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Amendment 6
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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital sections and digital line system – Metallic access networks

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Very high speed digital subscriber line transceivers 2 (VDSL2)

Amendment 6

CAUTION !

PREPUBLISHED RECOMMENDATION

This prepublication is an unedited version of a recently approved Recommendation. It will be replaced by the published version after editing. Therefore, there will be differences between this prepublication and the published version.

FOREWORD

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

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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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Amendment 6 to Recommendation ITU-T G.993.2 (2011)

Very high speed digital subscriber line transceivers 2 (VDSL2): Amendment 6

Summary

Amendment 6 to Recommendation ITU-T G.993.2 (2011) covers the following functionality:

1. SNRM Mode 5 (new functionality).

Amendment 6 to Recommendation ITU-T G.993.2 (2011)

Very high speed digital subscriber line transceivers 2 (VDSL2): Amendment 6

1. SNRM Mode 5 (new functionality).

Add to abbreviations

4. Abbreviations

SAVN Showtime Adaptive Virtual Noise

Change clause 11.2.3.2 as follows:

11.2.3.2 Command and response types

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Table 11-2 – High priority commands and responses

Command type and assigned value	Direction of command	Command content	Response content	Support
On-line reconfiguration (OLR) $0000\ 0001_2$	From the receiver of either VTU to the transmitter of the other	All the necessary PMD and PMS-TC control parameter values for the new configuration	Includes either a line signal marking the instant of re-configuration (Syncflag), or an OLR intermediate acknowledge (for segmented command), or an OLR command to defer or reject the proposed reconfiguration	See Table 11-6
Power Management $0000\ 0111_2$	From either VTU to the other	High priority LPM commands defined in Annex E/G.998.4	An acknowledgement or reject of high priority LPM command as defined in Annex E/G.998.4	Optional

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Table 11-4 – Normal priority commands and responses

Command type and assigned value	Direction of command	Command content	Response content	Support
Power Management $0000\ 0111_2$	From either VTU to the other	Proposed new power state, or normal priority LPM commands defined in Annex E/G.998.4	An acknowledgement to either reject or grant the new power state, or acknowledgement or reject of normal priority LPM command as defined in Annex E/G.998.4	Mandatory

Table 11-4 – Normal priority commands and responses

Command type and assigned value	Direction of command	Command content	Response content	Support
SAVN-Update 1010 0001_2	From VTU-O to VTU-R	Request to update the showtime adaptive virtual noise (SAVN)	Acknowledgment	Optional

Add new eoc message as follows (new clause):

11.2.3.17 SAVN-Update command and responses

The VTU-O shall send the SAVN-Update command to communicate the updated value of the downstream transmitter referred showtime adaptive virtual noise (TXREFSAVNds) to the VTU-R. Upon reception of the SAVN-Update command, the VTU-R shall send a SAVN-Update response.

The first octet of both the command and the response indicates the SAVN-Update command type, as defined in Table 11-4 (normal priority). The other octets of the SAVN-Update command are defined in Table 11-40.3. The SAVN-Update response shall be a simple acknowledgement that indicates the serial number of the update, as defined in Table 11-40.4. The SAVN-Update command shall be initiated by the VTU-O only. The SAVN-Update response shall be sent by the VTU-R only.

Table 11-40.3/G.993.2 –SAVN-Update command (sent by the VTU-O)

Name	Length (Octets)	Octet number	Content
SAVN-Update	~~4 + 3 × the number of breakpoints in the SAVN PSD descriptor~~ 7+(stop sub-carrier group index − start sub-carrier group index + 1)	2	09_{16} (Note 1)
		3	One octet containing the sequence number of the update (Note 2)
		4 to 5	2 octets describing the start sub-carrier group index
		6 to 7	2 octets describing the stop sub-carrier group index
		8 to 7+(stop sub-carrier group index − start sub-carrier group index + 1)	The transmitter-referred SAVN PSD, TXREFSAVNds
NOTE 1 – All other values for octet numbers 2 are reserved by ITU-T. NOTE 2 – The sequence number of the update shall be "1" for the first SAVN-Update command, and shall be incremented by 1 for each subsequent SAVN-Update command, wrapping around to "0" after "255".			

