-port network, normalized to a chosen reference resistance R_N. H(*f*) shall be defined as a complex value, equal to the U2/U1 voltage ratio (see Figures 11-3 and 11-4).

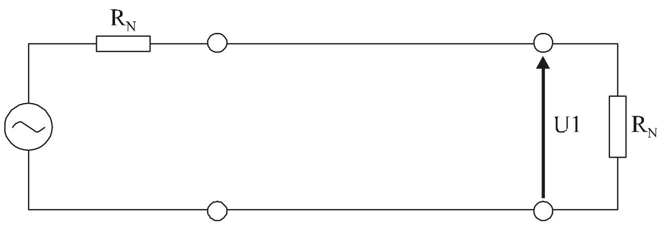

Figure 11-3/G.993.2 – Voltage across the load

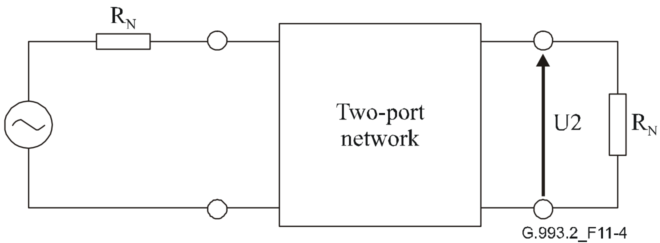

Figure 11-4/G.993.2 – Voltage across the load with a two-port network inserted

The measurement of a channel characteristics function is the result of the cascade of three functions:

- the transmitter filter characteristics function;
- the channel characteristics function; and
- the receiver filter characteristics function.

NOTE – The channel characteristics function corresponds to the $H_{channel}(f)$ function used in the definition of the far-end crosstalk (see 7.4.1/G.996.1).

The objective is to provide means by which the channel characteristics can be accurately identified. Therefore, it is necessary for the receive PMD function to report an estimate of the channel characteristics. This task may prove to be a difficult one given the fact that the receive PMD function only observes the cascade of all three elements of the channel. The passband part of the reported H(*f*), which is most essential to debug possible issues with the physical loop, is not expected to significantly depend upon the receiver filter characteristics (not including receiver AGC). The receive PMD function shall therefore invert the gain (AGC) it has applied to the received signal and do a best effort attempt to remove the impact of the near-end receiver filter characteristics. The result is then a best estimate of how the receiver views the passband channel characteristics plus the transmitter filter characteristics. Because the in-band portion of the spectrum is also expected not to significantly depend upon the transmitter filter characteristics, this result is considered a sufficient estimate of the channel characteristics for desired loop conditioning applications.

Two formats for the channel characteristics are defined:

- Hlin(*f*): a format providing complex values on a linear scale; and
- Hlog(*f*): a format providing magnitude values on a base 10 logarithmic scale.

For Hlog(*f*), the receive PMD function shall also use the value of the PSD at the U interface of the transmit PMD function (as conveyed in messages during initialization) to remove the impact of the far-end transmit filter characteristics.

For Hlin(*f*), if the channel characteristics are reported over the VTU-O OAM interface (see Figure 5-3), the VTU-O shall do a best effort attempt to remove the impact of the near-end transmit filter characteristics from the channel characteristics measured at the VTU-R. If the channel characteristics are reported over the VTU-R OAM interface, the VTU-R shall do a best effort attempt to remove the impact of the near-end transmit filter characteristics from the channel characteristics measured at the VTU-O.

Hlin(*f*) shall be sent to the far-end VME during the Loop Diagnostic mode and shall be sent on request to the near-end VME during the Loop Diagnostic mode.

Hlog(*f*) shall be measured by the receive PMD function during the Loop Diagnostic mode and initialization. The measurement shall not be updated during Showtime. Hlog(*f*) shall be sent to the far-end VME during the Loop Diagnostic mode and shall be sent on request to the near-end VME at any time. The near-end VME shall send Hlog(*f*) to the far-end VME on request during Showtime.

In Loop Diagnostic mode, both Hlin(*f*) and Hlog(*f*) shall be measured, because the corrections that can be done, relative to the receiver and/or transmitter filter characteristics with Hlin(*f*) and Hlog(*f*) may differ.

Hlin(*f*) and Hlog(*f*) shall be measured over a 1 second time period in Loop Diagnostic mode. In initialization, the VTU should do its best to optimize the accuracy of the Hlog(*f*) measurement, however, it shall measure over at least 256 symbols, and shall indicate the measurement period (in symbols, represented as a 16-bit unsigned value) to the far-end VME (see 11.2.3.11).

The channel characteristics function Hlin($k \times G \times \Delta f$) shall be the value of the channel characteristics on the sub-carrier $i = k \times G$. It shall be represented in linear format by a scale factor and a normalized complex number $a(k) + j \times b(k)$, $k = 0$ to 511. The scale factor shall be coded as a 16-bit unsigned integer. Both $a(k)$ and $b(k)$ shall be coded as 16-bit twos complement signed integers. The value of Hlin($k \times G \times \Delta f$) shall be defined as:

$$\text{Hlin}(k \times G \times \Delta f) = (scale/2^{15}) \times (a(k) + j \times b(k))/2^{15}$$

In order to maximize precision, the scale factor, *scale*, shall be chosen such that max($|a(k)|$, $|b(k)|$) over all k is equal to $2^{15} - 1$.

