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ITU-T

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G.993.5

Amendment 2

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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 2

Recommendation ITU-T G.993.5 (2010) – Amendment 2

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Recommendation ITU-T G.993.5

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

Amendment 2

Summary

Amendment 2 to Recommendation ITU-T G.993.5 (2010) covers the following functionalities:

1. Definition of flag tones and probe tones (corrigendum)
2. SRA with retransmission (corrigendum)
3. Definition of the SCC (corrigendum)
4. UPBO optimization for ITU-T G.993.5 (addition of a Note)
5. O-SIGNATURE message (corrigendum)
6. O-P-VECTOR 1 signal (corrigendum)
7. Markers (corrigendum)
8. R-P-VECTOR 1 signal (corrigendum)
9. O-TA_UPDATE message (corrigendum)
10. R-ERROR-FEEDBACK message (corrigendum)
11. Downstream Frequency Dependent Pilot Sequence (corrigendum)
12. Upstream Frequency Dependent Pilot Sequence (amendment)

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

FOREWORD

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

Recommendation ITU-T G.993.5

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

Amendment 2

1) Definitions of flag tones and probe tones

1.1) Clause 3

Change definitions 3.6 and 3.10 as follows:

3.6 flag tones: All sub-carriers of a sync symbol with ~~index~~indices equal to 10*n*+1 or 10*n*+7, with *n* an integer value. Flag tones are used to signal OLR transitions during showtime.

3.10 probe tones: All sub-carriers of a sync symbol with ~~index~~indices equal to 10*n*, 10*n*+2, 10*n*+3, 10*n*+4, 10*n*+5, 10*n*+6, 10n+8, or 10*n*+9, with *n* an integer value. Probe tones are used for transmission of pilot sequences.

2) SRA with retransmission

2.1) Clause 6.1

Add paragraph at the end of clause 6.1 as follows:

6.1 General

…

The VTU-O shall support seamless rate adaptation (SRA, OLR Type 3) in the downstream and upstream direction, including mandatory support within SRA of:

– dynamic interleaver reconfiguration (change of D_p);

– framing reconfiguration (change of T_p, G_p and B_{p0});

as defined in clause 13.1 of [ITU-T G.993.2], titled "Types of on-line reconfiguration".

If ITU-T G.998.4 is enabled in a particular direction, the VTU-O shall also support seamless rate adaptation (SRA, OLR Type 5) in this same direction, including mandatory support within SRA of all configurations specified in clause C.3.2 of [ITU-T G.998.4].

2.2) Clause 7.1

Add paragraph at the end of clause 7.1 as follows:

7.1 General

…

The VTU-R shall support seamless rate adaptation (SRA, OLR Type 3) in the downstream and upstream direction, including mandatory support within SRA of:

– dynamic interleaver reconfiguration (change of D_p);

– framing reconfiguration (change of T_p, G_p and B_{p0});

as defined in clause 13.1 of [ITU-T G.993.2], titled "Types of on-line reconfiguration".

If ITU-T G.998.4 is enabled in a particular direction, the VTU-R shall also support seamless rate adaptation (SRA, OLR Type 5) in this same direction, including mandatory support within SRA of all configurations specified in clause C.3.2 of [ITU-T G.998.4].

3) Definition of the SSC

3.1) Clause 7.2.4

Change clause 7.2.4 as follows:

7.2.4 Identification of the ERB during Showtime

At each of the sync symbol counts indicated by the VTU-O, the VTU-R shall transmit a single ERB. With each ERB, the VTU-R shall also transmit the downstream sync symbol count (as defined in clause 7.3.2) as identification of the downstream sync symbol the ERB corresponds to. The VTU-O shall indicate such sync symbol counts using the following time identification control parameters:

– the error sample update period (m);

– the error sample shift period (z).

The error sample update period gets value of m if the error sample has to be reported on every m-th sync symbol, i.e., on the sync symbol positions with sync symbol counts $SSC = m \times P + k$, where P is any integer in the range from 0 to $\lfloor (N\_SSC - 1 - k)/m \rfloor$, and k is the offset, which is an integer in the range from 0 to m–1. After the SSC counter wraps around at the value of N_SSC-1, the next sync symbol count at which ERB shall be reported is SSC = k (this count is obtained by setting P=0).

