International Telecommunication Union

ITU-T

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G.993.5

Amendment 3

(04/2013)

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

Digital sections and digital line system – Access networks

Self-FEXT cancellation (vectoring) for use with VDSL2 transceivers

Amendment 3

Recommendation ITU-T G.993.5 (2010) – Amendment 3

International Telecommunication Union

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Recommendation ITU-T G.993.5

Self-FEXT cancellation (vectoring) for use with VDSL2 transceivers

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Summary

Amendment 3 to Recommendation ITU-T G.993.5 (2010) covers the following functionalities:

1) Alignment with ITU-T G.997.1 VECTORMODE_ENABLE (new functionality).
2) VCE vendor ID and version number (new functionality).
3) Loop diagnostic mode procedures (corrigendum).

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.993.5	2010-04-22	15
1.1	ITU-T G.993.5 (2010) Cor. 1	2011-06-22	15
1.2	ITU-T G.993.5 (2010) Amd. 1	2011-12-16	15
1.3	ITU-T G.993.5 (2010) Cor. 2	2012-06-13	15
1.4	ITU-T G.993.5 (2010) Amd. 2	2012-10-29	15
1.5	ITU-T G.993.5 (2010) Amd. 3	2013-04-22	15

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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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Recommendation ITU-T G.993.5

Self-FEXT cancellation (vectoring) for use with VDSL2 transceivers

Amendment 3

1) Alignment with ITU-T G.997.1 VECTORMODE_ENABLE

Change clause 10.2 as follows:

10.2 ITU-T G.994.1 Handshake phase

The initialization procedure starts with the ITU-T G.994.1 handshake phase. During this phase, the VTU-O and the VTU-R shall exchange their enabled vectoring capabilities in addition to the parameters communicated in a regular handshake phase as defined in [ITU-T G.993.2]. The VTU-O shall support downstream vectoring and may support upstream vectoring. The VTU-R shall support downstream vectoring and shall support upstream vectoring. Based on these capabilities, the final mode of vectored operation (i.e., downstream and upstream vectoring, or downstream-only vectoring) is determined during the ITU-T G.994.1 phase of initialization (see Tables 11.68.0.1 and 11.68.10 of [ITU-T G.994.1~~+ Amd.5~~] and Tables 7-a/b/c/d).

Before transmission of the MS message, the VTU-O shall verify whether all of the following conditions are TRUE (Note 1):

- the CO-MIB parameter VECTORMODE_ENABLE bit 0 is set to 0;
- the Annex X "ITU-T G 993.5-friendly ITU-T G.993.2 operation in the downstream direction" NPar(2) bit is set to ZERO in the CL message or in the CLR message;
- the Annex Y "Full ITU-T G.993.5-friendly ITU-T G.993.2 operation" NPar(2) bit is set to ZERO in the CL message or in the CLR message;
- the "ITU-T G.993.5" Spar(2) bit is set to ZERO in the CL message or in the CLR message.

If all of the above conditions are TRUE, then the VTU-O shall ensure that the "ITU-T G.993.2" Spar(1) bit is set to ZERO in the last transmitted MS message before the ITU-T G.994.1 cleardown procedure (Note 2). Otherwise, the operating mode shall be negotiated solely based on the VTU-O and VTU-R enabled capabilities indicated in the CL and CLR message respectively, as defined in Annex X of [ITU-T G.993.2], Annex Y of [ITU-T G.993.2], and in this clause.

NOTE 1 – The verification of these conditions is for the VTU-O to ensure that the line will not initialize in "ITU-T G.993.2 mode with neither Annex X nor Annex Y enabled" if this mode is not allowed in the CO-MIB.

NOTE 2 – This may require the use of the ITU-T G.994.1 extended transaction A:B as defined in Table 14 of [ITU-T G.994.1].

The VCE shall force the VTU-O to set the sub-carrier spacing and symbol rate in the initializing line to the same value as used in the other vectored lines.

NOTE ~~1~~3 – The same symbol rate between all lines of the vectored group is achieved by setting the same ratio between the IDFT size and CE length in samples for upstream and downstream.

NOTE ~~2~~4 – During the Handshake phase, the VTU-O selects the value of CE based on the supported values indicated by the VTU-O and the VTU-R. Only the value CE=5×N/32 (where 2×N is the IDFT size) is mandatory. In the absence of other information about the CE capabilities of the VTU-R, this will be the only value that is guaranteed to be supported by a new initializing line.

Table 7-a – VTU-O CL message Spar(2) and NPar(3) bit definitions

ITU-T G.994.1 SPar(2) Bit	Definition of SPar(2) bit
ITU-T G.993.5	This bit shall be set to ONE, if and only if the VTU-O supports ITU-T G.993.5 and ITU-T G.993.5 is allowed via the CO-MIB (i.e., VECTORMODE_ENABLE bit 3 set to 1, see clause 7.3.1.13.9 of [ITU-T G.997.1]).
ITU-T G.994.1 NPar(3) Bit	**Definition of NPar(3) bits**
Downstream vectoring	This bit shall be set to ONE, indicating the VTU-O supports downstream vectoring.
Upstream vectoring	If set to ONE, this bit indicates the VTU-O supports upstream vectoring. If set to ZERO, this bit indicates the VTU-O does not support upstream vectoring.
Pilot sequence length multiple of 4	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.