This data format supports an Hlin(f) granularity of 2^{-15} and an Hlin(f) dynamic range of approximately 96 dB (+6 dB to −90 dB). The portion of the scale factor range above 0 dB is necessary because, due to manufacturing variations in signal path gains and filter responses, short loops may appear to have a gain rather than a loss.

An Hlin($k \times G \times \Delta f$) value indicated as $a(k) = b(k) = -2^{15}$ is a special value. It indicates that:

- ~~no measurement could be done for this sub-carrier because it is out of the transmitter SUPPORTEDCARRIERS set if the value is communicated in the Channel Discovery phase (see 12.3.3); or~~
- no measurement could be done for this sub-carrier because it is out of the transmitter MEDLEY set or its $g_i = 0$; or
- the attenuation is out of the range to be represented.

The channel characteristics function Hlog($k \times G \times \Delta f$) shall be the magnitude of the channel characteristics at sub-carrier $k \times G$. It shall be represented in base 10 logarithmic format by an integer number $m(k)$, where $k = 0$ to 511. The $m(k)$ shall be coded as 10-bit unsigned integers. The value of Hlog($k \times G \times \Delta f$) shall be defined as:

$$\text{Hlog}(k \times G \times \Delta f) = 6 - (m(k)/10)$$

This data format supports an Hlog(f) granularity of 0.1 dB and an Hlog(f) dynamic range of approximately 102 dB (+6 dB to −96 dB).

An Hlog($k \times G \times \Delta f$) value indicated as $m(k) = 2^{10} - 1$ is a special value. It indicates:

- that no measurement could be done for this sub-carrier because it is out of the transmitter SUPPORTEDCARRIERS set; or ~~if the value is communicated in the Channel Discovery phase (see 12.3.3); or~~
- ~~that no measurement could be done for this sub-carrier because it is out of the transmitter MEDLEY set or its $g_i = 0$; or~~
- that the attenuation is out of the range to be represented.

4) Clause 11.4.1.1.3

Revise 11.4.1.1.3 as follows:

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 shall not be taken into account in SNR(f).

The signal-to-noise ratio SNR(f) per sub-carrier shall be measured by the receive PMD function in Loop Diagnostic mode and initialization. The measurement may be updated autonomously and shall be updated on request during Showtime. The SNR(f) shall be sent to the far-end VME during Loop

Diagnostic mode and shall be sent on request to the near-end VME at any time. The near-end VME shall send the SNR(*f*) to the far-end VME on request during Showtime.

The receive PMD function shall measure the signal-to-noise ratio SNR(*f*) with the transmit PMD function in a MEDLEY or Showtime state. The signal-to-noise ratio SNR(*f*) shall be measured over a 1 second time interval in Loop Diagnostic mode. In initialization and Showtime, the VTU should do its best to minimize the SNR(*f*) measurement time, however it shall measure over at least 256 symbols, and it shall indicate the measurement period (in symbols, represented as a 16-bit unsigned value) to the far-end VME (see 11.2.3.11).

The signal-to-noise ratio SNR($k \times G \times \Delta f$) shall be the average of the base 10 logarithmic value of the signal-to-noise ratio on the sub-carriers $k \times G$ to $((k+1) \times G) - 1$. It shall be represented as an 8-bit unsigned integer *snr(k)*, where $k = 0$ to 511. The value of SNR($k \times G \times \Delta f$) shall be defined as SNR($k \times G \times \Delta f$) = $-32 + (snr(k)/2)$ dB. This data format supports an SNR($k \times G \times \Delta f$) granularity of 0.5 dB and an SNR($k \times G \times \Delta f$) dynamic range of 127 dB (−32 to 95 dB).

An SNR($k \times G \times \Delta f$) value indicated as $snr(k) = 255$ is a special value. It indicates that:

- ~~no measurement could be done for this sub-carrier group because one of its sub-carriers is out of the transmitter SUPPORTEDCARRIERS set; or~~
- no measurement could be done for this sub-carrier group because one of its sub-carriers is out of the transmitter MEDLEY set or its $g_i = 0$; or
- the signal-to-noise ratio is out of the range to be represented.

5) Clause 11.4.1.1.6.1

Revise the first paragraph as follows:

11.4.1.1.6.1 General definition of signal-to-noise ratio margin

The signal-to-noise ratio margin is the maximum increase (scalar gain, in dB) of the reference noise PSD (at all relevant frequencies), such that the BER of each ~~TPS-TC stream~~bearer channel does not exceed ~~the maximum BER specified for the corresponding TPS-TC stream~~10^{-7} (see 9.8), without any change of PMD parameters (e.g., bits and gains) and PMS-TC parameters (e.g., L_p, FEC parameters). The BER is referenced to the output of the PMS-TC function (i.e., the α/β interface).

6) Clause 11.4.1.1.7

Revise the first paragraph as follows:

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 10^{-7}~~the highest BER configured for one (or more) of the latency paths~~ (see 9.8);
- Latency not to exceed the highest latency configured for ~~one (or more) of the latency paths~~the bearer channel;
- 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.

