International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.993.2

Amendment 7

(06/2011)

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)

Amendment 7

Recommendation ITU-T G.993.2 (2006) – Amendment 7

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Recommendation ITU-T G.993.2

Very high speed digital subscriber line transceivers 2 (VDSL2)

Amendment 7

Summary

Amendment 7 to Recommendation ITU-T G.993.2 (2006) includes new Annex M on "Time of day distribution over VDSL2 links", specification of an alternative electrical length estimation method, and revision to Annex B "Region B (Europe)".

History

Edition	Recommendation	Approval	Study Group
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1.1	ITU-T G.993.2 (2006) Cor. 1	2006-12-14	15
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1.3	ITU-T G.993.2 (2006) Amd. 1 Cor. 1	2007-07-29	15
1.3	ITU-T G.993.2 (2006) Cor. 2	2007-07-29	15
1.5	ITU-T G.993.2 (2006) Amd. 2	2008-02-06	15
1.6	ITU-T G.993.2 (2006) Amd. 3	2008-08-22	15
1.7	ITU-T G.993.2 (2006) Amd. 4	2009-01-13	15
1.8	ITU-T G.993.2 (2006) Cor. 3	2009-06-29	15
1.9	ITU-T G.993.2 (2006) Amd. 5	2010-04-22	15
1.10	ITU-T G.993.2 (2006) Amd. 6	2010-11-29	15
1.11	ITU-T G.993.2 (2006) Cor. 4	2011-04-13	15
1.12	ITU-T G.993.2 (2006) Amd. 7	2011-06-22	15

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.

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.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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

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Recommendation ITU-T G.993.2

Very high speed digital subscriber line transceivers 2 (VDSL2)

Amendment 7

1 References

Add the following new referenced documents to clause 2:

[15] Recommendation ITU-T O.41 (1994), *Psophometer for use on telephone-type circuits*.

[16] IEEE 1588-2008, *IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems.*

[17] Recommendation ITU-T G.988.4 (2010), *Improved impulse noise protection for DSL transceivers.*

2 Terminology

Add the following new definitions to clause 3:

3.19*bis* **epoch**: The origin of a timescale.

3.47*bis* **precision time protocol (PTP)**: The protocol defined by IEEE 1588-2008 [16].

3.63*bis* **ToD phase difference value**: The value of the VTU-x real-time clock modulo 125 μs at the moment the reference sample crosses the U-x reference point (i.e., phase of t_n event relative to the time of day, in nanoseconds, see also clause 8.4.3.2).

3 Abbreviations

Add the following abbreviations to the abbreviations list in clause 4:

RTC Real-Time Clock

ToD Time-of-Day

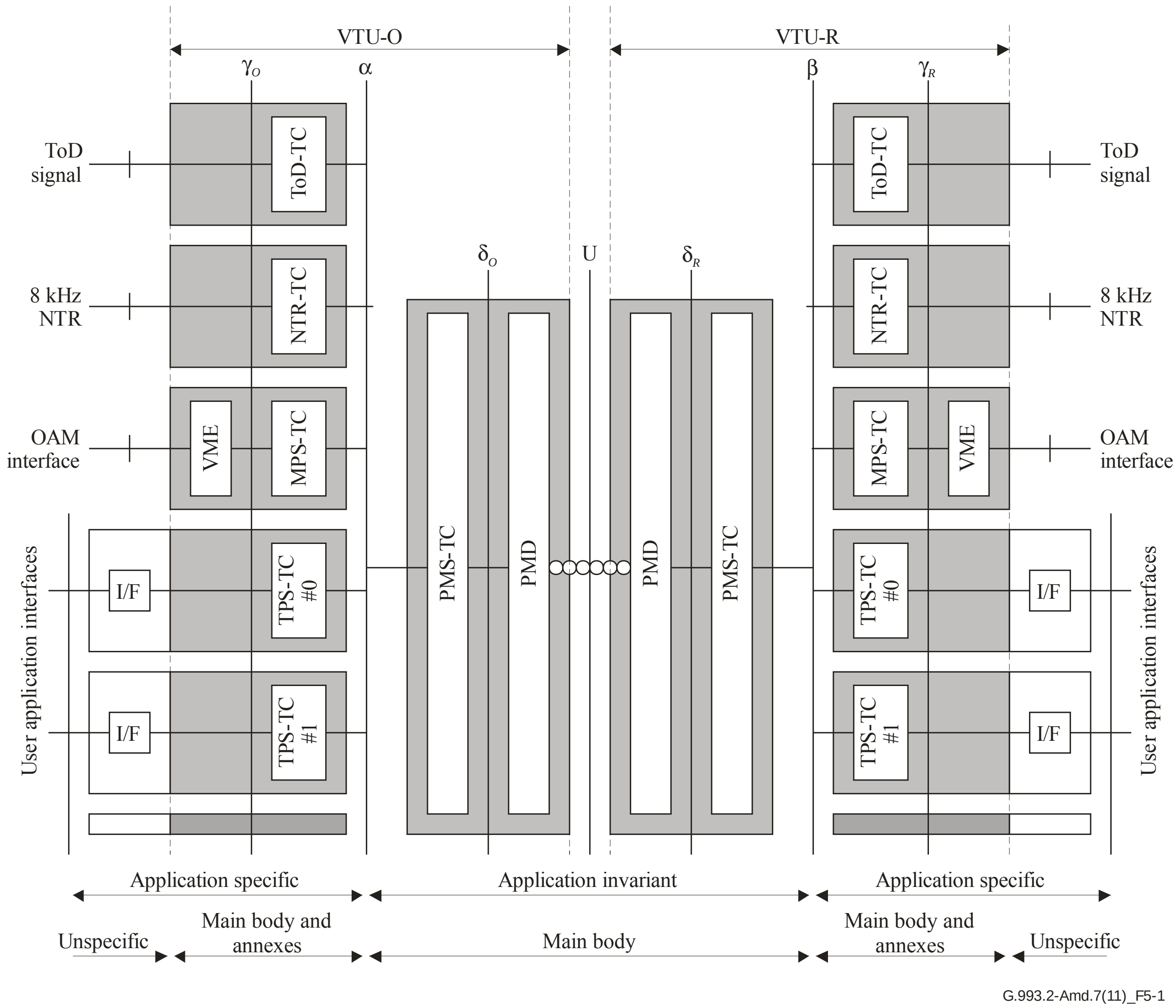
ToD-TC Time-of-Day Transmission Convergence

4 VTU functional model

Revise clause 5.1 as follows:

5.1 VTU functional model

The functional model of VDSL2, which includes functional blocks and interfaces of the VTU-O and VTU-R referenced in this Recommendation, is presented in Figure 5-1. The model illustrates the most basic functionality of VDSL2 and contains both an application-invariant section and an application-specific section. The application-invariant section consists of the physical medium dependent (PMD) sub-layer and physical media specific part of the transmission convergence sub-layer (PMS-TC), which are defined in clauses 10 and 9, respectively. The application-specific parts related to the user plane are defined in 8.1 and Annex K and are confined to the transport protocol specific transmission convergence (TPS-TC) sub-layer and application interfaces. The management protocol specific TC (MPS-TC) is intended for management data transport and is described in 8.2. The VDSL2 management entity (VME) supports management data communication protocols and is described in 11.2. Management plane functions at higher layers are typically controlled by the operator's network management system (NMS) and are not shown in Figure 5-1. The NTR-TC supports transport of the 8 kHz network timing reference (NTR) to the VTU-R and is described in 8.3. The ToD-TC supports distribution of accurate time-of-day to the VTU-R and is described in clause 8.4.