The VTU-R shall set k=0 for the first report after the VTU-O's error feedback request. This report shall be sent for the first available sync symbol with SSC count that is a multiple of m after reception of the ERB request (see clause 8.1). If $z > 0$, the VTU-R shall increase k by 1 ~~(MOD m)~~ after each error sample shift period of z reports, wrapping around k at m–1.

If $m = 1$, the VTU-R shall report on each sync symbol. The error sample update period value of $m = 0$ is special and shall be used to indicate that the VTU-R shall stop error sample reporting. The non-zero error sample shift period z is valid only for $m > 1$. The error sample shift period value of $z = 0$ ~~is special and~~ shall be used if no error sample shift is to be done and if m=1.

NOTE 1 – The parameters m and z should be selected such that the error samples are reported at least once for all the bits of the pilot sequence after a certain time.

~~NOTE 2 – Denoting the n-th report is on sync symbol count SSC_n, the SSC_1 is a multiple of m and the SSC_n can be calculated for n>1 as follows:~~

~~If (z>0) and (n MOD z = 1) then $SSC_n = SSC_{n-1} + m + 1$; else $SSC_n = SSC_{n-1} + m$;~~

~~If ($SSC_n > N\_SSC - 1$) then $SSC_n = SSC_n$ MOD m.~~

~~For example, with N_SSC=1024, the reports are on the following sync symbol counts:~~

~~m=3 and z=0 then SSC=0, 3, 6, …, 1020, 1023, 0, 3, 6, …~~

~~m=3 and z=128 then SSC=0, 3, …, 126*3, 127*3, 128*3+1, 129*3+1, …~~

NOTE 2 – For example, with N_SSC = 1024, m = 3, and the first report sent at SSC = 6, the reports are on the following sync symbol counts:

m = 3 and z = 0 then SSC = 6, 9, …, 1020, 1023, 0, 3, 6, 9, …

m = 3 and z = 128 then SSC = 6, 9, …, 128×3, 129×3, 130×3+1, 131×3+1, … 257×3+1, 258×3+2, 259×3+2,…. 340×3+2, 2, 5, ….44×3+2, 45×3, 46×3, 47×3, …

The values for the time identification control parameters are defined in Table 7-4.

Table 7-4 – Values of time identification control parameters

Parameter	Valid values for VCE	Mandatory values for VTU-R to support
m	0, 1, 2, …, 63, 64	All valid values
z	If $m > 1$: 0, 2, …, 254, 255, 256 If $m \leq 1$: 0	All valid values

4) UPBO optimization for ITU-T G.993.5

4.1) Clause 10.1

Renumber existing Note as Note 2 and add a new Note to clause 10.1 as follows:

10.1 Overview

….

Furthermore, other optional parameters may be added to the O-P-SIGNATURE message for upstream transmit power reduction during the initial upstream phase (R-P-VECTOR 1). The upstream transmit power reduction can be used to reduce the crosstalk of the R-P-VECTOR 1 signals into non-vectored lines operating in the same binder and provides a flat attenuation of the upstream transmit PSD of R-P-VECTOR 1 in addition to the standard upstream power back-off as defined in [ITU-T G.993.2].

NOTE 1 – Parameters *a*, *b* that determine the limiting upstream PSD mask (UPBOMASK, see clause 7.2.1.3.2.2 of [ITU-T G.993.2]) are provided by the operator via the CO-MIB as specified in [ITU-T G.997.1]. The operator may provision or allow for default values of *a*, *b* that are different from those geographic region specific values defined in [ITU-T G.993.2] (e.g., Annexes A.2.3, B.3, and C.2.1.4), and thus allow higher upstream PSDs, since upstream FEXT is reduced through crosstalk cancellation. After UPBO has been applied (during the initialization), the VTU-R may further adjust its transmit PSD (while it remains below the UPBOMASK) during the Showtime by request from the VTU-O, via SRA, as per clause 7.2.1.3.1 of [ITU-T G.993.2], to improve upstream performance (under control of the VCE). The operator may also adjust the applied parameters *a*, *b* via a new initialization.