7) Clause 12.3.3.2.1.1

a) Replace the formula in Field #10 of O-SIGNATURE with the following formula:

$$r_n = \frac{total\_data\_rate_n}{net\_data\_rate_n} = \frac{1}{1 - \dfrac{2 \times INP\_\min_n}{delay\_\max_n \times f_s}}$$

b) Revise the text of Field #11 of O-SIGNATURE as follows:

Field #11 "Downstream maximum SNR margin (MAXSNRMds)" indicates the maximum SNR margin the VTU-R receiver shall try to sustain. The definition and use of this parameter shall be the same as for the parameter "Downstream Maximum Noise Margin (MAXSNRMds)" specified in ITU-T Rec. G.997.1 [4]. The field shall be formatted as a 16-bit unsigned integer with LSB weight of 0.1 dB and the valid range between 0 and 31 dB. The special value defined in ITU-T Rec. G.997.1 [4] shall be coded as $FFFF_{16}$~~The value of $FFFF_{16}$ shall indicate that no limit on the maximum downstream SNR margin is to be applied (i.e., the maximum value is infinite)~~.

8) New clause 12.4.1.1

Insert a new clause as follows:

12.4.1.1 SOC message mapping during loop diagnostic mode

In order to increase the robustness of the messages exchanged during the channel discovery and training phases of the loop diagnostic mode, all SOC messages shall be sent using 1 information bit per DMT symbol, where each bit is sent 5 times in 5 consecutive DMT symbols. The mapping of the SOC bits to sub-carriers during loop diagnostic mode shall be as summarized in Table 12-60.1.

Table 12-60.1/G.993.2 – Bit mapping during loop diagnostic mode

Sub-carrier index	Constellation bits for SOC bit = 0	Constellation bits for SOC bit = 1
Even	00	00
1, 11, 21, …,10*n*+1,...	00	11
3, 13, 23, …,10*n*+3,...	00	11
5, 15, 25, ... ,10*n*+5,...	00	11
7, 17, 27, …,10*n*+7,...	00	11
9, 19, 29, …,10*n*+9,...	00	00

When the SOC is inactive, the symbols shall be transmitted as described in 12.3.3 without modification.

9) Clause 12.4.2.1.1

Revise the text of Field #13 and Field #14 as follows:

Field #13 "Quiet line noise per sub-carrier group, QLN($k \times G \times \Delta f$)" indicates the parameter QLN for 512 sub-carrier groups in the upstream direction (measured at the VTU-O receiver). The parameter QLN for each group shall be represented as an 8-bit value as specified in 11.4.1.1.2, mapped to a single octet. The octets representing QLN values for different groups shall be mapped to Field #13 so that they are transmitted in ascending order of group index *k*, for *k* = 0 to 511. The groups shall be formed as specified in 11.4.1.~~ The values of QLN for groups containing at least one sub-carrier that is not in the MEDLEYus set shall be set to FF_{16}.~~

Field #14 "Channel characteristics function Hlog per sub-carrier, Hlog($k \times G \times \Delta f$)" indicates the parameter Hlog for 512 sub-carrier groups in the upstream direction. The parameter Hlog for each group shall be represented as a 10-bit value as specified in 11.4.1.1.1, mapped to 2 octets by adding six MSBs equal to 0. The pairs of octets representing Hlog values for different groups shall be mapped to Field #14 so that they are transmitted in ascending order of group index *k*, for *k* = 0 to 511. The groups shall be formed as specified in 11.4.1.~~ The fields representing values of Hlog for groups containing at least one sub-carrier that is not in the MEDLEYus set shall be set to $FFFF_{16}$.~~

10) Clause 12.4.2.1.2

Revise the text of Field #13 and Field #14 as follows:

Field #13 "Quiet line noise per sub-carrier group, QLN($k \times G \times \Delta f$)" indicates the parameter QLN for 512 sub-carrier groups in the downstream direction (measured at the VTU-R receiver). The parameter QLN for each group shall be represented as an 8-bit value as specified in 11.4.1.1.2, mapped into a single octet. The octets representing QLN values for different groups shall be mapped to Field #13 so that they are transmitted in ascending order of group index *k*, for *k* = 0 to 511. The groups shall be formed as specified in 11.4.1.~~ The values of QLN for the groups containing at least one sub-carrier that is not in MEDLEYds set shall be set to FF_{16}.~~

Field #14 "Channel characteristics function Hlog per sub-carrier, Hlog($k \times G \times \Delta f$)" indicates the parameter Hlog for 512 sub-carrier groups in the downstream direction. The parameter Hlog for each group shall be represented as a 10-bit value as specified in 11.4.1.1.1, mapped into 2 octets by adding six MSBs equal to 0. The pairs of octets representing Hlog values for different groups shall be mapped to Field #14 so that they are transmitted in ascending order of group index *k*, for *k* = 0 to 511. The groups shall be formed as specified in 11.4.1. ~~The pairs of octets representing values of Hlog for the groups containing at least one sub-carrier that is not in MEDLEYds set shall be set to $FFFF_{16}$.~~

11) Clause 12.4.2.2

Revise 12.4.2.2 as follows:

12.4.2.2 Signals transmitted during the channel discovery and training phases

The signals transmitted during the channel discovery and training phases are the same as defined in initialization (see 12.3.3 and 12.3.4) with the following exceptions:

- The SOC message mapping shall be as defined in 12.4.1.1;
- The duration of O-P-QUIET 1 shall be at least 8192 symbols but not longer than 16384 symbols.