VTU-O
VTU-R
γ_O
α
β
γ_R
ToD signal
ToD-TC
8 kHz NTR
NTR-TC
OAM interface
VME
MPS-TC
User application interfaces
I/F
TPS-TC #0
TPS-TC #1
δ_O
U
δ_R
PMS-TC
PMD
Application specific
Application invariant
Unspecific
Main body and annexes
Main body
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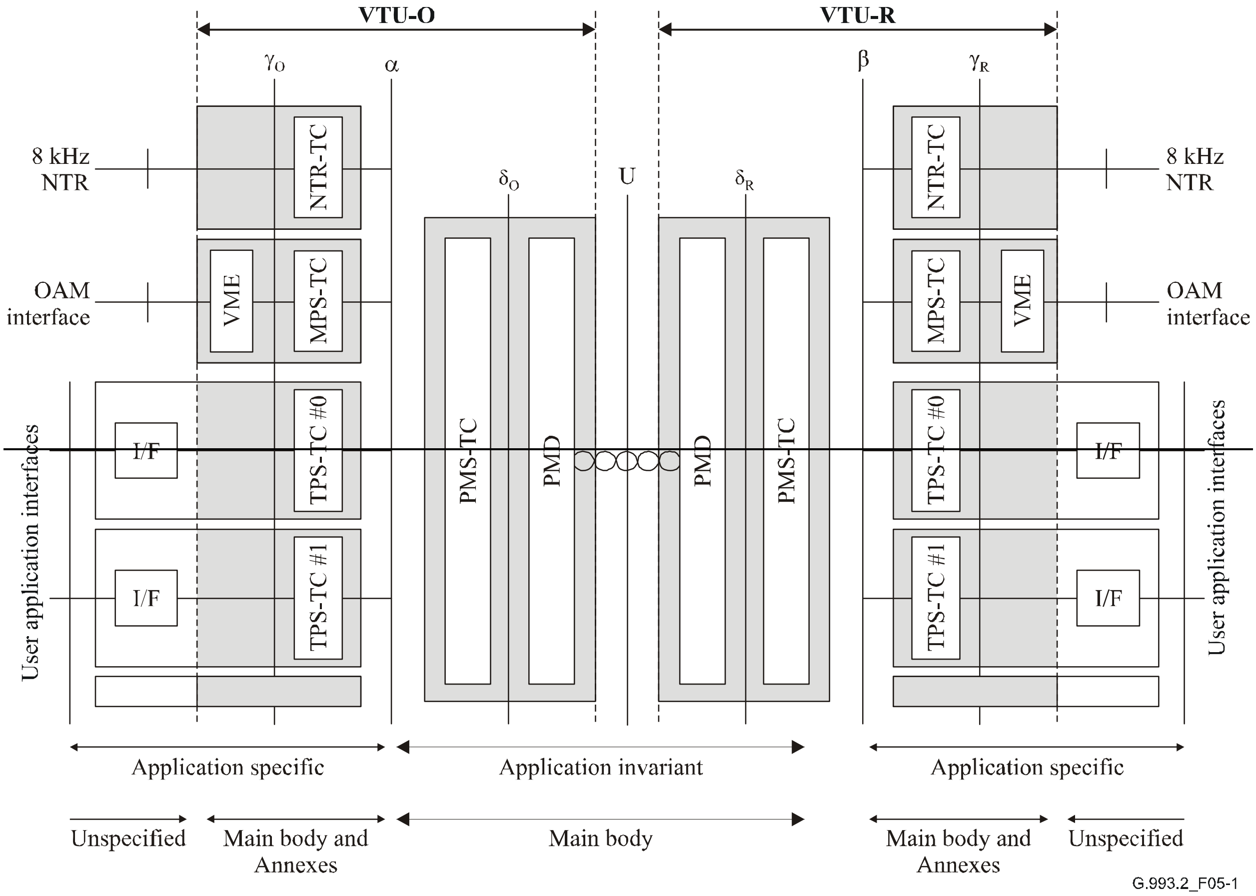


Figure 5-1 – VDSL2 and VTU functional model

The principal functions of the PMD are symbol timing generation and recovery, encoding and decoding, and modulation and demodulation. The PMD may also include echo cancellation and line equalization.

The PMS-TC sub-layer contains framing and frame synchronization functions, as well as forward error correction (FEC), error detection, interleaving and de-interleaving, scrambling and descrambling functions. Additionally, the PMS-TC sub-layer provides an overhead channel that is used to transport management data (control messages generated by the VME).

The PMS-TC is connected to the PMD across the δ interface, and is connected to the TPS-TC across α and β interfaces in the VTU-O and the VTU-R, respectively.

The TPS-TC is application specific and is mainly intended to convert applicable data transport protocols into the unified format required at the α and β interfaces and to provide bit rate adaptation between the user data and the data link established by the VTU. Depending on the specific application, the TPS-TC sub-layer may support one or more channels of user data. The TPS-TC communicates with the user data interface blocks at the VTU-R and VTU-O across the γ_R and γ_O interfaces, respectively. The definition of the data interface blocks is beyond the scope of this Recommendation. The MPS-TC, ~~and~~ NTR-TC and ToD-TC provide TPS-TC functions for management data, ~~and~~ 8 kHz NTR signals, and ToD signal respectively.

The VME function facilitates the management of the VTU. It communicates with higher management layer functions in the management plane as described in ITU-T Rec. G.997.1 [4], e.g., the NMS controlling the CO-MIB. Management information is exchanged between the VME functions of the VTU-O and VTU-R through the overhead channel provided by the PMS-TC.

The MPS-TC converts the incoming management data into the unified format required at the α and β interfaces to be multiplexed into the PMS-TC. The management information contains indications of anomalies and defects, and related performance monitoring counters, and management command/response messages facilitating procedures defined for use by higher layer functions, specifically for testing purposes.

The α, β, γ_R and γ_O interfaces are only intended as logical separations and are defined as a set of functional primitives; they are not expected to be physically accessible. Concerning the user data plane, the γ_R and γ_O interfaces are logically equivalent, respectively, to the T and V interfaces shown in Figure 5-4.

5 Power back-off PSD mask

Revise clause 7.2.1.3.2 as follows:

7.2.1.3.2 Power back-off PSD mask

The VTU-R shall explicitly estimate the electrical length of its loop, kl_0, optionally kl_0 per band (i.e., $kl_0[band]$), and use this value to calculate the UPBO PSD mask, UPBOMASK, at the beginning of initialization. The VTU-R shall then adapt its transmit signal to conform strictly to the mask UPBOMASK(kl_0, f) during initialization and ~~s~~Showtime, while remaining below the PSDMASKus limit determined by the VTU-O as described in 7.2.1.3.1, and within the limit imposed by the upstream PSD ceiling (CDMAXMASKus, MAXMASKus).

Two methods for upstream power back-off method are defined:

- the Reference PSD UPBO method;
- the Equalized FEXT UPBO method (optional).

The VTU-C and VTU-R shall support the reference PSD UPBO method, and may support the equalized FEXT UPBO method. If the equalized FEXT UPBO method is supported, it shall be supported for all upstream bands (except US0). This latter method is controlled via the parameter UPBO reference electrical length kl_{0-REF}, which is specified for each upstream band (see Table 12-21).

7.2.1.3.2.1 Electrical length estimation method

Two methods are defined for deriving the electrical length autonomously:

- ELE-M0 the default method.
- ELE-M1 the alternative method.

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

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

7.2.1.3.2.1.1 The default electrical length estimation method (ELE-M0)

The ELE-M0 method is implementation dependent.

NOTE – A possible estimate of kl_0 is as follows:

$$kl_0 = MIN\left(\frac{loss(f)}{\sqrt{f}}\right) \quad \text{dB}$$

where the minimum is taken over the usable VDSL2 frequency band above 1 MHz. The function *loss*(*f*) is the insertion loss in dB of the loop at frequency *f*. This definition is abstract, implying an infinitely fine grid of frequencies.

7.2.1.3.2.1.2 The alternative electrical length estimation method (ELE-M1)

The ELE-M1 method is applied in the VTU-R to separately estimate the electrical length, in each downstream band, and in the VTU-O to separately estimate the electrical length, in each upstream band, excluding US0:

$$ELE[band] = PERCENTILE\left(\left\{\frac{loss(f, rx\_thresh(band))}{\sqrt{f}} \mid f \in band\right\}, UPBOELMT\right) \quad [dB]$$

Where:

1) *band* ∈ {*aele_bands*}, where {*aele_bands*} is the set of all supported upstream and downstream bands except US0, and $f > 1.8*f_1$ for DS1.

   NOTE 1 – $1.8*f_1$ is used as the lower limit in calculations on the basis that for most cables above this frequency the $\sqrt{f}$ approximation is sufficiently accurate for the purposes of UPBO, and is sufficiently above the US0-DS1 boundary to limit the impact of DS1 high pass filtering. Compared to the use of 1 MHz, this frequency makes it less likely that in-premises bridge taps will have a large effect on the electrical length estimate ELE[DS1].

2) *loss(f,rx_threshold*(*band*)) is the estimated transmission path loss in dB at tone frequency *f* in MHz, which is set to the *special value 307.1 dB* if the minimum received signal plus noise power during loss estimation is less than *rx_threshold* (*dBm/Hz*) for the particular *band*.

   The maximum values for *rx_threshold*(*band*) are: –130 dBm/Hz in the downstream bands, and –115 dBm/Hz in the upstream bands. However, the VTU may use lower threshold *rx_threshold*(*band*) settings. The actual threshold used shall be reported in CO-MIB parameters RXTHRSHDS and RXTHRSUS.

3) The *PERCENTILE* ({*x*},*y*) function returns the maximum value *w* in set {*x*} such that the number of elements in {*x*} with value less than *w* is less than *y* percent of the total number of elements in {x}.