TXREFSAVNds indicates the PSD of the SAVN that shall be taken into account when determining bit loading and active tone set using SNRM_MODE = 5 (see clause 11.4.1.1.6.1.5). In case SAVN is not used, both the start sub-carrier group index and the stop sub-carrier group index shall be equal to 0 and the TXREFSAVNds field shall be of zero length.

TXREFSAVNds($k \times G \times \Delta f$) shall be the value of the transmitter referred SAVN PSD for subcarriers with indices from $k \times G$ to $((k+1) \times G) - 1$, inclusive. It shall be represented as an 8 bit unsigned integer $savn(k)$, where $k = 0$ to 511. The value of TXREFSAVNds($k \times G \times \Delta f$) shall be defined as TXREFSAVNds($k \times G \times \Delta f$) = $-23 - (savn(k)/2)$ dBm/Hz. This data format supports a TXREFSAVNds(f) granularity of 0.5 dB with a valid range of values for TXREFSAVNds(f) from −150 (coded 254) to −23 (coded 0) dBm/Hz. The value coded 255 is reserved for future use by ITU-T.

The group size for TXREFSAVNds shall be $G = 8$.

Table 11-40.4/G.993.2 –SAVN-Update response (sent by the VTU-R)

Name	Length (Octets)	Octet number	Content
SAVN-ACK	4	2	$0A_{16}$ (Note 1)
		3	One octet containing the sequence number of the acknowledged SAVN-Update command
		4	One octet indicating whether or not an SRA will follow (Note 1): 00_{16} SRA will follow 01_{16} No SRA will follow
SAVN-NACK	3	2	$0B_{16}$ (Note 1)
		3	Reason code (Note 1): 00_{16} Invalid parameter set 01_{16} Violation of initialization policy
NOTE 1 – All other values for this octet are reserved by ITU-T.			

The VTU-R shall compute the bit loading and framing parameters corresponding to the updated value of the TXREFSAVNds. The updated value of TXREFSAVNds may require a modification of the bit loading, or framing parameters, or both, in the aim to maintain operation of the line within the boundaries set at initialization (e.g., SNRM boundaries). If no modification of the bit loading, or framing parameters is required, then the VTU-R shall reply with the SAVN-ACK response, indicating no SRA will follow. If modification of the bit loading or framing parameters is required and the required modification of the bit loading or framing parameters is within the boundaries set at initialization (e.g., related to ETR), then the VTU-R shall reply with the SAVN-ACK response indicating an SRA will follow and shall initiate an SRA (Request Type 3 for G.993.2 and Request Type 5 for G.998.4) within 1 second after sending the SAVN-ACK response. If the requirednot modification cannot be made within the boundaries set at initialization (e.g., related to ETR), then the VTU-R shall reply with the SAVN-NACK response using a reason code 01_{16}, which means that the requested SAVN PSD cannot be applied within the initialization policy.

Upon receiving a SAVN-NACK response, the VTU-O may either send another SAVN PSD update or re-initialize the line with new boundaries for performance parameters, which can fit the required SAVN settings.

VTU-O shall not send SAVN-Update command when the VTU-R is involved in an OLR procedure associated with change of the bit loading or framing parameters in the downstream direction.~~, such as bit swap, SRA, LPM entry/exit step, etc~~.

Change clause 11.4.1.1.2 as follows:

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

The quiet line noise PSD QLN(*f*) for a particular subcarrier is the rms level of the noise present on the loop when no VDSL2 signals are present on the loop. The received virtual noise PSD as defined in SNRM_MODE=2, SNRM_MODE=3, ~~and~~ SNRM_MODE=4, and SNRM_MODE=5 shall not be taken into account in QLN(*f*).

...

Add new clause for definition of SNRM_MODE = 5

11.4.1.1.6.1.5 SNRM_MODE = 5

SNRM_MODE = 5 is an optional capability for both upstream and downstream. A transceiver supporting operation with SNRM_MODE = 5 shall also support SRA.

The SNRM_MODE = 5 can be applied in both directions (i.e., for both VTU-O and VTU-R receivers). If SNRM_MODE = 5 is applied in at least one direction, then an *msg* bit rate of at least 64 kbit/s shall be used in both directions.