~~However, in order to increase the robustness of the messages exchanged during the Channel Discovery and Training phases of the Loop Diagnostic mode, all SOC messages shall be sent using 1 information bit per DMT symbol, where each bit is sent 5 times in 5 consecutive DMT symbols. For an information bit value of 1, the value 11 shall be mapped to all of the allowed sub-carriers using 4-QAM. For an information bit value of 0 the value 00 shall be mapped to all of the allowed sub-carriers using 4-QAM. This applies to all SOC messages sent during O-P-CHANNEL DISCOVERY 1, O-P-CHANNEL DISCOVERY 2, R-P-CHANNEL DISCOVERY 1, R-P-CHANNEL DISCOVERY 2, O-P-TRAINING 2 and R-P-TRAINING 2.~~

~~The constellation points of all sub-carriers shall be rotated based on the 2-bit number provided by the quadrant scrambler. The scrambler shall be used in reset mode, as described in 12.3.6.2.1.~~

12) Clause 12.4.3

Revise 12.4.3 as follows:

12.4.3 Channel analysis & exchange phase of loop diagnostic mode

Figure 12-11 presents the timing diagram for the stages of the channel analysis & exchange phase of the loop diagnostic mode. It gives an overview of the sequence of signals transmitted and the sequence of SOC messages sent by the VTU-O and VTU-R during the channel analysis & exchange phase of the loop diagnostic mode. The shaded areas correspond to periods of time when the SOC is in its inactive state.

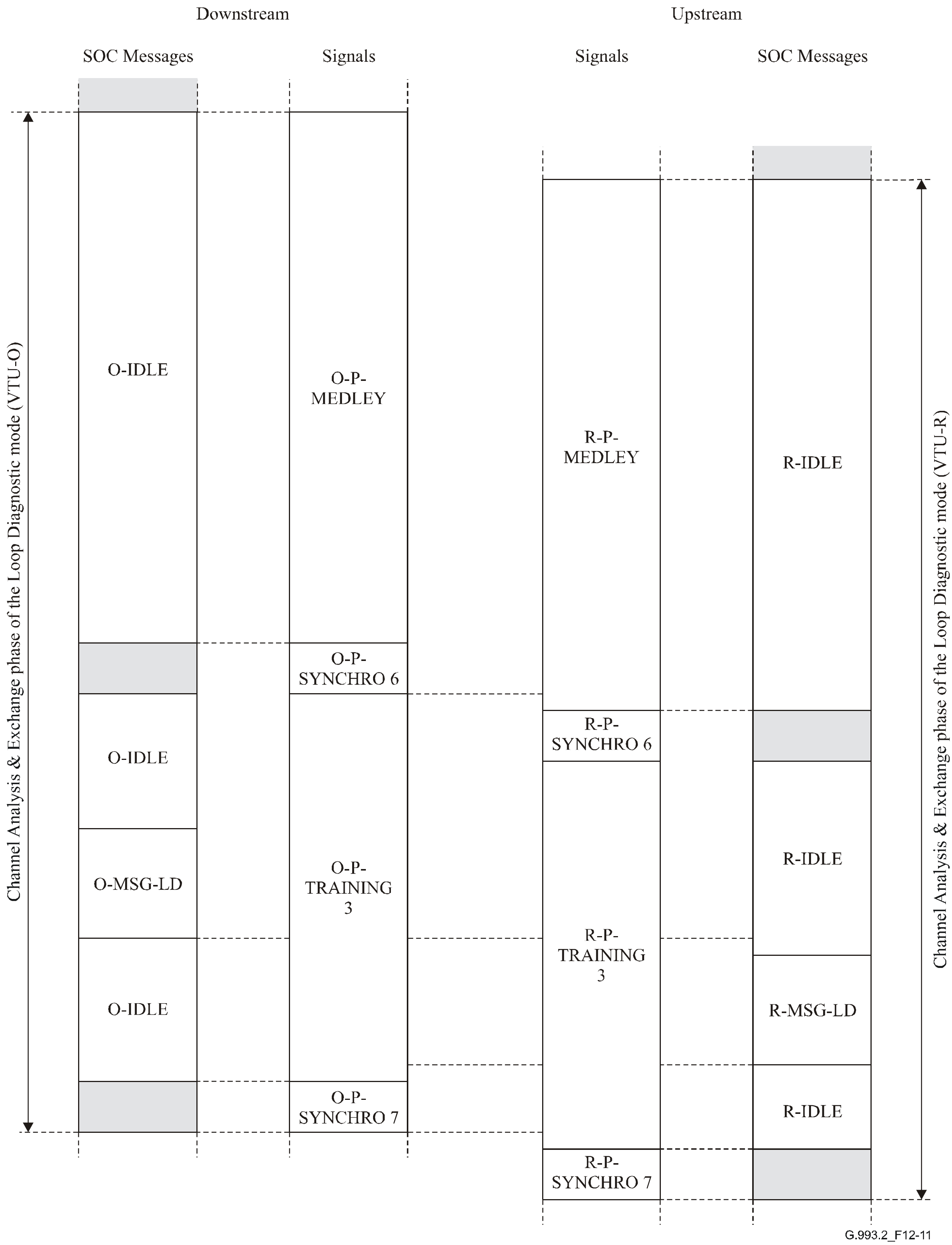

Figure 12-11/G.993.2 – Timing diagram for the stages of the channel analysis & exchange phase of the loop diagnostic mode

Upon entering this phase the VTU-O shall transmit ~~3225~~~~6~~80000 DMT symbols of O-P-MEDLEY with O-IDLE being sent over the SOC. Upon entering this phase the VTU-R shall transmit ~~32256~~80000 DMT symbols of R-P-MEDLEY with R-IDLE being sent over the SOC.~~ O-P MEDLEY and R-P-MEDLEY shall be as defined in 12.3.5.3.~~

O-P-MEDLEY and R-P-MEDLEY shall be followed by O-P-SYNCHRO 6 and R-P-SYNCHRO 6, respectively. O-P-SYNCHRO 6 and R-P-SYNCHRO 6 shall be as defined in 12.3.5.3.