4) UPBO electrical length minimum threshold (UPBOELMT) is a CO-MIB parameter which determines the percentile to be used in finding the qualified minimum of a set of frequency dependent electrical length estimates in a particular VDSL2 band.

   NOTE 2 – The *PERCENTILE* function is used to mitigate the effect of RFI ingress. It provides an estimate of the minimum of a set of per-tone electrical length estimates, ignoring a small proportion of tones affected by high level narrow band RFI ingress.

If ELE-M1 is applied, the same value for kl_0 (*ELEDS*) is applied in all upstream bands except US0, at the beginning of initialization. This is derived from *ELE*[*band*] values estimated in the VTU-R for all downstream bands :

$$ELEDS = MIN(ELE[band]),\ where\ band \in \{ds\_bands\},$$
$$and$$
$$kl_0[us\_band] = ELEDS\ \ for\ all\ us\_band \in \{upbo\_bands\}$$

Where {*ds_bands*} is the set of all supported downstream bands with $f > 1.8*f_1$ for DS1, and *us_band* ∈ {*upbo_bands*} the set of all supported upstream bands except US0.

The intermediate value ELEDS is sent to the VTU-O as "Estimate of electrical length" in R-MSG 1, as defined in 12.3.3.2.2.1.

An intermediate value ELEUS is determined in the VTU-O as follows:

$$ELEUS = MIN(ELE[band]),\ where\ band \in \{upbo\_bands\}$$

The final electrical length is determined during initialization and sent from the VTU-O to the VTU-R during initialization in the O-UPDATE message (see clause 12.3.3.2.1.2). Separate values are provided for each upstream band, excluding US0. The values are selected according to the CO-MIB parameter AELE-MODE:

For all upstream bands except US0, $band \in$ {upbo_bands}

AELE-MODE = 0 kl_0[band] = ELE-M0 VTU-O kl_0 estimate

AELE-MODE = 1 kl_0[band] = ELEDS [dB], $band \in \{upbo\_bands\}$

AELE-MODE = 2 kl_0[band] = ELE[band] [dB], $band \in \{upbo\_bands\}$

AELE-MODE = 3 kl_0[band] = MIN(ELEUS, ELEDS) [dB], $band \in \{upbo\_bands\}$

If the CO-MIB parameter UPBOKLF (*Force CO-MIB electrical length*) is set to 1 then the final electrical length is set defined by the CO-MIB parameter UPBOKL (*Upstream electrical length*), and applied as follows:

$kl_0[band] = UPBOKL,\ band \in \{upbo\_bands\}$

If ELE-M1 is supported the following parameters shall be reported by the transceivers, whether or not *UPBOKLF* is set:

ELE[*band*], band$\in$ {*ds_bands*} shall be reported by the VTU-R to the VTU-O in the R-MSG 1 message (see clause 12.3.3.2.2.1).

ELE[*band*], $band \in \{aele\_bands\}$ shall be reported by the VTU-O via the CO-MIB, where $\{aele\_bands\}=\{ds\_bands\}\ U\{upbo\_bands\}$.

7.2.1.3.2.2 UPBO mask

If the optional equalized FEXT UPBO method is not supported, or if the optional equalized FEXT UPBO method is supported but $kl_{0-REF} = 0$ for a given upstream band, the UPBOMASK for that given band is calculated as:

$$\text{UPBOMASK}(kl_0, f) = \text{UPBOPSD}(f) + \text{LOSS}(kl_0,f) + 3.5 \text{ [dBm/Hz]},$$

where:

$$\text{LOSS}(kl_0,f) = kl_0\sqrt{f} \text{ [dB], and}$$

$$\text{UPBOPSD}(f) = -a - b\sqrt{f} \text{ [dB]/Hz]}$$

with f expressed in MHz.

In case ELE-M0 is used, kl_0 is defined as a single value.

In case ELE-M1 is used, kl_0 is defined separately for each band in {*upbo_bands*}, i.e., $kl_0[band]$.

UPBOPSD(f) is a function of frequency but is independent of length and type of loop.

If the optional equalized FEXT UPBO method is supported, and $kl_{0-REF} \neq 0$ for a given upstream band, the UPBOMASK for that given band is calculated as:

- for ($1.8 \le kl_0 < kl_{0\_REF}$):

$$UPBOMASK(f) = -a - b\sqrt{f} + 10\log_{10}\left(\frac{kl_{0\_REF}}{kl_0}\right) + LOSS(kl_0, f) + 3.5 \qquad \text{[dBm/Hz]}$$

- for ($kl_0 < 1.8$):

$$UPBOMASK(f) = -a - b\sqrt{f} + 10\log_{10}\left(\frac{kl_{0\_REF}}{1.8}\right) + LOSS(1.8, f) + 3.5 \qquad \text{[dBm/Hz]}$$

- for ($kl_0 \ge kl_{0\_REF}$):

$$UPBOMASK(f) = -a - b\sqrt{f} + LOSS(kl_0, f) + 3.5 \qquad \text{[dBm/Hz]}$$

where:

$$LOSS(kl_0, f) = kl_0\sqrt{f} \qquad \text{[dB]}$$

with *f* expressed in MHz.

For both methods of UPBO, the values of *a* and *b*, which may differ for each upstream band, are obtained from the CO-MIB as specified in ITU-T Rec. G.997.1 [4] and shall be provided to the VTU-R during initialization (see 12.3.3.2.1.1). Specific values may depend on the geographic region (Annex A.2.3, Annex B.2.6, and Annex C.2.1.4).

For the optional equalized FEXT UPBO method, the value kl_{0-REF} is obtained from the CO-MIB as specified in ITU-T Rec. G.997.1 [4] and shall be provided to the VTU-R during initialization (see 12.3.3.2.1.1).

If the estimated value of kl_0 is smaller than 1.8, the ~~modem~~VTU shall be allowed to perform power back-off as if kl_0 were equal to 1.8. The estimate of the electrical length should be sufficiently accurate to avoid spectrum management problems and additional performance loss.

~~NOTE 1 – A possible estimate of kl_0 is min[*loss*(*f*)/ $\sqrt{f}$]. The minimum is taken over the usable VDSL2 frequency band above 1 MHz. The function *loss* is the insertion loss in dB of the loop at frequency *f*. This definition is abstract, implying an infinitely fine grid of frequencies.~~

NOTE ~~2~~1 – To meet network specific requirements, network management may provide a means to override the VTU-R's autonomous estimate of kl_0 (see 12.3.3.2.1.2, O-UPDATE).

NOTE ~~3~~2 – The nature of coupling between loops in a cable binder results in a rapidly decreasing FEXT as the loop length decreases. As the electrical length kl_0 of the loop decreases below 1.8, no further increase in power back-off is needed. An electrical length of 1.8 corresponds to, for example, a 0.4 mm loop about 70 m long.

6 Transport protocol specific transmission convergence (TPS-TC) function

Revise clause 8 as follows:

8 Transport protocol specific transmission convergence (TPS-TC) function

The TPS-TC sub-layer resides between the γ reference point and the α/β reference point as presented in the VDSL2 and VTU functional model in Figure 5-1. This functional model defines the TPS-TC sub-layer as containing one or more TPS-TCs providing transport of user data utilizing different transport protocols, a management TPS-TC (MPS-TC) providing eoc transport over the VDSL2 link, ~~and~~ an NTR-TC providing transport of the network timing reference, and a ToD-TC providing transport of the time-of-day.

Functionality, parameters, and application interface (γ interface) characteristics of the user data TPS-TC are specified in 8.1. Functionality, parameters, and application interface (γ interface) characteristics of the MPS-TC are specified in 8.2. Functionality, parameters, and application interface (γ interface) characteristics of the NTR-TC are specified in 8.3. Functionality, parameters, and application interface (γ interface) characteristics of the ToD-TC are specified in 8.4.

The mandatory TPS-TC sub-layer configuration shall include the MPS-TC, the NTR-TC, and at least one user data TPS-TC. Support of a second user data TPS-TC or the ToD-TC is optional. Each TPS-TC operates over a separate bearer channel, where the PMS-TC may allocate these bearer channels to a single or to separate latency paths.

7 Transmitter

Revise clause 8.2.4.1 as follows:

8.2.4.1 Transmitter

The transmitter shall encapsulate eoc messages prior to transmission using the HDLC frame structure described in 8.2.3. The frame check sequence (FCS), the octet transparency mechanism, and HDLC inter-frame time filling shall be as described in ITU-T Rec. G.997.1 [4]. Opening and closing flags of two adjacent HDLC frames may be shared: the closing flag of one frame can serve as an opening flag for the subsequent frame.