At the beginning of the Training phase, the initializing VTU-R will transmit the R-P-VECTOR 1-1 signal, which is the same as R-P-VECTOR 1, and allows the VCE to update the upstream FEXT channel estimates from the initializing lines into the vectored lines, prior to transitioning into the ITU-T G.993.2 Training phase. The VTU-O transmits the O-P-TRAINING V1 signal as a time fill signal while the VTU-R transmits R-P-VECTOR 1-1.

….

5) O-SIGNATURE message

5.1) Clause 10.3.2.1

Change field #7 at the end of clause 10.3.2.1 as follows:

10.3.2.1 O-SIGNATURE

…

Field #7 "Downstream sync symbol counter modulo value (*N_SSC*)", defines the modulo value to be used for maintaining the downstream sync symbols counter during showtime. If the "pilot sequence length multiple of 4" is enabled (see clause 10.2), then this field is coded as an unsigned

integer representing the value of *N_SSC*, with a single valid value being the lowest $(2^n \times Npilot\_ds) \geq 1024$, ~~with~~ where *n* is an integer. Otherwise, it is coded as an unsigned integer with a single valid value of *N_SSC* equal to 1024.

NOTE – If *N_SSC* is an integer multiple of the downstream pilot sequence length, then the pilot sequence bit index may be derived from the downstream sync symbol counter through a modulo operation.

6) O-P-VECTOR 1 signal

6.1) Clause 10.3.3.1

Change clause 10.3.3.1 as follows:

10.3.3.1 O-P-VECTOR 1

The O-P-QUIET 1 signal shall be followed by the O-P-VECTOR 1 signal.

The O-P-VECTOR 1 signal shall consist of sync symbols and quiet symbols only. Sync symbols shall be transmitted at each downstream sync symbol position (as defined in clause 6.2.3). Quiet symbols shall be transmitted at all other symbol positions (see Figure 10-2).

The O-P-VECTOR 1 sync symbols shall be generated as described in clause 10.5 of [ITU-T G.993.2]. These sync symbols shall modulate a pilot sequence. The pilot sequence is a ~~one bit per sync symbol~~ repetitive sequence, as defined in clause 6.2.3, assigned to the initializing line by the vectoring control entity (VCE). Each probe tone of a ~~S~~sync symbol from the SUPPORTEDCARRIERSds set with a pilot sequence bit equal to ZERO shall modulate a 00 constellation point, ~~on all sub-carriers from the SUPPORTEDCARRIERSds set. Each Sync symbol~~ and with a pilot sequence bit equal to ONE shall modulate a 11 constellation point ~~on all sub-carriers from the SUPPORTEDCARRIERSds set~~. The 00 and 11 constellation points shall be per the 4-QAM constellation defined in clause 10.3.3.2.1 of [ITU-T G.993.2]. The constellation points on sub-carriers shall then be rotated by the quadrant scrambler defined in clause 12.3.6.2 of [ITU-T G.993.2].

For sync symbols, the transmit PSD of all sub-carriers shall be equal to CDPSDds.

The duration of O-P-VECTOR 1 is vendor discretionary, but shall be minimum 4×257 symbols and maximum 1024×257 symbols.

NOTE – The O-P-VECTOR 1 signal should be shortened by the VCE to accelerate full system start-up.

During transmission of the O-P-VECTOR 1 signal, the SOC is in its inactive state.

During transmission of the O-P-VECTOR 1 signal, the VCE estimates the downstream FEXT channels from the initializing lines into the vectored lines based on the reported clipped error samples from the VTU-Rs of the vectored lines. From this point on, FEXT cancellation matrices are established in the VTU-Os for all vectored lines in the downstream direction and FEXT from the initializing line into vectored lines is cancelled.

The O-P-VECTOR 1 signal shall be followed by the O-P-CHANNEL DISCOVERY V1 signal, which determines the actual duration of O-P-VECTOR 1. The start time of O-P-CHANNEL DISCOVERY V1 transmission is determined by the VCE.