The reference noise PSD is equal to the maximum of the received current-condition external noise PSD (as defined in SNRM_MODE=1) and the received showtime adaptive virtual noise (SAVN) PSD, at a common internal reference point.

The received SAVN PSD value shall be determined by the transceiver as defined in the following equation.

$$\text{Received\_ SAVN\_PSD} = |H(f)|^2 \times \text{TXREFSAVN}(f),$$

where TXREFSAVN*(f)* is the transmitter-referred SAVN PSD parameter at frequency *f*, and $|H(f)|^2$ is calculated as defined in clause 11.4.1.1.6.1.2.

The value of TXREFSAVN is set at initialization and may be updated during showtime. At initialization, the downstream SAVN PSD and upstream SAVN PSD are determined by the VTU-O~~, where the TXREFVNds and TXREFVNus (see clause 11.4.2.1) set in the CO-MIB may be taken into account~~. The initial value of the downstream SAVN PSD (TXREFSAVNds) is communicated to the VTU-R in the TXREFVNds field in the O-SIGNATURE message (see clause 12.3.3.2.1.1). During showtime, the VTU-O may update the value of the downstream SAVN PSD based on noise estimations or actual noise measurements at the VTU-R, e.g., noise changes due to other lines going in and out of the low power mode (see Annex E/G.998.4). The update of TXREFSAVNds is communicated to the VTU-R via a SAVN-Update eoc command (see clause 11.2.3.16). During showtime, the VTU-O may also update the value of the upstream SAVN PSD based on noise estimations or actual noise measurements at the near-end. The VTU-O may estimate the SNR at the remote end by using the Test Parameter Read command defined in clause 11.2.3.11. Other estimation methods are for further study. Upon an update of the received SAVN PSD, the

VTU shall verify whether the update requires a modification of the bit loading. If a modification is required, the VTU shall perform an SRA to adjust the bit loading in accordance with the updated value of the received SAVN PSD.

NOTE - To identify changes in the SNR, the VTU-O ME may request the SNR read right after implementation of an SRA command, or a bit swap command, or after SOS.

The range of TXREFSAVNds, TXREFSAVNus values shall be in the boundaries determined by the CO-MIB (parameters TXREFSAVNds-MIN/MAX, TXREFSAVNus-MIN/MAX defined in ~~G.997.1~~Table 11-42.1).

NOTE - To set the initial values of TXREFSAVNds, TXREFSAVNus, the VTU-O may take in account the values TXREFVNds and TXREFVNus (see clause 11.4.2.1) ~~set in~~ provided by the CO-MIB, respectively.

Table 11-42.1/G.993.2 – CO-MIB configuration parameters related to SAVN

Configuration parameter	Definition
TXREFSAVNds-MIN	TXREFSAVNds-MIN indicates a minimum value, such that TXREFSAVNds is greater than or equal to TXREFSAVNds-MIN for all applicable sub-carriers. The valid range is -150 to -23 dBm/Hz in steps of 0.5dB.
TXREFSAVNds-MAX	TXREFSAVNds-MAX indicates a maximum value, such that TXREFSAVNds is less than or equal to TXREFSAVNds-MAX for all applicable sub-carriers. The valid range is -150 to -23 dBm/Hz in steps of 0.5dB.
TXREFSAVNus-MIN	TXREFSAVNus-MIN indicates a minimum value, such that TXREFSAVNus is greater than or equal to TXREFSAVNus-MIN for all applicable sub-carriers. The valid range is -150 to -23 dBm/Hz in steps of 0.5dB.
TXREFSAVNus-MAX	TXREFSAVNus-MAX indicates a maximum value, such that TXREFSAVNus is less than or equal to TXREFSAVNus-MAX for all applicable sub-carriers. The valid range is -150 to -23 dBm/Hz in steps of 0.5dB.