If a *Tx_Stop* signal is set, the transmitter shall stop the transmission of the current message using the abort sequence described in ITU-T Rec. G.997.1 [4] (i.e., by a control escape octet followed by a flag), and get ready to receive a new message from the VME to be transmitted. If the transmission of the message is already completed when a *Tx_Stop* signal is set, the MPS-TC shall ignore it.

The transmitter shall set the two LSBs of the Address field in accordance with the priority level of the command sent, indicated by the *Tx_PrF* signal, as follows:

00 – High priority;

01 – Normal priority;

10 – Low priority;

11 – ~~Reserved~~Near High priority.

All other bits of the Address field shall be set to ZERO.

The transmitter shall set the second LSB of the Control field with a command code (0) or a response code (1), in accordance with the signal *Tx_RF*. All other bits of the Control field shall be set to ZERO.

Upon the completion of the transmission of the HDLC frame, the transmitter shall set the *Sent* signal, indicating to the VME the start of the time-out timer (see Table 11-1).

8 Time-of-day TPS-TC

Add new clause 8.4 as follows:

8.4 Time-of-day TPS-TC (ToD-TC)

Transport of time-of-day (ToD) from the VTU-O to the VTU-R should be supported in order to support services that require accurate ToD at both sides of the VDSL2 line to operate the higher layers of the protocol stack. The VTU-O shall indicate ToD transport during initialization (see 12.3.5.2.1.1).

NOTE 1 – Exchange of network time management information from VTU-R to VTU-O related to the quality of the ToD frequency and/or time recovery at the VTU-R is for further study.

NOTE 2 – Exchange of relevant clock information from AN to CPE to support the ToD interface output from CPE is for further study. For PTP, this information includes source traceability, number of hops, and leap seconds.

NOTE 3 – The γ-O to γ-R ToD accuracy requirements are for further study, but expected to be in the order of 100/200 nsec.

8.4.1 Time-of-day distribution operational overview

Figure 8-1 shows the system reference model identifying the key elements in support of time-of-day transport across a VDSL2 link. The VTU-O receives a time-of-day signal from the master clock across the γ-O interface and the VTU-R outputs a time-of-day signal across the γ-R interface to slave clock external to the VTU-R that is synchronous in frequency, phase and time to the master clock. A master clock source external to the VTU-O provides a time-of-day signal to the VTU-O across the γ-interface. The details of the time-of-day signal are for further study; however, the components include a time-of-day value (*ToD_mc_value*) to a corresponding clock edge (*ToD_mc_edge*) that is synchronous to the master clock's internal driving frequency. The ToD_mc_edge shall provide at least one edge per second. A component of the driving frequency (f_{mc}) shall be available to the VTU-O and shall be at least 8 kHz and shall be frequency and phase synchronized with the ToD_mc_edge to facilitate time-of-day transport processing in the VTU-O. Similarly, the time-of-day signal at the VTU-R is assumed to include a time-of-day value (*ToD_sc_value*) together with corresponding time edge marker (*ToD_sc_edge*) that is synchronous to the driving frequency of the master clock. A component of the driving frequency (f_{sc}) may be available from the VTU-R to facilitate time-of-day transport processing.

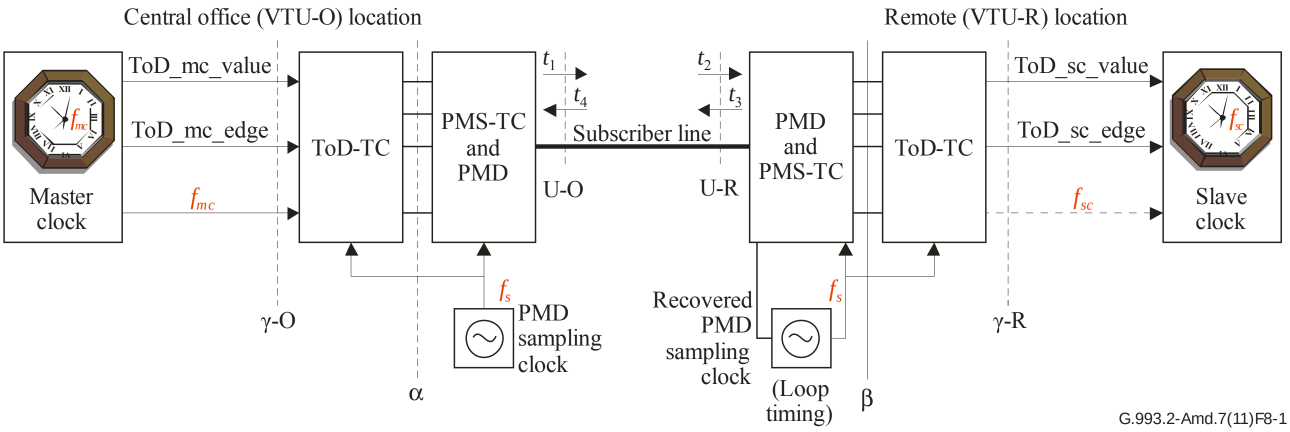


Figure 8-1 – End-to-end system reference model for time-of-day transport in VDSL2

The VDSL2 PMD operates with a sampling clock for transmission of the DMT symbols on the subscriber line. The VTU-R's PMD sampling clock and the VTU-O's PMD sampling clock are assumed to be frequency locked, typically through loop timing in the VTU-R. For both the upstream and downstream transmit signals, the reference sample is defined as the first time-domain representation sample (see Figure 8-2 and Figure 8-3) of the first symbol in a superframe period (64.25 ms on the PMD sampling clock timebase if the CE length corresponds to $m = 5$, see clause 10.4.4).

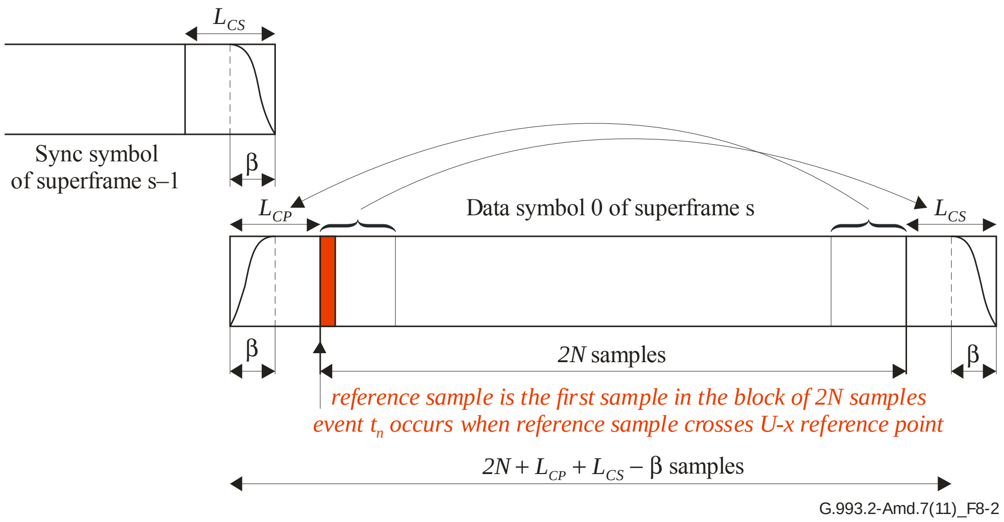
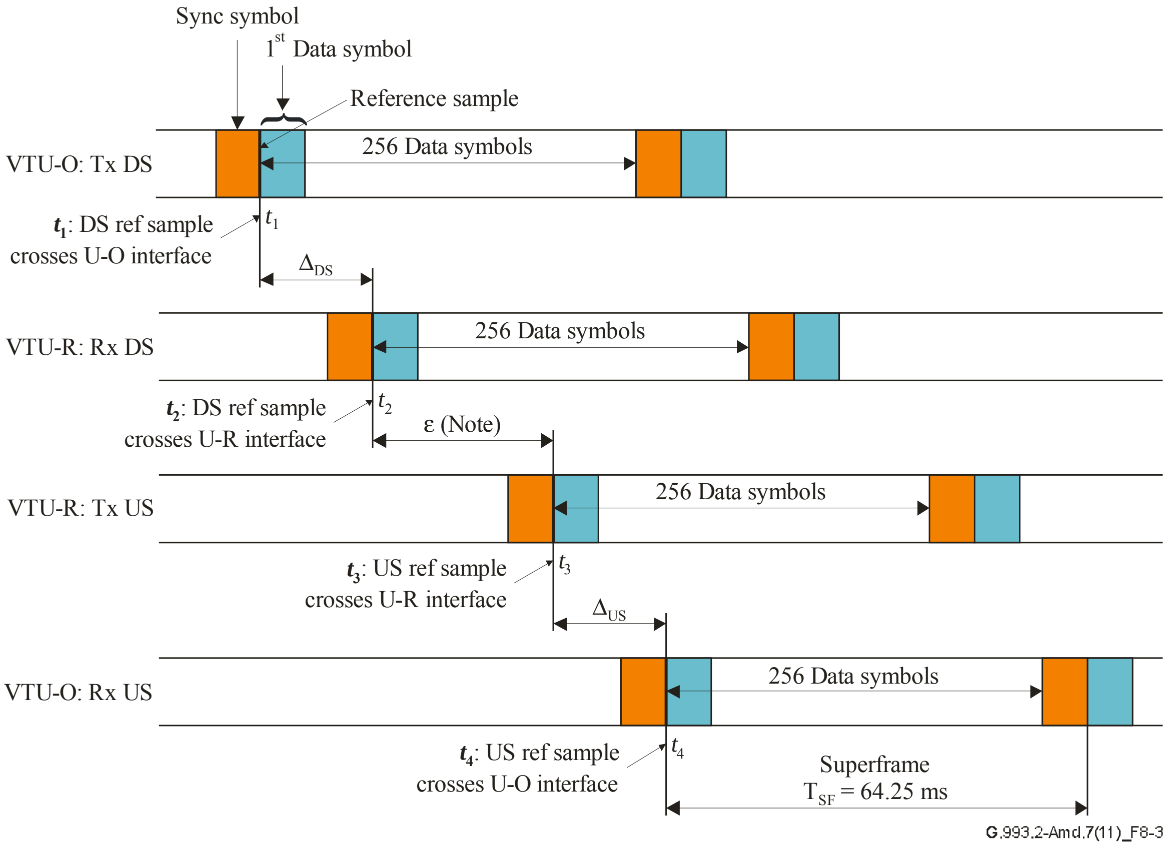