7) Markers

7.1) Clause 10.3.3.5

Change clause 10.3.3.5 as follows:

10.3.3.5 Downstream sync symbol and upstream pilot sequence markers

To indicate the time position of the downstream sync symbols and the required by VCE time position of the upstream sync symbols and upstream pilot sequence, the VTU-O shall modulate the subset of sub-carriers with indices 10*n*+9 with either the constellation point (00) or the constellation point (11) of the 4-QAM constellation, before the quadrant scrambler. All those sub-carriers shall be modulated with the same information per symbol, i.e., either 00 or 11. Symbols whose sub-carriers are modulated with either 00 or 11 are further noted in this clause as either ZERO or ONE symbols, respectively. A sequence of ZERO and ONE symbols forms a pattern that is used to indicate time positions of the sync symbol and pilot sequence.

Figure 10-6 shows the symbol modulation pattern. The time position of a downstream sync symbol shall be indicated by eight consecutive ONE symbols, starting at the time position of the downstream sync symbol of the vectored lines. The VTU-R shall derive the time position of the upstream sync symbol from the indicated time position of the downstream sync symbol by applying the offset between upstream and downstream sync symbols, which is communicated to the VTU-R in O-SIGNATURE.

The time position of the upstream pilot sequence shall be indicated by a 20-symbol pattern following the eight consecutive ONEs pattern, see Figure 10-6. This pattern of ONE and ZERO symbols shall represent the bit index of the upstream pilot sequence that modulates sub-carriers of the upstream sync symbol associated (through the value of the offset) with this downstream sync symbol that precedes the mentioned 20-symbol pattern (and shown in Figure 10-6).~~through the value of the offset.~~

The bit index of the upstream pilot sequence shall be represented as an unsigned integer, and each bit of this integer is represented by two consecutive symbols of the pattern, with symbols 7 and 8 in Figure 10-6 representing the LSB. A bit value 0 shall be represented by a ZERO symbol followed by a ONE symbol. A bit value 1 shall be represented by a ONE symbol followed by a ZERO symbol. All the symbols after the 20-symbol pattern shall be ZERO symbols until the time position of the next downstream sync symbol.

…

8) R-P-VECTOR 1 signal

8.1) Clause 10.3.4.1

Change paragraph in clause 10.3.4.1 as follows:

10.3.4.1 R-P-VECTOR 1

…

The pilot sequence is a ~~one bit per sync symbol~~ repetitive sequence, as defined in clause 6.3.3, assigned to the initializing line by the VCE and communicated to the VTU-R in the O-SIGNATURE message. Each probe tone of a ~~S~~ssync symbol from the SUPPORTEDCARRIERSus set with a pilot sequence bit equal to ZERO shall modulate a 00 constellation point, ~~on all sub-carriers from the SUPPORTEDCARRIERSus set indicated in O-SIGNATURE. Each Sync symbol~~ and with a pilot sequence bit equal to ONE shall modulate a 11 constellation point (~~on all sub-carriers of~~ the SUPPORTEDCARRIERSus set is also indicated in O-SIGNATURE message). The 00 and 11 constellation points shall be per the 4-QAM constellation

defined in clause 10.3.3.2.1 of [ITU-T G.993.2]. The constellation points on sub-carriers shall then be rotated by the quadrant scrambler defined in clause 12.3.6.2 of [ITU-T G.993.2].

…

9) O-TA_UPDATE message

9.1) Clause 10.4.2.1

Change field #4 in clause 10.4.2.1 as follows:

10.4.2.1 O-TA_UPDATE

…

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 clipped error samples shall be reported in a format defined by Field #2. The field shall be formatted as an unsigned integer with valid values *K*=1, 2, 4, 6, and 8. The value of *K* shall not exceed the VTU-R capability (*Kmax*) indicated in the R-MSG1 message. Clause 10.4.2.2 defines the symbol positions for which clipped error samples shall be reported for different values of *K*.