Table 7-b – VTU-O MS message Spar(2) and NPar(3) bit definitions

ITU-T G.994.1 SPar(2) Bit	Definition of SPar(2) bits
ITU-T G.993.5	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 both VTUs shall enter ITU-T G.993.5 initialization.
ITU-T G.994.1 NPar(3) Bit	**Definition of NPar(3) bits**
Downstream vectoring	This bit shall be set to ONE, indicating downstream vectoring.
Upstream vectoring	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 upstream vectoring is enabled. If set to ZERO, this bit indicates upstream vectoring is disabled.
Pilot sequence length multiple of 4	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.

Table 7-c – VTU-R CLR message Spar(2) and NPar(3) bit definitions

ITU-T G.994.1 SPar(2) Bit	**Definition of SPar(2) bits**
ITU-T G.993.5	This bit shall be set to ONE, if and only if the VTU-R supports ITU-T G.993.5.
ITU-T G.994.1 NPar(3) Bit	**Definition of NPar(3) bits**
Downstream vectoring	This bit shall be set to ONE, indicating the VTU-R supports downstream vectoring.
Upstream vectoring	This bit shall be set to ONE, indicating the VTU-R supports upstream vectoring.
Pilot sequence length multiple of 4	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.

Table 7-d – VTU-R MS message SPar(2) and NPar(3) bit definitions

ITU-T G.994.1 SPar(2) Bit	**Definition of SPar(2) bits**
ITU-T G.993.5	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 both VTUs shall enter ITU-T G.993.5 initialization.
ITU-T G.994.1 NPar(3) Bit	**Definition of NPar(3) bits**
Downstream vectoring	This bit shall be set to ONE, indicating downstream vectoring.
Upstream vectoring	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 upstream vectoring is enabled. If set to ZERO, this bit indicates upstream vectoring is disabled.
Pilot sequence length multiple of 4	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.

2) Clause 10.3.2.1 – Modification of Table 10-1

Add Field #8 – VCE vendor ID and version number to Table 10-1 of clause 10.3.2.1, as follows:

10.3.2.1 O-SIGNATURE

…

Table 10-1 – Parameter field in message O-SIGNATURE

Field	Content of field	Format
1	ITU-T G.993.5 parameter field length	1 byte
2	Vectored downstream bands	Bands descriptor
3	Upstream pilot sequence length	2 bytes
4	Upstream pilot sequence	(1-64) bytes
5	Upstream sync symbol offset	1 bytes
6	Upstream R-P-VECTOR 1 PSD cutback	1 bytes
7	Downstream sync symbol counter modulo value (*N_SSC*)	2 bytes
8	VCE vendor ID and version number	10 bytes

• • •

Add the following text at the end of clause 10.3.2.1:

Field #8 "VCE vendor ID and version number" defines the VCE vendor ID and version number. It consists of 10 bytes, with definition and format as depicted in Table 10-1a.

Table 10-1a – VCE Vendor ID information block (10 bytes)

ITU-T T.35 country code (2 bytes – Note 1)
Provider code (vendor identification) (4 bytes – Note 2)
Vendor specific version number (4 bytes)
NOTE 1 – If the bits in the first octet are not all set to binary ONE, the bits in the second octet shall be set to binary ZERO by the transmitter and ignored by the receiver. The only purpose of the country code is to identify the country of registry of the provider code. NOTE 2 – Specification of the coding and order of transmission of this field is the responsibility of the regional standards body allocating the provider code. See Appendix II of [ITU-T G.994.1] for provider code contact information.

3) New clause 10.7 - Loop diagnostic mode procedures

Add new clause 10.7 as follows:

10.7 Loop diagnostic mode procedures

10.7.1 Overview

The loop diagnostic mode procedure described in this clause is based on the initialization as described in clause 10.1 through 10.6, with addition of steps specific for loop diagnostic mode, and without sending R-ERROR-FEEDBACK messages.

If the loop diagnostic mode codepoint in the MS message is set (see clauses 12.3.2.1.2 and 12.3.2.2.2 of [ITU-T G.993.2]), then the loop diagnostic mode shall be entered after completion of the ITU-T G.994.1 Handshake phase. Loop diagnostic mode shall be entered upon request by either VTU. Both VTUs shall support the loop diagnostic mode.

The sequence of stages in the loop diagnostic mode shall be the same as for initialization (defined in clause 10.1 through 10.6) up to the channel analysis and exchange phase, where the test parameters listed in Table 12-64 of [ITU-T G.993.2] and defined in clause 11.4.1 of [ITU-T G.993.2] are exchanged. However, the test parameters for the quiet line noise (QLN) and the channel characteristics function (Hlog) shall be measured and exchanged during the channel discovery phase, as described in clause 12.4.3 of [ITU-T G.993.2].