Figure 8-2 – Cyclic extension, windowing and overlap of DMT symbols

The VDSL2 PMD in the VTU-O identifies the moment the downstream reference sample crosses the U-O interface (event t_1) and the moment (within one superframe from event t_1) the upstream reference sample crosses the U-O interface (event t_4); at the instant each event occurs, the ToD-TC (time-of-day – transmission convergence) in the VTU-O records the corresponding time values of its local real-time clock (RTC-O) to apply a time stamp to each of the respective events t_1 and t_4. For each event t_1, the VTU-O sends the ToD phase difference (i.e., the corresponding t_1 time stamp MOD 125000 ns, represented in units of 2 ns) and the t_1 event number (i.e., representing the superframe counter value at the t_1 event) to the VTU-R. The VTU-R processes the ToD phase difference values to recover the ToD frequency. At a much slower rate, the VTU-O also sends the t_1 and t_4 time stamps together with a t_1 and t_4 event number to VTU-R for time/phase synchronization of the real time clocks. Similarly, the VDSL2 PMD in the VTU-R identifies the moment the downstream reference sample crosses the U-R interface (event t_2) and the upstream reference sample crosses the U-R interface (event t_3); at the instant each event occurs, the ToD-TC in the VTU-R records the corresponding time of the local slave clock to apply a time stamp to each of the respective events t_2 and t_3. The ToD-TC in the VTU-R processes the time stamp values of events t_1, t_2, t_3, and t_4 so as to synchronize in phase and time its local real-time clock (RTC-R) to the VTU-O's real-time clock (RTC-O).

NOTE 1 – The time period between consecutive reference samples is fixed and equal to the number of samples in a superframe. This time period is therefore locked to theVTU's PMD sampling clock. With this relation, the time stamp values are recorded at regularly repeating intervals.

NOTE 2 – The VTU-R sends the values of events t_2 and t_3 to the VTU-O in response to a VTU-O command sending the corresponding t_1 and t_4 event values for phase/time synchronization.



NOTE – ε may be a positive or a negative time.

Figure 8-3 – Reference samples and corresponding time stamp events t_1, t_2, t_3, and t_4

The ToD-TC in the VTU-O and that in the VTU-R implement functionality with the objective of synchronizing the RTC-R to the RTC-O in frequency, phase and time. Two methods are defined to achieve this objective:

– Frequency synchronization through locking the PMD sampling clock with the ToD frequency (f_{mc}): the VTU-R achieves frequency synchronization through loop timing and performs phase/time synchronization through the processing of time stamps at reference samples, or

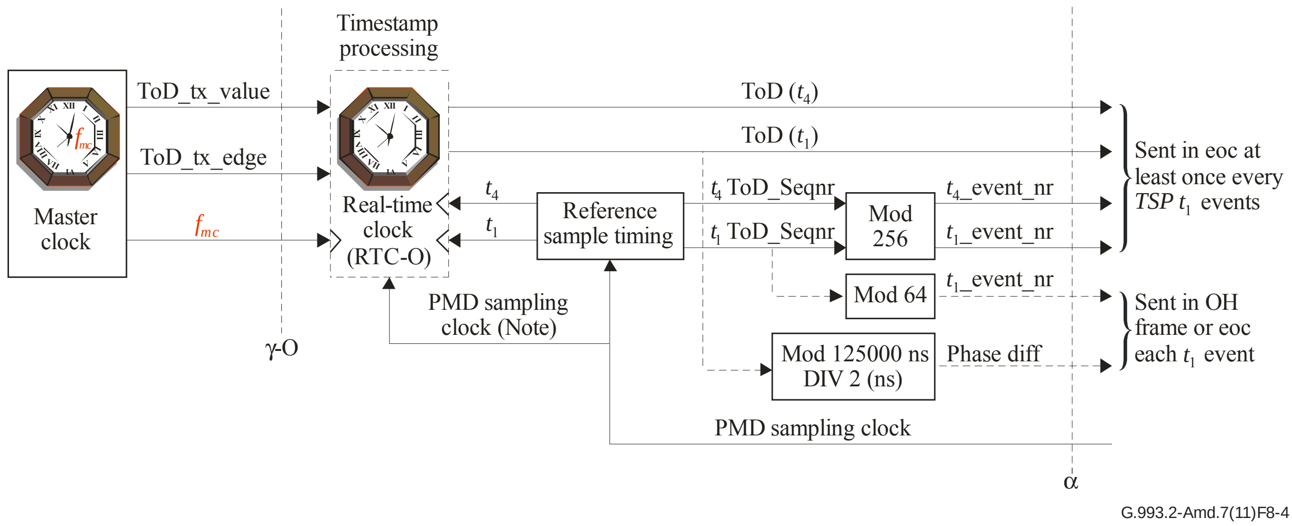
– Frequency synchronization using ToD phase difference values: the VTU-R achieves frequency synchronization through processing of ToD phase difference values (i.e., phase of t_1 event relative to ToD) and performs phase/time synchronization through the processing of time stamps (of events t_1, t_2, t_3, and t_4) at the reference samples.

The frequency synchronization method adopted in the VTU-O is communicated to the VTU-R during initialization (see clause 12.3.5.2.1.2). For each of the above cases, the corresponding functional processing is described.

The block diagram in Figure 8-4 shows a functional model of the required processing in the VTU-O ToD-TC. The ToD-TC receives the time-of-day signals from the master clock and assigns time stamps to reference samples per the real-time clock (RTC-O), that is synchronous to the external master clock time base.

In the VTU-O, the ToD-TC implements a real-time clock (RTC-O) that is synchronized to the external master clock for the purpose of applying time stamps to the reference samples. The VDSL2 PMD identifies the moment that the reference samples cross the U-O interface; the reference sample timing block generates pulses t_1 and t_4, for reading the value of the RTC-O clock in recording of the respective time stamps for the downstream and upstream reference samples. The time stamp values, ToD(t_1) and ToD(t_4) together with the reference sample identification (event number) are sent to the VTU-R via the eoc.

In the VTU-R, frequency synchronization of the RTC-R clock to the RTC-O clock in the VTU-O may be performed using any of the two methods mentioned above; the frequency synchronization method is selected by the VTU-O during initialization (see clause 12.3.5.2.1.2). Shown in Figure 8-4 is the method of computing phase difference values for frequency synchronization of the real-time clock in the VTU-R (RTC-R) with the RTC-O. Phase difference values may be transported to the VTU-R via dedicated bytes in the OH Frame (see clause 9.5.2.2.1) or via the eoc (see clause 11.3.2.14); the transport method is selected by the VTU-R during initialization (see clause 12.3.5.2.2.1). The time stamp values for ToD phase synchronization (i.e., ToD(t_1) and ToD(t_4)) are transported to the VTU-R by dedicated eoc commands (see clause 11.2.3.15).



NOTE – Use of the PMD sampling clock for implementation of the RTC-O is vendor discretionary.