…

10) R-ERROR-FEEDBACK message

10.1) Clause 10.4.2.2

Change paragraph in clause 10.4.2.2 as follows:

10.4.2.2 R-ERROR-FEEDBACK

…

Through the O-TA_UPDATE message, the VCE indicates how many FEXT estimation symbols per super-frame (i.e., the value of *K* determined by the O-TA_UPDATE message) the clipped error samples shall be reported. For the given value of *K* (assigned by O-TA_UPDATE), the VTU-R shall report clipped error samples for all the O-P-VECTOR 2-1 symbols of each downstream super-frame with symbol count $i(k) = (k+1) \times \lfloor 256/K \rfloor$, where $k = 0,1, 2, \ldots, K–1$. The value of *W_max* for the given value of *K* shall be computed as $W\_max = \lfloor 257/K \rfloor - 2$.

NOTE 1 – If K=1, the VTU-R reports clipped error samples on the O-P-VECTOR 2-1 downstream sync symbols only.

…

11) Downstream Frequency Dependent Pilot Sequence (FDPS)

11.1) Clause 6.2.3

Change paragraph in clause 6.2.3 as follows:

6.2.3 Modulation of a pilot sequence

…

The modulation of a frequency dependent pilot sequence on a probe tone of sync symbols is defined as whether the sync frame bits modulated onto the probe tone shall be set to either 00 (if the pilot sequence bit for that probe tone is ZERO) or set to 11 (if the pilot sequence bit for that probe tone is

ONE). Over the tones of a particular sync symbol, the pilot sequence bit shall have a periodicity of ~~20~~10 tones (considering both probe and flag tones).

…

11.2) Clause 7.2

Change clause 7.2 as follows:

7.2 Downstream vectoring requirements for the VTU-R

The VTU-R shall comply with [ITU-T G.993.2], with exceptions and additional requirements contained in this Recommendation.

This Recommendation defines that all probe tones of a sync symbol, both during initialization and during Showtime, may have the same sign (i.e., if a frequency independent pilot sequence is modulated, see clause 6.2.3) or may not have the same sign (i.e., if frequency dependent pilot sequence is modulated, see clause 6.2.3). The VTU-R shall support reception and all related functionalities required for computing error signals also in case when not all probe tones of the sync symbol have the same sign, but the sign pattern over the tones of the downstream sync symbol has a periodicity of ~~20~~10 tones (considering both probe and flag tones).

12) Upstream frequency dependent pilot sequence (FDPS)

12.1) Clause 6.3

Add paragraph at end of clause 6.3 as follows:

6.3 Upstream vectoring requirements for the VTU-O

…

The VTU-O shall have the capability to convey the control parameters of the upstream vectored group defined in clause 7 and clause 10 from the VCE to the CP-side.

If upstream vectoring is enabled, the VTU-O shall support operation also in the case when not all probe tones of the upstream sync symbol have the same sign, but the sign pattern over the tones of the sync symbol has a periodicity of 10 tones (considering both probe and flag tones).

12.2) Clause 7.3.3

Change last paragraph in clause 7.3.3 as follows:

7.3.3 Modulation of pilot sequence

…

The modulation of a pilot sequence on the probe tones (see clause 3.10) of sync symbols is defined as whether the sync frame bits modulated onto the probe tones are set to ~~all ZEROs~~ either 00 (if the pilot sequence bit is ZERO) or set to ~~all ONEs~~ 11 (if the pilot sequence bit is ONE) ~~(i.e., a 1-bit control per sync symbol)~~. Over the tones of a particular sync symbol, the pilot sequence bit shall have a periodicity of 10 tones (considering both probe and flag tones).

If upstream frequency dependent pilot sequence (upstream FDPS) is enabled through ITU-T G.994.1, then eight pilot sequences with indices from 0 to 7 are defined. The pilot sequences #(0,1,2,3,4,5,6,7) shall be modulated onto tone indices 10*n*+(0,2,3,4,5,6,8,9) respectively. All eight pilot sequences shall have the same length *Npilot_us*. All pilot sequences shall start at the same sync symbol position.

The sync frame bits modulated on the flag tones (see clause 3.6) shall be used for the transmission of a Syncflag as defined in clause 10.5.3 of [ITU-T G.993.2]. The sync frame shall be modulated onto a sync symbol as defined in clause 10.5 of [ITU-T G.993.2] (including the quadrant scrambling of all MEDLEY sub-carriers, regardless of it being a flag or a probe tone).