After transmitting O-P-SYNCHRO 6, the VTU-O shall transmit O-P-TRAINING 3. While transmitting O-P-TRAINING 3, the VTU-O shall send O-IDLE over the SOC for at least 256 DMT symbols, and shall then send O-MSG-LD. Similarly, after transmitting R-P-SYNCHRO 6, the VTU-R shall transmit R-P-TRAINING 3. While transmitting R-P-TRAINING 3, the VTU-R shall send R-IDLE over the SOC. The VTU-R shall acknowledge the reception of O-MSG-LD by sending R-MSG-LD. Both VTUs shall use the RQ mode, as specified in 12.2.2.2.

The VTU-O shall acknowledge the reception of R-MSG-LD by transmitting O-P-SYNCHRO 7, which also indicates that the VTU-O has completed the channel analysis & exchange phase. The VTU-R acknowledges O-P-SYNCHRO 7 by transmitting R-P-SYNCHRO 7, indicating full completion of the loop diagnostic mode.

Table 12-64/G.993.2 – VTU-O signals and SOC messages in the channel analysis & exchange phase of loop diagnostic mode

Signal	Signal type	Signal duration in DMT symbols with CE	SOC messages and IDLE flags	SOC state
O-P-MEDLEY	Non-periodic	~~32256~~80000	O-IDLE	Active
O-P-SYNCHRO 6	Non-periodic	15	None	Inactive
O-P-TRAINING 3	Non-periodic	Variable	O-MSG-LD	Active (RQ)
O-P-SYNCHRO 7	Non-periodic	15	None	Inactive

Table 12-65/G.993.2 – VTU-R signals and SOC messages during the channel analysis & exchange phase of loop diagnostic mode

Signal	Signal type	Signal duration in DMT symbols with CE	SOC messages and IDLE flags	SOC state
R-P-MEDLEY	Non-periodic	~~32256~~80000	R-IDLE	Active
R-P-SYNCHRO 6	Non-periodic	15	None	Inactive
R-P-TRAINING 3	Non-periodic	Variable	R-MSG-LD	Active (RQ)
R-P-SYNCHRO 7	Non-periodic	15	None	Inactive

13) Clause 12.4.3.1.1

Revise the text of Field #2 as follows:

Field #2 "Hlin($k \times G \times \Delta f$)" indicates the parameter Hlin for 512 sub-carrier groups in the upstream direction. The parameter Hlin for each group shall be mapped to 6 octets as [*s*cale *a(k) b(k)*], where *s*cale, *a(k)*, and *b(k)* are 16-bit values ~~representing, respectively, the scale factor *s*, and the parameters *a* and *b* of Hlin,~~ as specified in 11.4.1.1.1. The 6 octets representing Hlin values for different groups shall be mapped to Field #2 so that they are transmitted in ascending order of group index *k*, for *k* = 0 to 511. The groups shall be formed as specified in 11.4.1.~~ The 16-bit values of *s*,~~

~~*a*, and *b* for the groups containing at least one sub-carrier that is not in the MEDLEYus set shall be set to FFFF$_{16}$.~~

14) Clause 12.4.3.1.2

Revise the text of Field #2 as follows:

Field #2 "Hlin($k \times G \times \Delta f$)" indicates the parameter Hlin for 512 sub-carrier groups in the downstream direction. The parameter Hlin for each group shall be mapped into 6 octets as [*scale a(k) b(k)*], where *scale*, *a(k)*, and *b(k)* are 16-bit values ~~representing, respectively, the scale factor *s*, and the parameters *a* and *b* of Hlin,~~ as specified in 11.4.1.1.1. The 6 octets representing Hlin values for different groups shall be mapped to Field #2 so that they are transmitted in ascending order of group index *k*, for *k* = 0 to 511. The groups shall be formed as specified in 11.4.1. ~~The 16-bit values of *s*, *a*, and *b* for the groups containing at least one sub-carrier that is not in the MEDLEYds set shall be set to FFFF$_{16}$.~~

15) Clause 12.4.3.2

Revise 12.4.3.2 and its subclauses as follows:

12.4.3.2 Signals transmitted during the channel analysis & exchange phase of loop diagnostic mode

The O-P-MEDLEY~~,~~ and R-P-MEDLEY~~, O-P-SYNCHRO 6, R-P-SYNCHRO 6 O-P-SYNCHRO 7 and R-P-SYNCHRO 7~~ signals shall be as defined in 12.3.5.3 for initialization with the following exceptions:

- the duration of O-P-MEDLEY and R-P-MEDLEY shall each be 80000 symbols; and
- the SOC message mapping shall be as defined in 12.4.1.1.