Figure 8-4 – Functional reference model for ToD-TC in the VTU-O

During initialization, the VTU-O indicates to the VTU-R the configured ToD frequency synchronization method, namely via locking of the VDSL PMD sampling clock to the ToD frequency or via transport of phase difference values. If the VTU-O selects the locking of the PMD sampling clock to the ToD frequency, then the VTU-R achieves ToD frequency synchronization through normal loop timing recovery. If the VTU-O selects the mechanism of passing phase difference values to the VTU-R for ToD frequency synchronization, then the VTU-R selects the mechanism for which the VTU-O is to communicate the phase difference values: i.e., via dedicated fixed octets in the OH frame, or via phase difference messages communicated in the eoc. In either case, time synchronization is provided through processing of the time synchronization messages communicated to the VTU-R by the VTU-O.

In the VTU-R the ToD-TC processes the time stamp values placed on the downstream (event t_2) and upstream (event t_3) reference samples together with those values received from the VTU-O for events t_1 and t_4 to achieve phase/time synchronization of the RTC-R to the RTC-O. The ToD-TC then outputs a time of day value (ToD_sc_value) together with a corresponding timing edge marker (ToD_sc_edge) that is synchronous to the driving master clock frequency. The ToD_sc_value and ToD_sc_edge signals (and possibly a slave clock frequency f_{sc}) are transported across the γ-R interface to a device external to the VTU-R. The time stamp values placed on the downstream (event t_2) and upstream (event t_3) reference samples are sent back to the VTU-O (see clause 11.2.3.15). The VTU-O passes information related to these time stamps over the γ-O reference point. The nature and use of this information is for further study.

The time-of-day (phase) synchronization of the RTC-R to the RTC-O, is done in the ToD-TC in the VTU-R. The time stamp processing block reads the value of the local RTC-R as the downstream reference sample crosses the U-R reference point (event t_2) and upstream reference sample crosses the U-R reference point (event t_3), and assigns corresponding time stamp values ToD(t_2) and ToD(t_3). The computation of the offset value (τ) is computed from the reported time stamps using the following equation:

$$\tau = \frac{(ToD(t_2) - ToD(t_1)) - (ToD(t_4) - ToD(t_3))}{2}$$

NOTE 3 – The above computation of the offset value is based on the assumption that the downstream and upstream propagation delays between the U-C and U-R reference points are approximately identical. Any asymmetry in the propagation delay between the U-C and U-R reference points will result in an error in calculation of the offset value whose magnitude is approximately:

$$|error| = \left| \frac{(upstream\_propagation\_delay) - (downstream\_propagation\_delay)}{2} \right|$$

8.4.2 Interfaces

The $\gamma_{m\text{-}O}$ and $\gamma_{m\text{-}R}$ reference points define interfaces between the ToD source and the ToD-TC at the VTU-O and between the ToD-TC and the ToD receiver at the VTU-R, respectively, as shown in Figure 5-1. Both interfaces are functionally identical, and are defined in Table 8-6.

Table 8-6 – ToD-TC: γ interface signal summary

Flow	Signal	Description	Direction
Transmit signals (VTU-O)			
ToD	*Tx_ToD*	Transmit time-of-day signal	ToD source → ToD-TC
Receive signals (VTU-R)			
ToD	*Rx_ToD*	Receive time-of-day signal	ToD receiver ← ToD-TC

The α and β reference points define interfaces between the ToD-TC and PMS-TC at the VTU-O and VTU-R, respectively. Both interfaces are functional, and shall comply with the definition in clause 8.1.2 with the additional condition that ToD data is transmitted only in the direction from the VTU-O to the VTU-R. The parameters of ToD-TC are not subject to on-line reconfiguration.

8.4.3 Functionality

8.4.3.1 Frequency synchronization by locking PMD sampling clock with ToD frequency

This clause defines a mechanism for frequency synchronization of the real-time clock in the VTU-R (RTC-R) with the real-time clock in the VTU-O (RTC-O) by locking the PMD sampling clock with the ToD frequency (f_{mc}). The VTU-R shall achieve frequency synchronization between RTC-R and RTC-O through loop timing.

8.4.3.2 Frequency synchronization using ToD phase difference values

This clause defines a mechanism for frequency synchronization of the real-time clock in the VTU-R (RTC-R) with the real-time clock in VTU-O (RTC-O) by processing of the ToD phase difference values between the local superframe clock (i.e., event t_1) and the ToD (i.e., RTC-O) clock.

The real-time clock represents the time of day value with a 6-octet seconds field followed by a 4-octet nanosecond field, where the nanosecond field resets to zero every 10^9 ns and the seconds field increments by one.

Figure 8-5 demonstrates the computation of the ToD phase difference value (Δϕ). The top row in the figure represents the counting of the nanoseconds in the RTC-O. The ToD nanoseconds counter counts the nanoseconds of the RTC-O modulo 125 µs (shown by the 8 kHz waveform in the middle row of the figure). The third row in the figure represents the superframe (SF) counter of the local clock that is synchronous with the VTU's PMD sampling clock; the rising edge of the SF local clock represents the moment that the downstream reference sample crosses the U-O reference point (i.e., the t_1 event). At the moment the downstream reference sample crosses the U-O reference point, the value of the ToD ns_counter modulo 125 µs is recorded as the 'ToD Phase Difference Value' to be communicated to the VTU-R.

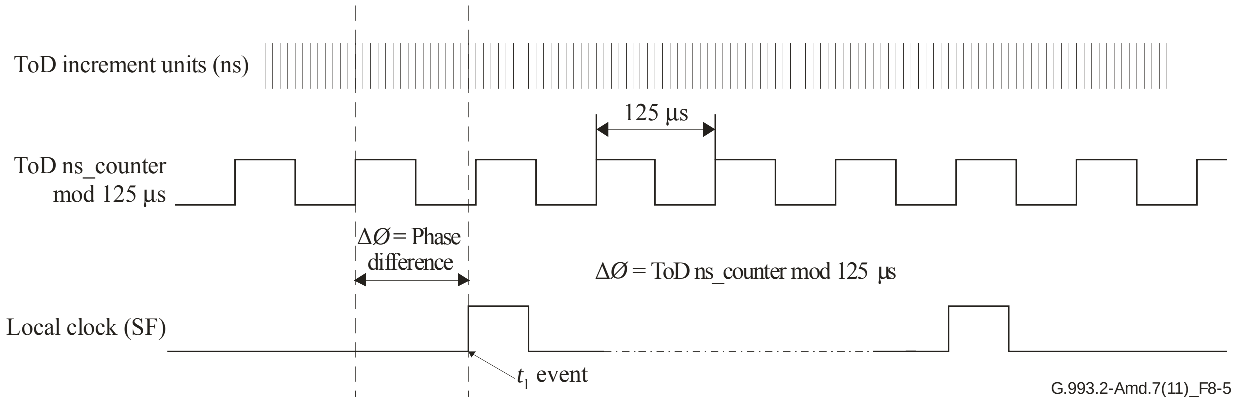


Figure 8-5 – ToD phase difference (Δϕ) computation

The ToD phase difference value (Δϕ) is calculated each t_1 event. The ToD phase difference value shall be represented by a 16-bit value, calculated as the ns_counter value of the RTC-O mod 125000 ns divided by 2, where the resolution of the least significant bit is 2 ns. Each t_1 event shall be counted modulo 64 (i.e., represented by a 6-bit value). The phase difference value (16 bits) and corresponding t_1 event value (6 bits) shall be communicated to the VTU-R either via the OH frame (see clause 9.5.2.2.1) or via the eoc (see clause 11.2.3.14). During initialization (see clause 12.3.5.2.2.1), the VTU-R shall select the use of either the OH frame or *eoc* for communication of ToD phase difference value and corresponding t_1 event value.

8.4.3.3 Time synchronization of real-time clocks

Time-of-day (ToD) transport is facilitated by the ToD-TC. The VTU-O shall maintain a real-time clock RTC-O which is synchronized with the ToD signal. The VTU-R shall also maintain a real-time clock RTC-R with an arbitrary initial time. The RTC-O shall run in a frequency which is an integer multiple of 8 kHz and is at least the PMD sampling frequency, with time adjustment to the master clock at each f_{mc} edge (see Figure 8-1). At the VTU-O, the ToD-TC receives the ToD signal to synchronize RTC-O, generates time stamps using RTC-O, and transports these time stamps to the VTU-R with eoc messages. At the VTU-R, the ToD-TC generates time stamps using RTC-R, extracts the time stamps contained in the eoc messages sent from the VTU-O, estimates the time offset between RTC-O and RTC-R using the time stamps, adjusts RTC-R using the estimated time offset, and controls the output ToD signal.