12.3) Clause 10.2

Change Tables 7-a/b/c/d in clause 10.2 as follows:

10.2 ITU-T G.994.1 Handshake phase

…

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

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.
Upstream FDPS	If set to ONE, this bit indicates the VTU-O supports upstream FDPS. If set to ZERO, this bit indicates the VTU-O does not support upstream FDPS.

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

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.
Upstream FDPS	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 upstream FDPS is enabled. If set to ZERO, this bit indicates that upstream FDPS is disabled.

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

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.
Upstream FDPS	If set to ONE, this bit indicates the VTU-R supports upstream FDPS. If set to ZERO, this bit indicates the VTU-R does not support upstream FDPS.

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

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.
Upstream FDPS	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 upstream FDPS is enabled. If set to ZERO, this bit indicates that upstream FDPS is disabled.

12.4) Clause 10.3.2.1

Change clause 10.3.2.1 as follows:

10.3.2.1 O-SIGNATURE

The O-SIGNATURE message which is transmitted during O-P-CHANNEL DISCOVERY V1 contains an ITU-T G.993.5 parameter field A and an ITU-T G.993.5 parameter field B. The ITU-T G.993.5 parameter field A is of variable length and contains several parameters needed for the FEXT cancellation operation, as shown in Table 10-1. The ITU-T G.993.5 parameter field B includes parameters needed to define the upstream FDPS, as shown in Table 10-1a.

Table 10-1 – ITU-T G.993.5 ~~P~~parameter field A in message O-SIGNATURE

Field	Content of field	Format
1	ITU-T G.993.5 parameter field A length	1 byte
2	Vectored downstream bands	Bands descriptor
3	Upstream pilot sequence length	2 bytes
4	Upstream pilot sequence	~~(1-64) bytes~~ $\lceil Npilot\_us/8 \rceil$ 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

Field #1, "ITU-T G.993.5 parameter field A length", indicates the length of the ITU-T G.993.5 parameter field A in bytes, excluding the ITU-T G.993.5 parameter field A length field. All fields shown in Table 10-1 shall be included in the ITU-T G.993.5 parameter field A in the O-SIGNATURE message. The field shall be represented as an unsigned integer.

...

Add Tables 10-1a, 10-1b, and text at the end of clause 10.3.2.1 as follows:

Table 10-1a – ITU-T G.993.5 parameter field B in message O-SIGNATURE

Field	Content of field	Format
1	ITU-T G.993.5 parameter field B length	2 bytes
2	Upstream FDPS	Upstream FDPS descriptor

Field #1, "ITU-T G.993.5 parameter field B length", indicates the length of the ITU-T G.993.5 parameter field B in bytes, excluding the ITU-T G.993.5 parameter field B length field. If none of the fields following field #1 is included in the ITU-T G.993.5 parameter field B, then the ITU-T G.993.5 parameter field B shall be 2 bytes long with value 0000_{16}. The field shall be represented as an unsigned integer.

Field #2, "Upstream FDPS", defines the additional independent pilot sequences allocated by the VCE and how the upstream pilot sequences to be modulated on the sync symbols contained in the R-P-VECTOR signals are derived. This field shall be formatted as "Upstream FDPS descriptor" (see Table 10-1b). If upstream FDPS is disabled through ITU-T G.994.1, then the Upstream FDPS descriptor shall not be included in the ITU-T G.993.5 parameter field B.

Table 10-1b – Upstream FDPS descriptor

Field	Content of field	Format
1	Index of the associated independent pilot sequence	3 bytes
2	Sign of the sequence relatively to the associated independent sequence	1 byte
3	Cyclical shift of the sequence relative to the associated independent sequence	3 bytes
4	Number of additional independent pilot sequences (*Naips*)	1 byte
5	Bits of independent pilot sequence #1	$\lceil Npilot\_us/8 \rceil$ bytes
	…	…
	Bits of independent pilot sequence #*Naips*	$\lceil Npilot\_us/8 \rceil$ bytes

Field #1, "Index of the associated independent pilot sequence", is a 24-bit field divided into eight 3-bit subfields. The first subfield (in the 3 LSB) represents the index of the independent pilot sequence to be the pilot sequence #0, the eighth subfield (in the 3 MSB) represents the index of the independent pilot sequence to be the pilot sequence #7. The index shall be represented as a 3-bit unsigned integer.