The time-outs specified in clause 12.3.1 of [ITU-T G.993.2] do not apply to loop diagnostic mode. Time-out values are for further study.

10.7.1.1 SOC message mapping during loop diagnostic mode

See clause 12.4.1.1of [ITU-T G.993.2].

10.7.2 Channel discovery and training phases of loop diagnostic mode

10.7.2.1 SOC messages exchanged during the channel discovery and training phases of loop diagnostic mode

The SOC messages for the channel discovery phase and the training phase of the loop diagnostic mode shall be the same as for the initialization procedure described in clauses 10.3 and 10.4, respectively, except for O-PRM, R-PRM, R-MSG1 and O-TA_UPDATE.

10.7.2.1.1 O-PRM & R-PRM

The test parameters for the quiet line noise (QLN) and the channel characteristics function (Hlog) shall be measured and exchanged during the channel discovery phase in the O-PRM-LD and R-PRM-LD messages described in clause 12.4.2.1 of [ITU-T G.993.2], which replace O-PRM and R-PRM.

NOTE – Field #13 and field #14 in O-PRM and R-PRM contain the ITU-T G.998.4 parameter field and the ITU-T G.993.5 parameter field. While field #13 and field #14 in O-PRM-LD and R-PRM-LD contain QLN and Hlog.

10.7.2.1.2 R-MSG1 (supplements clause 10.3.2.2)

Field #2, "Maximum number of FEXT estimation symbols per super-frame", defines the maximum number (*Kmax*) of symbols in the super-frame for which the VTU-R supports error sample reporting. The field shall be formatted as an unsigned integer with value *Kmax* = 0.

Field #3, "Support of optional backchannel control parameters", indicate the optional values of control parameters supported by the VTU-R. The field shall be formatted as an unsigned integer with value 00_{16}.

NOTE – This text is identical to Annex Y, clause Y.10.3.2.2 of [ITU-T G.993.2].

10.7.2.1.3 O TA_UPDATE (supplements clause 10.4.2.1)

Field #2, "Error report control parameters", defines the control parameters for each of the vectored bands indicated in O-SIGNATURE. The VTU-R shall ignore the error report control parameters.

Field #3, "SOC Repetition Factor", defines the SOC repetition factor, 1/R, as set by the VCE. The VTU R shall ignore this field.

Field #4, "FEXT estimation symbols per super-frame", defines the number of symbols (*K*) in the super-frame for which a clipped error sample shall be reported. The field shall be formatted as an unsigned integer with value *K* = 0.

NOTE – This text is identical to clause Y.10.4.2.1, Annex Y of [ITU-T G.993.2], except for field #3.

10.7.2.2 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 clauses 10.3 and 10.4 for initialization, with the following exceptions:

- The SOC message mapping shall be as defined in clause 12.4.1.1 of [ITU-T G.993.2];
- The duration of O-P-QUIET 1 shall be at least 8192 symbols but not longer than 16384 symbols;
- R-P-VECTOR 2 definition.

10.7.2.2.1 R-P-VECTOR 2 (replaces clause 10.4.4.5)

At sync symbol positions, the R-P-VECTOR 2 signal shall contain sync symbols, modulated as defined for the R-P-VECTOR 1 signal. At other symbol positions, the symbols shall be modulated as for the R-P-TRAINING 2 signal, with the SOC message mapping as defined in clause 12.4.1.1 of [ITU-T G.993.2].

Transmission of R-P-VECTOR 2 enables the VCE to estimate upstream FEXT channels from the vectored lines into the initializing line, and update the estimates of the upstream FEXT from the initializing lines into the vectored lines.

During the sync symbols, the SOC is in the inactive state. During the other symbols, the SOC is in the active state, and the VTU-R shall transmit the R-IDLE message.

The duration of R-P-VECTOR 2 signal is controlled by the VTU-O. Within 64 symbols after the last symbol of the O-P-SYNCHRO V4 signal, the VTU-R shall end the transmission of the R-P-VECTOR 2 signal.

The R-P-VECTOR 2 signal shall be followed by the R-P-SYNCHRO V2 signal.

NOTE 1 – The R-P-VECTOR 2 signal in loop diagnostic mode is identical to the R-P-VECTOR 2 signal defined in clause 10.4.4.5 for initialization, without extended SOC and with the VTU-R transmitting R-IDLE messages instead of R-ERROR-FEEDBACK messages.

NOTE 2 – This text is identical to clause Y.10.4.4.5, Annex Y of [ITU-T G.993.2], except for the SOC message mapping.

10.7.3 Channel analysis and exchange phase of loop diagnostic mode

The channel analysis and exchange phase of loop diagnostic mode in ITU-T G.993.5 does not require any changes in comparison to loop diagnostic mode in [ITU-T G.993.2].

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