The time synchronization procedure is defined as follows. A downstream (or upstream) reference sample is defined as the first time-domain sample of specific symbols in the downstream (or upstream) direction during showtime.

1) At the VTU-O, a time stamp is taken by the ToD-TC when the downstream reference sample, being transmitted to the VTU-R, arrives at the U-C reference point (event t_1). The time-of-day corresponding to event t_1 is denoted by ToD(t_1).
2) At the VTU-R, a time stamp is taken by the ToD-TC when the same downstream reference sample arrives at the U-R reference point (event t_2). The time-of-day corresponding to event t_2 is denoted by ToD(t_2).
3) At the VTU-R, a time stamp is taken by the ToD-TC when the upstream reference sample, being transmitted to the VTU-O, arrives at the U-R reference point (event t_3). The time-of-day corresponding to event t_3 is denoted by ToD(t_3).
4) At the VTU-O, a time stamp is taken by the ToD-TC when the same upstream reference sample arrives at the U-O reference point (event t_4). The time-of-day corresponding to event t_4 is denoted by ToD(t_4).
5) The time stamp values ToD(t_1) and ToD(t_4) are transmitted from the VTU-O to the VTU-R with eoc messages, the time stamp values ToD(t_2) and ToD(t_3) are transmitted from the VTU-R to the VTU-O with eoc messages (see clause 11.2.3.15).

The VTU-O shall maintain a counter of the transmitted downstream superframes since the VTU-O entered showtime. Each time the first symbol in a downstream superframe (i.e., the symbol modulating downstream data frame 0 per Figure 10-2) is sent, the value of the downstream superframe counter shall be increased by 1. The downstream reference sample shall be the first time-domain representation sample of the first symbol in a downstream superframe period (i.e., the first sample after the cyclic prefix of the symbol modulating data frame 0 as defined in Figure 10-14 and Figure 10-2. The index of the downstream reference sample shall be the index of the downstream superframe it belongs to. The index of the first downstream reference sample (i.e., first t_1 event index) sent in showtime shall be 0.

The VTU-O shall maintain a counter of the received upstream superframes since the VTU-R entered showtime. Each time the first symbol in an upstream superframe (i.e, the symbol modulating upstream data frame 0 per Figure 10-2) is sent, the value of the upstream superframe counter shall be increased by 1. The upstream reference sample shall be the first time-domain sample of the first symbol in an upstream superframe. The index of the upstream reference sample shall be the index of the upstream superframe it belongs to. The index of the first upstream reference sample (i.e., first t_4 event index) sent in showtime shall be 0.

The VTU-O initiates a time synchronization procedure. The increment of the t_1 event index between any two consecutive time synchronization procedures shall not exceed the value of the parameter time synchronization period (*TSP*), which is indicated by the VTU-R during initialization (see 12.3.5.2.1.5). The t_1 event index shall be a multiple of 16 superframes.

After receiving both time stamp values ToD(t_1) and ToD(t_4), the VTU-R shall compute the time offset *Offset* between the real-time clocks RTC-O and RTC-R as:

$Offset = (\mathrm{ToD}(t_2) + \mathrm{ToD}(t_3) - \mathrm{ToD}(t_1) - \mathrm{ToD}(t_4)) / 2$

The RTC-R shall be adjusted with this estimated time offset *Offset* so that it is time synchronized with the RTC-O (i.e., the value of *Offset* for the next time synchronization procedure is expected to be 0).

NOTE – Instead of taking the time stamp ToD(t_1) for event t_1 (i.e., when the reference sample arrives at the U-O reference point), it is easier to implement by taking a time stamp – when the same reference sample arrives at the output of the IDFT of the VTU-O (event t_1'). This time stamp is denoted by $\text{ToD}(t_1')$. The time stamp ToD(t_1) for event t_1 is obtained by adjusting the time stamp ToD(t_1') for event t_1' with an estimate of $\Delta t_1 = ToD(t_1) - ToD(t_1')$. The method of adjustment is vender discretionary. Instead of taking the time stamp ToD(t_2) for event t_2 (i.e., when the reference sample arrives at the U-R reference point), it is easier to implement by taking a time stamp when the same reference sample arrives at the input of the DFT of the VTU-R (event t_2'). This time stamp is denoted by ToD(t_2'). The time stamp ToD(t_2) for event t_2 is obtained by adjusting the time stamp ToD(t_2') for event t_2' with an estimate of $\Delta t_2 = ToD(t_2') - ToD(t_2)$. The method of adjustment is vender discretionary. The time stamps t_3 and t_4 can be obtained in the same way.

9 Communication of ToD frequency synchronization data via OH frame type 1

Add new clause 9.5.2.2.1 at the end of clause 9.5.2.2 as follows:

9.5.2.2.1 Communication of ToD frequency synchronization data via OH frame type 1

Table 9-5.1 shows the modified OH frame type 1 structure for passing the ToD frequency synchronization data (i.e., ToD phase difference and corresponding t_1 event number) from the VTU-O to the VTU-R. Octet number 7, the ToD_FSync octet, is inserted after the NTR octet prior to the MSG field. The ToD frequency synchronization data is sent in a ToD_FSync frame that contains three octets: one octet contains the 6 bits of the t_1 event number, and two octets identifying the 16-bit ToD phase difference value. One octet of the ToD_FSync frame is transmitted in each OH frame, so the ToD_FSync frame spans three OH frame periods (PER_p). Table 9-5.2 defines the frame format structure of the ToD_FSync frame. Special values for the syncbyte are used to identify the beginning of the ToD_FSync frame.

The VTU-O shall insert the ToD frequency synchronization data in the OH frame once per superframe for each t_1 event. The value of $PER_p \leq 20$ ms. Therefore the ToD_FSync frame spans less than a superframe period, and occasionally a ToD phase difference and corresponding t_1 event number may need to be transmitted twice.

The ToD frequency synchronization data should be sent in the first available OH frame immediately following the t_1 event.

The value of the capacity of the MSG channel is reduced by one octet, so the message overhead data rate for the updated OH frame Type 1 is $msg_p = OR_p \times (SEQ_p - 7) / SEQ_p$ and the upper lower msg_p rates are scaled accordingly (see the msg_p entry in Table 9-6). The above frame structure shall be used if and only if during initialization the time synchronization is enabled and the OH frame is selected for the transport of the ToD phase difference values.

Table 9-5.1 – Modified OH frame type 1 with ToD frequency synchronization frame extension

OH frame type 1		
Octet number	**OH field**	**Description**
1	CRC_p	Cyclic redundancy check (9.5.2.3)
2	Syncbyte	Values for the Syncbyte are defined in Figure 9-4.1
3	IB-1	PMD-related primitives (Note 1, Table 9-5)

Table 9-5.1 – Modified OH frame type 1 with ToD frequency synchronization frame extension

OH frame type 1		
Octet number	**OH field**	**Description**
4	IB-2	PMS-TC-related primitives (Note 1, Table 9-5)
5	IB-3	TPS-TC-related and system-related primitives (Note 1, Table 9-5)
6	NTR	Network timing reference (Note 2, clause 8.3)
7	ToD_FSync	One byte of ToD FSync frame (See Table 9-5.2)
> 7	MSG	Message overhead (Note 3, clause 11.2)

Table 9-5.2 – ToD_FSync frame structure

Octet number	OH field	Description
1	[0 0 c_5 c_4 c_3 c_2 c_1 c_0]	t_1 event number
2	[b_7 … b_2 b_1 b_0]	Lower byte of the ToD phase difference value
3	[b_{15} … b_{10} b_9 b_8]	Higher byte of the ToD phase difference

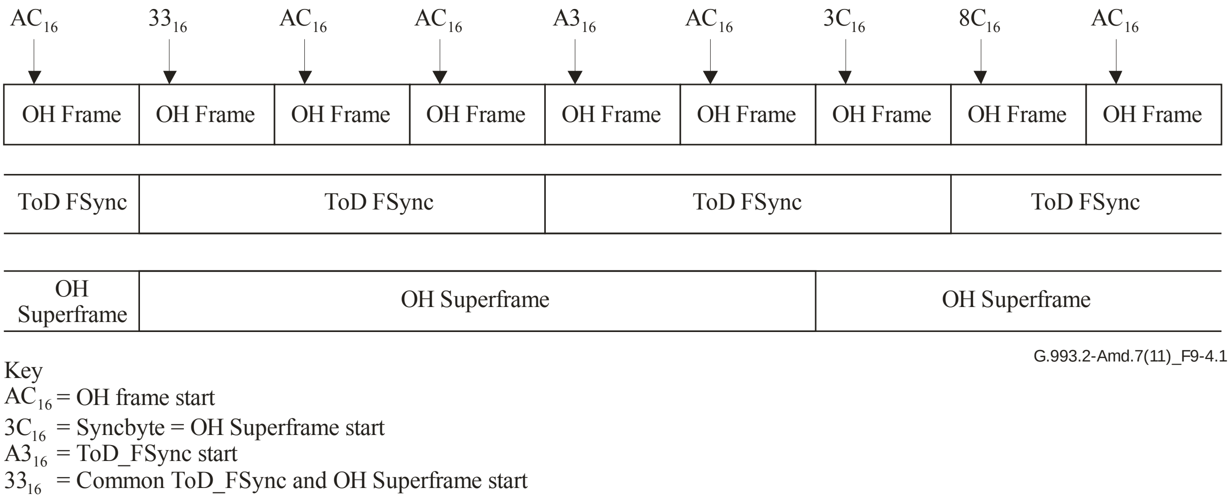


Figure 9-4.1 – Definition of OH sync byte values

10 Framing parameters

Revise clause 9.5.4 as follows:

9.5.4 Framing parameters

Framing parameters for latency path *p* are specified in Table 9-6. Two groups of parameters are specified:

– primary framing parameters; and

– derived framing parameters.