Field #2, "Sign of the sequence relatively to the associated independent pilot sequence", is an 8-bit bitmap, where a 0 indicates that the pilot sequence with the given index has the same sign as the associated independent pilot sequence and a 1 indicates that it has an inverted sign relative to the associated independent pilot sequence. The LSB indicates whether the sign inversion shall be applied to pilot sequence #0, the MSB indicates whether the sign inversion shall be applied to pilot sequence #7.

Field #3, "Cyclical shift of the sequence relative to the associated independent pilot sequence", is a 24-bit field divided into eight 3-bit subfields. The first subfield (in the 3 LSB) represents the cyclic shift of pilot sequence #0 relative to the associated independent pilot sequence, the eighth subfield (in the 3 MSB) represents the cyclic shift of pilot sequence #7 relative to the associated independent pilot sequence. The value of the subfield is the actual cyclic shift (*CyS*) represented as unsigned integer with values 0 to 7, where:

Pilot sequence bit [*i*] =

Associated independent pilot sequence bit [(*i* + *CyS* × *Npilot_us* / 8) MOD *Npilot_us*].

If *Npilot_us* is an odd multiple of 4, then the value of *CyS* shall be even.

Field #4, "Number of additional independent pilot sequences (*Naips*)" is a 1-byte field field representing the number of additional independent pilot sequences included in the Upstream FDPS descriptor. Valid *Naips* values are 0 to 7.

Field #5, "Bits of additional independent pilot sequences", defines the bits of the *Naips* additional independent pilot sequences (i.e., independent pilot sequence #1 to independent pilot sequence #*Naips*) allocated by the VCE to be modulated on the upstream sync symbols. Each sequence is *Npilot_us* bits long (see clause 7.3.3). Each sequence is mapped into $\lceil Npilot\_us/8 \rceil$ bytes as defined for field #4 in Table 10-1 (the last byte can be incomplete). The total length of the field shall be *Naips* × $\lceil Npilot\_us/8 \rceil$ bytes. Bits of the independent pilot sequence #0 are communicated in the "Upstream pilot sequence" field #4 of the ITU-T G.993.5 parameter field A.

12.5) Clause 8.2

Change clause 8.2 as follows:

8.2 Pilot sequence update command and response

The VTU-O VME shall use the pilot sequence update command and response to force an update of the upstream pilot sequence(s) and communicate the updated pilot sequence(s) for the vectored line (see clause 7.3.3) to the VTU-R VME. Separate commands are defined for updating a single pilot sequence (in case upstream FDPS is disabled through ITU-T G.994.1) and for updating 8 upstream pilot sequences (in case upstream FDPS is enabled through ITU-T G.994.1). These commands ~~is~~ are shown in Table 8-9, and may be initiated only by the VTU-O; the VTU-R shall respond with the ACK, using the format shown in Table 8-10.

The first octet of the command shall be the assigned value of the pilot sequence update command type, as shown in Table 8-2. The second and subsequent octets shall be as shown in Table 8-9 for commands and in Table 8-10 for responses. The data octets shall be mapped using the format described in clause 11.2.3.1 of [ITU-T G.993.2].

Using the pilot sequence update message, the VCE may update the upstream pilot sequence(s).

The command message length depends on the length of the upstream pilot sequence (*Npilot_us* bits, see clause 7.3.3). Only the upstream pilot sequence bits may be changed during Showtime. The newly assigned upstream pilot sequence length shall be the same as the length of the upstream pilot sequence that was set at Initialization.

The command message bytes shall be defined as shown in Table 8-9.