O-P-SYNCHRO 6, R-P-SYNCHRO 6, O-P-SYNCHRO 7 and R-P-SYNCHRO 7 shall be as defined in 12.3.5.3 for initialization.

12.4.3.2.1 O-P-TRAINING 3

The O-P-TRAINING 3 signal is used to send the O-MSG-LD SOC message. During transmission of O-P-TRAINING 3, the SOC is in its active state.

The duration of O-P-TRAINING 3 is variable. The VTU-O terminates O-P-TRAINING 3 by transmitting O-P-SYNCHRO 7.

O-P-TRAINING 3 shall be composed of all sub-carriers in the MEDLEYds set. These sub-carriers shall be modulated by 4-QAM with SOC bit mapping as described in 12.4.1.1. ~~These sub-carriers shall carry 1 information bit per DMT symbol, where each bit is sent 5 times in 5 consecutive DMT symbols. For an information bit value of 1, the value 11 shall be mapped to all of the allowed sub-carriers using 4-QAM. For an information bit value of 0 the value 00 shall be mapped to all of the allowed sub-carriers using 4-QAM.~~

The constellation points of all sub-carriers shall be rotated based on the 2-bit number provided by the quadrant scrambler described in 12.3.6.2. The scrambler shall be used in reset mode (see 12.3.6.2.1).

The symbol length shall be $2N_{ds}+L_{CE}$ samples. Windowing shall be applied at the transmitter, and the overall window length shall be equal to β_{ds}. (See 10.4.4.). The values of $2N_{ds}$, L_{CE}, β_{ds} and cyclic prefix length shall be set to the values communicated by the VTU-O in O-PRM-LD.

The transmit PSD of the MEDLEYds sub-carriers in O-P-TRAINING 3 shall be the same as for O-P-TRAINING 2.

12.4.3.2.2 R-P-TRAINING 3

The R-P-TRAINING 3 signal is used to send the R-MSG-LD SOC message. During transmission of R-P-TRAINING 3, the SOC is in its active state.

The duration of R-P-TRAINING 3 is variable. The VTU-O terminates R-P-TRAINING 3 by transmitting R-P-SYNCHRO 7.

R-P-TRAINING 3 shall be composed of all sub-carriers in the MEDLEYus set. These sub-carriers shall be modulated by 4-QAM with SOC bit mapping as described in 12.4.1.1. ~~These sub-carriers shall carry 1 information bit per DMT symbol, where each bit is sent 5 times in 5 consecutive DMT symbols. For an information bit value of 1, the value 11 shall be mapped to all of the allowed sub-carriers using 4-QAM. For an information bit value of 0 the value 00 shall be mapped to all of the allowed sub-carriers using 4-QAM.~~

The constellation points of all sub-carriers shall be rotated based on the 2-bit number provided by the quadrant scrambler, as described in 12.3.6.2. The scrambler shall be used in reset mode (see 12.3.6.2.1).

The symbol length shall be $2N_{us}+L_{CE}$ samples. Windowing shall be applied at the transmitter, and the overall window length shall be equal to β_{us}. (See 10.4.4). The values of $2N_{us}$, β_{us} and cyclic prefix length shall be set to the values communicated by the VTU-R in R-PRM-LD. The value of L_{CE} shall be as communicated by the VTU-O in O-PRM-LD.

The transmit PSD of the MEDLEYus sub-carriers in R-P-TRAINING 3 shall be the same as for R-P-TRAINING 2.

16) Tables 12-28, 12-29, 12-34, 12-35, 12-37, 12-55 to 12-58

Add a note to the following tables as follows:

Table 12-28/G.993.2 – Bit mapping for O-P-CHANNEL DISCOVERY 1

Sub-carrier index	Constellation point
Even	00
1, 11, 21, …, 10*n*+1, ...	SOC message bits 0 & 1
3, 13, 23, …, 10*n*+3, ...	SOC message bits 2 & 3
5, 15, 25, ... , 10*n*+5, ...	SOC message bits 4 & 5
7, 17, 27, …, 10*n*+7, ...	SOC message bits 6 & 7
9, 19, 29, …, 10*n*+9, ...	00
NOTE – The byte is given as (b7, b6, b5, b4, b3, b2, b1, b0), where b7 is the MSB and b0 is the LSB. Mapping e.g., "SOC message bits 0 & 1" to sub-carriers 10*n*+1 means that the two-bit value (b1,b0) shall be used to determine the constellation point in accordance with the encoding rules given in 10.3.3.2. This constellation point will then be scrambled using the quadrant scrambler described in 12.3.6.2.	

Table 12-29/G.993.2 – Bit mapping for R-P-CHANNEL DISCOVERY 1

Sub-carrier index	Constellation point
Even	00
1, 11, 21, …, $10n+1$, ...	SOC message bits 0 & 1
3, 13, 23, …, $10n+3$, ...	SOC message bits 2 & 3
5, 15, 25, ... , $10n+5$, ...	SOC message bits 4 & 5
7, 17, 27, …, $10n+7$, ...	SOC message bits 6 & 7
9, 19, 29, …, $10n+9$, ...	00
NOTE – The byte is given as (b7, b6, b5, b4, b3, b2, b1, b0), where b7 is the MSB and b0 is the LSB. Mapping e.g., "SOC message bits 0 & 1" to sub-carriers $10n+1$ means that the two-bit value (b1,b0) shall be used to determine the constellation point in accordance with the encoding rules given in 10.3.3.2. This constellation point will then be scrambled using the quadrant scrambler described in 12.3.6.2.	