Change clause 11.4.1.1.6.2 as follows:

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

The signal-to-noise ratio margin parameter, SNRM, is the signal-to-noise ratio margin (as defined in clause 11.4.1.1.6.1) measured over all subcarriers, except the subcarriers assigned to the ROC, in a transmission direction for which $b_i > 0$. The received virtual noise PSD as defined in clauses 11.4.1.1.6.1.2, 11.4.1.1.6.1.3, ~~and~~ 11.4.1.1.6.1.4 and 11.4.1.1.5 shall be taken into account, respectively, when configured in SNRM_MODE=2, SNRM_MODE=3, ~~and~~ SNRM_MODE=4, and SNRM_MODE=5.

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Change clause 11.4.1.1.6.3 as follows:

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

…

The signal-to-noise ratio margin per band parameter SNRM-pb is the signal-to-noise ratio margin (as defined in clause 11.4.1.1.6.1) measured over all subcarriers in a particular band for which $b_i > 0$. The received virtual noise PSD as defined in clauses 11.4.1.1.6.1.2, 11.4.1.1.6.1.3, ~~and~~ 11.4.1.1.6.1.4, and 11.4.1.1.6.1.5 shall be taken into account, respectively, when configured in SNRM_MODE=2, SNRM_MODE=3, ~~and~~ SNRM_MODE=4, and SNRM_MODE=5.

…

Change clause 11.4.1.1.7 as follows:

11.4.1.1.7 Attainable net data rate (ATTNDR)

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To accurately determine the attainable net data rate (ATTNDR), the receive PMD function must be able to first determine the bits and gains table. Therefore, during loop diagnostic mode, the ATTNDR value for upstream and downstream shall be calculated as:

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

with SNR($i \times \Delta f$) in dB as defined in clause 11.4.1.1.3, but accounting for the received virtual noise PSD when configured in SNRM_MODE=2, SNRM_MODE=3, ~~or~~ SNRM_MODE=4, or SNRM_MODE=5 and SNRGAP= 9.75 dB (Note 1).

NOTE 1 – The SNRGAP value is defined for a 10^{-7} bit error ratio on 4-QAM (no coding gain, $INP\_min_0 = 0$).

NOTE 2 – The value calculated for ATTNDR during loop diagnostic mode may not be identical to the value calculated during Showtime with the same PMD parameters and under the same loop conditions.

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Change clause 11.4.1.1.7.1 as follows:

11.4.1.1.7.1 The basic attainable net data rate method

Support of the basic attainable net data rate method is mandatory.

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

- single bearer channel and single latency operation;
- target SNR margin equal to the configured TARSNRMds/TARSNRMus downstream and upstream, respectively;
- latency not to exceed the highest latency configured for the bearer channel ($delay\_act_0 \leq delay\_max_0$);
- accounting for all coding gains available (e.g., trellis coding, FEC) within the latency bound;
- accounting for the channel characteristics at the instant of measurement; and

- accounting for the received virtual noise PSD when configured in SNRM_MODE=2, SNRM_MODE=3, ~~or~~ SNRM_MODE=4, or SNRM_MODE=5.

NOTE – The conditions of the basic method in this version of the Recommendation are unchanged compared to the conditions for ATTNDR calculation in previous versions of this Recommendation. This set of conditions did not specify a number of conditions to calculate ATTNDR, which lead to vendor discretionary behaviour in the reported ATTNDR values. It is recommended that implementations that are upgraded from a previous version of this Recommendation to this version of this Recommendation, in case of *attndr_method*=0 use the same vendor discretionary behaviour as used when operating according to the previous version of this Recommendation.

Change clause 11.4.2 as follows:

11.4.2 Configuration parameters

11.4.2.1 Transmitter-referred virtual noise PSD

This clause describes the transmitter-referred virtual noise PSD parameter TXREFVN, used only in the optional SNR margin mode SNRM_MODE = 2, ~~and~~ SNRM_MODE = 4, and SNRM_MODE=5.

11.4.2.1.1 Definition of parameter TXREFVN

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

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

NOTE - For SNRM_MODE=5, the TXREFVN parameter provided by the CO-MIB may be taken into account by the VTU-O to determine the initial value of TXREFSAVN (see clause 11.4.1.1.6.1.5).