Table 8-9 – Pilot sequence update commands transmitted by the VTU-O

Name	Length (Octets)	Octet number	Content
Pilot sequence configuration (FDPS disabled through ITU-T G.994.1)	$3 + \lceil Npilot\_us/8 \rceil$	2	01_{16} for change of upstream pilot sequence with upstream FDPS disabled through ITU-T G.994.1 (see Note)
		3	01_{16} if interruption of current upstream pilot sequence is not allowed; 02_{16} if interruption of current upstream pilot sequence is allowed (see Note)
		4 to $3 + \lceil Npilot\_us/8 \rceil$	Upstream pilot sequence bits, coded as defined for field #4 in Table 10-1.
Pilot sequence configuration (FDPS enabled through ITU-T G.994.1)	$11 + (Naips + 1) \times \lceil Npilot\_us/8 \rceil$	2	02_{16} for change of upstream pilot sequences with upstream FDPS enabled through ITU-T G.994.1 (see Note)
		3	01_{16} if interruption of current upstream pilot sequence is not allowed; 02_{16} if interruption of current upstream pilot sequence is allowed (see Note)
		4 to $3 + \lceil Npilot\_us/8 \rceil$	Upstream pilot sequence bits, coded as defined for field #4 in Table 10-1.
		$4 + \lceil Npilot\_us/8 \rceil$ to $11 + (Naips + 1) \times \lceil Npilot\_us/8 \rceil$	Field #5 of the upstream FDPS descriptor as defined in Table 10-1b.
NOTE – All other values for this octet are reserved by ITU-T.			

The third octet of the pilot sequence update command defines the time at which the upstream pilot sequence change shall occur:

- If interruption of the current upstream pilot sequence is not allowed (value 01_{16}), the upstream pilot sequence change shall be applied starting from the next sync symbol position after the end of the current upstream pilot sequence, i.e., after the sync symbol that modulates the last bit of the old upstream pilot sequence, the next sync symbol shall modulate the first bit of the new upstream pilot sequence.
- If interruption of the current upstream pilot sequence is allowed (value 02_{16}), the upstream pilot sequence change may occur at any sync symbol position, i.e., after the sync symbol that modulates bit *i* of old upstream pilot sequence, the next sync symbol shall modulate bit *i*+1 of the new upstream pilot sequence.

The only allowed response from the VTU-R is to acknowledge the correct reception of the command, as shown in Table 8-10.

Table 8-10 – Pilot sequence update response transmitted by the VTU-R

Name	Length (Octets)	Octet number	Content
ACK	2	2	80_{16} (see Note)
NACK	3	2	81_{16} (see Note)
		3	1 octet for reason code (see Table 8-11)
NOTE – All other values for this octet are reserved by ITU-T.			

Table 8-11 – NACK reason codes

Value	Definition
01_{16}	Invalid set of parameters.
NOTE – All other reason codes are reserved by ITU-T.	

If the pilot sequence update command updates the upstream pilot sequence(s), the VTU-R shall apply the change only after sending the ACK message. If interruption of the current pilot sequence(s) is allowed, the update should occur as soon as possible, and shall occur within 200 ms after sending the ACK message.

The timing diagram of the pilot sequence eoc command and response is shown in Figure 8-1.

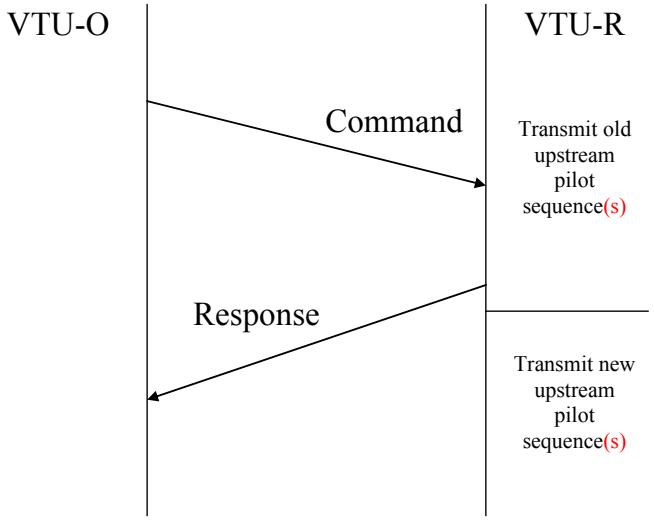

Figure 8-1 – Timing diagram of the pilot sequence update command and response

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