Table 12-34/G.993.2 – Bit mapping for O-P-TRAINING 1

Sub-carrier index	Constellation point
Even	00
1, 11, 21, …, $10n+1$, ...	First 2 bits from the PRBS byte
3, 13, 23, …, $10n+3$, ...	Second 2 bits from the PRBS byte
5, 15, 25, ... , $10n+5$, ...	Third 2 bits from the PRBS byte
7, 17, 27, …, $10n+7$, ...	Fourth 2 bits from the PRBS byte
9, 19, 29, …, $10n+9$, ...	00
NOTE – The byte is given as (b7, b6, b5, b4, b3, b2, b1, b0), where b7 is the MSB and b0 is the LSB. Mapping e.g., "SOC message bits 0 & 1" to sub-carriers $10n+1$ means that the two-bit value (b1,b0) shall be used to determine the constellation point in accordance with the encoding rules given in 10.3.3.2. This constellation point will then be scrambled using the quadrant scrambler described in 12.3.6.2.	

Table 12-35/G.993.2 – Bit mapping for O-P-TRAINING 2

Sub-carrier index	Constellation point
Even	00
1, 11, 21, …, $10n+1$, ...	SOC message bits 0 & 1
3, 13, 23, …, $10n+3$, ...	SOC message bits 2 & 3
5, 15, 25, ... , $10n+5$, ...	SOC message bits 4 & 5
7, 17, 27, …, $10n+7$, ...	SOC message bits 6 & 7
9, 19, 29, …, $10n+9$, ...	00
NOTE – The byte is given as (b7, b6, b5, b4, b3, b2, b1, b0), where b7 is the MSB and b0 is the LSB. Mapping e.g., "SOC message bits 0 & 1" to sub-carriers $10n+1$ means that the two-bit value (b1,b0) shall be used to determine the constellation point in accordance with the encoding rules given in 10.3.3.2. This constellation point will then be scrambled using the quadrant scrambler described in 12.3.6.2.	

Table 12-37/G.993.2 – Bit mapping for R-P-TRAINING 2

Sub-carrier index	Constellation point
Even	00
1, 11, 21, …, 10*n*+1, ...	SOC message bits 0 & 1
3, 13, 23, …, 10*n*+3, ...	SOC message bits 2 & 3
5, 15, 25, ... , 10*n*+5, ...	SOC message bits 4 & 5
7, 17, 27, …, 10*n*+7, ...	SOC message bits 6 & 7
9, 19, 29, …, 10*n*+9, ...	00
NOTE – The byte is given as (b7, b6, b5, b4, b3, b2, b1, b0), where b7 is the MSB and b0 is the LSB. Mapping e.g., "SOC message bits 0 & 1" to sub-carriers 10*n*+1 means that the two-bit value (b1,b0) shall be used to determine the constellation point in accordance with the encoding rules given in 10.3.3.2. This constellation point will then be scrambled using the quadrant scrambler described in 12.3.6.2.	

Table 12-55/G.993.2 – Bit mapping for O-P-MEDLEY with two bytes per DMT symbol

Sub-carrier index	Constellation point
5, 10, 15,..., 5 *n*, ...	00
1, 11, 21, ..., 10*n*+1, ...	SOC message bits 0 & 1
2, 12, 22, ..., 10*n*+2, ...	SOC message bits 2 & 3
3, 13, 23, ..., 10*n*+3, ...	SOC message bits 4 & 5
4, 14, 24, ..., 10*n*+4, ...	SOC message bits 6 & 7
6, 16, 26, ..., 10*n*+6, ...	SOC message bits 8 & 9
7, 17, 27, ..., 10*n*+7, ...	SOC message bits 10 & 11
8, 18, 28, ..., 10*n*+8, ...	SOC message bits 12 & 13
9, 19, 29, ..., 10*n*+9, ...	SOC message bits 14 & 15
NOTE – The byte is given as (b7, b6, b5, b4, b3, b2, b1, b0), where b7 is the MSB and b0 is the LSB. Mapping e.g., "SOC message bits 0 & 1" to sub-carriers 10*n*+1 means that the two-bit value (b1,b0) shall be used to determine the constellation point in accordance with the encoding rules given in 10.3.3.2. This constellation point will then be scrambled using the quadrant scrambler described in 12.3.6.2.	

Table 12-56/G.993.2 – Bit mapping for O-P-MEDLEY with one byte per DMT symbol

Sub-carrier index	Constellation point
Even	00
1, 11, 21, …, 10*n*+1, ...	SOC message bits 0 & 1
3, 13, 23, …, 10*n*+3, ...	SOC message bits 2 & 3
5, 15, 25, ... , 10*n*+5, ...	SOC message bits 4 & 5
7, 17, 27, …, 10*n*+7, ...	SOC message bits 6 & 7
9, 19, 29, …, 10*n*+9, ...	00
NOTE – The byte is given as (b7, b6, b5, b4, b3, b2, b1, b0), where b7 is the MSB and b0 is the LSB. Mapping e.g., "SOC message bits 0 & 1" to sub-carriers 10*n*+1 means that the two-bit value (b1,b0) shall be used to determine the constellation point in accordance with the encoding rules given in 10.3.3.2. This constellation point will then be scrambled using the quadrant scrambler described in 12.3.6.2.	