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Add a row at the end of the following Tables in clause 12.3.2.1.x and 13.3.2.2.x:

Table 12-7 – VTU-O CL message NPar(2) bit definitions

ITU-T G.994.1 NPar(2) Bit	Definition of NPar(2) bit
Support of downstream SAVN	If set to ONE, signifies that the VTU-O supports the use of the downstream SAVN mechanism.

Table 12-10 – VTU-O MS message NPar(2) bit definitions

ITU-T G.994.1 NPar(2) Bit	Definition of NPar(2) bit
Support of downstream SAVN	Set to ONE if and only if both the last previous CLR and the last previous CL messages have set this bit to ONE. Indicates that the downstream SAVN mechanism may be used.

Table 12-13 – VTU-R CLR message NPar(2) bit definitions

ITU-T G.994.1 NPar(2) Bit	Definition of NPar(2) bit
Support of downstream SAVN	If set to ONE, signifies that the VTU-R supports the use of the downstream SAVN mechanism.

Table 12-16 – VTU-R MS message NPar(2) bit definitions

ITU-T G.994.1 NPar(2) Bit	Definition of NPar(2) bit
Support of downstream SAVN	Set to ONE if and only if both the last previous CLR and the last previous CL messages have set this bit to ONE. Indicates that the downstream SAVN mechanism may be used.

Update O-SIGNATURE as follows:

12.3.3.2.1.1 O-SIGNATURE

...

Field #16 "Downstream transmitter referred virtual noise PSD (TXREFVNds)" indicates the PSD of the virtual noise in the downstream direction for SNRM_MODE=2 and SNRM_MODE=4. For SNRM_MODE=5, this field indicates the initial value of the downstream SAVN PSD (TXREFSAVNds, see clause 11.4.1.1.6.1.5). This information shall be taken into account when determining the SNR margin (for optional SNRM_MODE = 2, ~~optional SNRM_MODE = 3, and~~ optional SNRM_MODE = 4, and optional SNRM_MODE = 5), which in turn shall be taken into account in determining the possible power cutback during the channel discovery phase, and for performing the bit loading later in initialization. The "PSD descriptor" format specified in Table 12-23 shall be used, and the number of subcarriers being described shall be limited to ≤ 32. When SNRM_MODE = 1, the PSD descriptor field shall contain zero breakpoints (only 1 byte with a value of zero).

NOTE 5 - For SNRM_MODE=5, the TXREFVNds parameter provided by the CO-MIB may be taken into account by the VTU-O to determine the initial value of TXREFSAVNds (see clause 11.4.1.1.6.1.5).

Field #17 "SNRM_MODE" indicates the mode of downstream and upstream SNRM computation as described in clause 11.4.1.1.6. Bits 0 to 3 of the field shall be used to indicate the downstream SNR mode with valid values of 0_{16} (Downstream SNRM_MODE = 1, mandatory) ~~and~~ 1_{16} (Downstream SNRM_MODE = 2, optional), 3_{16} (Downstream SNRM_MODE=4, optional), and 4_{16} (Downstream SNRM_MODE=5, optional). All other values are reserved. Bits 4 to 7 of the field shall be used to indicate the upstream SNR mode with valid values of 0_{16} (Upstream SNRM_MODE = 1, mandatory), 1_{16} (Upstream SNRM_MODE = 2, optional), 2_{16} (~~Down~~Upstream SNRM_MODE = 3, optional), ~~and~~ 3_{16} (Downstream SNRM_MODE = 4, optional), and 4_{16} (Upstream SNRM_MODE=5, optional). All other values are reserved.

Field #18 "Upstream transmitter referred virtual noise PSD (TXREFVNus)" indicates the PSD of the virtual noise in the upstream direction. The "PSD descriptor" format specified in Table 12-23 shall be used, and the number of subcarriers being described shall be limited to ≤ 16. When SNRM_MODE = 1, 3, 4 or ~~4~~5, the PSD descriptor field shall contain zero breakpoints (only 1 byte with a value of zero).

NOTE 6~~5~~ – Improper setting of TXREFVN or RXREFVN can interact with the setting of one or more of the following parameters: maximum net data rate, downstream maximum SNR margin, impulse noise protection, and maximum interleaving delay. This interaction can result in high levels of transmit power that can lead to high crosstalk experienced by DSLs on other pairs in the same binder.

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