Table 12-57/G.993.2 –Bit mapping for R-P-MEDLEY with two bytes per DMT symbol

Sub-carrier index	Constellation point
5, 10, 15, ..., 5 *n*, ...	00
1, 11, 21, ..., 10*n*+1, ...	SOC message bits 0 & 1
2, 12, 22, ..., 10*n*+2, ...	SOC message bits 2 & 3
3, 13, 23, ..., 10*n*+3, ...	SOC message bits 4 & 5
4, 14, 24, ..., 10*n*+4, ...	SOC message bits 6 & 7
6, 16, 26, ..., 10*n*+6, ...	SOC message bits 8 & 9
7, 17, 27, ..., 10*n*+7, ...	SOC message bits 10 & 11
8, 18, 28, ..., 10*n*+8, ...	SOC message bits 12 & 13
9, 19, 29, ..., 10*n*+9, ...	SOC message bits 14 & 15
NOTE – The byte is given as (b7, b6, b5, b4, b3, b2, b1, b0), where b7 is the MSB and b0 is the LSB. Mapping e.g., "SOC message bits 0 & 1" to sub-carriers 10*n*+1 means that the two-bit value (b1,b0) shall be used to determine the constellation point in accordance with the encoding rules given in 10.3.3.2. This constellation point will then be scrambled using the quadrant scrambler described in 12.3.6.2.	

Table 12-58/G.993.2 – Bit mapping for R-P-MEDLEY with one byte per DMT symbol

Sub-carrier index	Constellation point
Even	00
1, 11, 21, …, 10*n*+1, ...	SOC message bits 0 & 1
3, 13, 23, …, 10*n*+3, ...	SOC message bits 2 & 3
5, 15, 25, ... , 10*n*+5, ...	SOC message bits 4 & 5
7, 17, 27, …, 10*n*+7, ...	SOC message bits 6 & 7
9, 19, 29, …, 10*n*+9, ...	00
NOTE – The byte is given as (b7, b6, b5, b4, b3, b2, b1, b0), where b7 is the MSB and b0 is the LSB. Mapping e.g., "SOC message bits 0 & 1" to sub-carriers 10*n*+1 means that the two-bit value (b1,b0) shall be used to determine the constellation point in accordance with the encoding rules given in 10.3.3.2. This constellation point will then be scrambled using the quadrant scrambler described in 12.3.6.2.	

17) Clause B.2.3

Revise Table B.5 as follows:

B.2.3 Downstream Limit PSD masks for band plan 997

Table B.5/G.993.2 – Downstream Limit PSD masks for band plan 997

Name	B7-1	B7-2	B7-3	B7-4	B7-5	B7-6
Long Name	997-M1c-A-7	997-M1x-M-8	997-M1x-M	997-M2x-M-8	997-M2x-A	997-M2x-M
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	−92.5	−92.5	−92.5	−92.5	−92.5	−92.5
80	−72.5	−92.5	−92.5	−92.5	−72.5	−92.5
101.2	Interp	−92.5	−92.5	−92.5	Interp	−92.5
138	−49.5	Interp	Interp	Interp	−44.2	Interp
138	−49.5	Interp	Interp	Interp	−36.5	Interp
227.11	−49.5	−62	−62	−62	−36.5	−62
276	−49.5	−48.5	−48.5	−48.5	−36.5	−48.5
276	−49.5	−36.5	−36.5	−36.5	−36.5	−36.5
1104	−49.5	−36.5	−36.5	−36.5	−36.5	−36.5
1622	−49.5	−46.5	−46.5	−46.5	−46.5	−46.5
2208	−49.5	−48	−48	interp	interp	interp
2236	−49.5	Interp	Interp	interp	interp	interp
2249	−49.5	−49.5	−49.5	Interp	Interp	Interp
2423	−56.5	Interp	Interp	Interp	Interp	Interp
2500	−56.5	−56.5	−56.5	Interp	Interp	Interp
3000	−56.5	−56.5	−56.5	−49.6	−49.6	−49.6
3000	−80	−80	−80	−80	−80	−80
3175	−100	−100	−100	−100	−100	−100
3750	−100	−100	−100	−100	−100	−100
3750	−100	−100	−100	−100	−100	−100
3925	−100	−100	−100	−100	−100	−100
4925	−100	−100	−100	−100	−100	−100
5100	−80	−80	−80	−80	−80	−80
5100	−56.5	−56.5	−56.5	−52.6	−52.6	−52.6
5200	−56.5	−56.5	−56.5	Interp	Interp	Interp
5200	−56.5	−56.5	−56.5	Interp	Interp	Interp
7050	−56.5	−56.5	−56.5	−54	−54	−54
7050	−80	−80	−80	−80	−80	−80
7225	−100	−100	−100	−100	−100	−100
8500	−100	−100	−100	−100	−100	−100
8500	−100	−100	−100	−100	−100	−100
8675	−100	−100	−100	−100	−100	−100
30000	−100	−100	−100	−100	−100	−100

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/$\log_{10}(f)$ basis; and

– above f_1 on a dB/f basis;

– where f_1 is defined in Table B.1.

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Printed in Switzerland
Geneva, 2007