Primary framing parameters are those communicated to the other VTU during initialization for frame set-up (see clause 12.3.5). Derived framing parameters are computed by the VTU using the primary framing parameters to establish the complete frame setting and parameters intended for verification of the data channel and overhead channel bit rates and provide other important characteristics of the PMS-TC when specific framing parameters are set.

Table 9-6 – Framing parameters for latency path *p*

Parameter	Definition
Primary framing parameters	
B_{pn}	The number of octets from bearer channel #*n* per MDF. The range of values is from 0 to 254. When G_p/T_p is not an integer, the number of octets from the bearer channel #0 varies between B_{p0} and $B_{p0}+1$.
R_p	The number of redundancy octets in the RS codeword.
M_p	The number of MDFs in an RS codeword. Only values of 1, 2, 4, 8 and 16 shall be supported.
T_p	The number of MDFs in an OH sub-frame; $T_p = k \times M_p$, where *k* is an integer. The value of T_p shall not exceed 64.
G_p	The total number of overhead octets in an OH sub-frame; $1 \le G_p \le 32$.
F_p	Number of OH frames in the OH superframe; $1 \le F_p \le 255$.
L_p	The number of bits from latency path *p* transmitted in each data symbol.
Derived framing parameters	
N_{FECp}	The RS codeword size: $N_{FECp} = M_p \times \left[\text{ceiling}\left(\frac{G_p}{T_p}\right) + B_{p0} + B_{p1} \right] + R_p$ bytes
O_{pi}	The number of overhead octets in the i^{th} MDF of the OH sub-frame: $O_{pi} = \begin{cases} \left\lceil \frac{G_p}{T_p} \right\rceil & \text{for } i \le G_p - T_p \times \left\lfloor \frac{G_p}{T_p} \right\rfloor \\ \left\lfloor \frac{G_p}{T_p} \right\rfloor & \text{otherwise} \end{cases}, \quad i = 1, 2, ..., T_p;\ 0 \le O_{pi} \le 8$

Table 9-6 – Framing parameters for latency path *p*

Parameter	Definition
$PERB_p$	The number of bytes in the overhead frame: $$PERB_p = \frac{T_p \times N_{FECp}}{M_p} \times \left\lfloor \frac{\hat{Q} \times M_p}{T_p \times N_{FECp}} \right\rfloor \text{ bytes}$$ where: $$\hat{Q} = \begin{cases} Q & \text{if } TDR_p \geq TDR_0 \\ Q \cdot \dfrac{TDR_p}{TDR_0} & \text{if } TDR_p < TDR_0 \end{cases}$$ and where: TDR_p is the total data rate of latency path p in kbit/s, Q =17000 bytes, TDR_0 = 7880 kbit/s
TDR_p	The total data rate of latency path p (at reference point C): $TDR_p = L_p \times f_s$ kbit/s, where f_s is the data symbol rate in ksymbols/s (see 10.4.4).
S_p	The number of data symbols over which the RS codeword spans, $$S_p = \frac{8 \times N_{FECp}}{L_p}$$ The value of S_p may be a non-integer, and shall not exceed 64.
NDR_{pn}	The net data rate for bearer channel #0: $$NDR_{p0} = \left[B_{p0} + \text{ceiling}\left(\frac{G_p}{T_p}\right) - \frac{G_p}{T_p} \right] \times \frac{8 \times M_p \times f_s}{S_p} \text{ kbit/s}$$ The net data rate for bearer channel #1: $$NDR_{p1} = B_{p1} \times \frac{8 \times M_p \times f_s}{S_p} \text{ kbit/s}$$ The settings of framing parameters shall provide $net\_min_n < NDR_{pn} < net\_max_n$ for all defined bearer channels over relevant latency paths.
NDR_p	The net data rate for latency path p: $$NDR_p = L_p \times f_s \times \frac{K_p}{N_{FECp}} - OR_p = \left(K_p - \frac{G_p \times M_p}{T_p} \right) \times \frac{8 \times f_s}{S_p} \text{ kbit/s}$$ where $K_p = N_{FECp} - R_p$.

Table 9-6 – Framing parameters for latency path *p*

Parameter	Definition
U_p	The number of OH sub-frames in the OH frame: $$U_p = \frac{PERB_p}{N_{FECp}} \times \frac{M_p}{T_p}$$
SEQ_p	The number of overhead bytes in the OH frame: $$SEQ_p = U_p \times G_p \text{ bytes}$$
OR_p	The overhead data rate for latency path *p*: $$OR_p = \frac{G_p \times M_p}{S_p \times T_p} \times 8 \times f_s \text{ kbit/s}$$
msg_p	The message overhead data rate (for OH frame type 1 only, excluding the ToD_FSync octet – see Table 9-5.1): $$msg_p = OR_p \times \frac{SEQ_p - 6}{SEQ_p} \text{ kbit/s}$$ The settings of framing parameters shall provide $msg_{min} < msg_p < msg_{max}$. The settings for msg_{min} and msg_{max} shall comply with the following conditions: 16 kbit/s ≤ msg_{min} ≤ 236 kbit/s; msg_{max} = 256 kbit/s. The message overhead data rate (for OH frame Type 1 including the ToD_FSync octet – see Table 9-5.1): $$msg_p = OR_p \times (SEQ_p - 7) / SEQ_p \text{ kbit/s}$$
PER_p	The duration of the overhead frame in ms (see Note): $$PER_p = \frac{T_p \times S_p \times U_p}{f_s \times M_p} = \frac{8 \times PERB_p}{L_p \times f_s} \text{ ms}$$
NOTE – In clauses 7.2.1.1.3 and 7.2.1.2.3 of ITU-T G.997.1 [4], a one-second counter is used to declare a near-end severely errored second (SES). The one-second counter shall be incremented by the $\Delta CRCsec_p$ (the one-second normalized CRC anomaly counter increment) for each occurrence of a *crc-p* anomaly. A $\Delta CRCsec_p$ value is defined for each downstream and upstream latency path separately, as a real value in the 0.125 to 8 range, as: $$\Delta CRCsec_p = \begin{cases} 1 \text{ if } 15 \le PER_p \le 20 \\ \frac{PER_p}{15} \text{ if } PER_p < 15 \end{cases}$$	

11 eoc transmission protocol

Revise clause 11.2.2 as follows:

11.2.2 eoc transmission protocol

A VTU invokes eoc communication with the VTU at the other end of the link by sending an eoc command message. The responding VTU, acting as a slave, shall acknowledge a command it has received correctly by sending a response, unless one is not required for the particular command type. Furthermore, it shall perform the requested management function. Both VTUs shall be capable of sending eoc commands and responding to received eoc commands. The same eoc protocol format shall be used in both transmission directions. To send commands and responses over the line, the VME originates eoc messages. Each eoc message is a command, a command segment, a response, or a response segment. The VME sends each eoc message to the MPS-TC.

The MPS-TC encapsulates all incoming messages into HDLC format, as specified in 8.2.3. The length of any eoc message shall be less than or equal to 1024 octets, as described in 11.2.3.1.

Each command and the corresponding response are associated with a priority level specified in 11.2.3.1. To maintain priorities of eoc commands when sent over the link, the VME shall send messages to the MPS-TC via the γ_m interface in accordance with the priority levels of the commands (responses) carried by these messages, as specified in Table 11-1.

Table 11-1 – eoc message priority levels

Priority level	Associated time-out value	eoc command (response)
High	400 ms	Table 11-2, UTC (11.2.3.2)
Near High	For further study	Table 11-2.1
Normal	800 ms	Table 11-3
Low	1 s	Table 11-4

The VME shall send the eoc command only once and wait for a response, if one is required. No more than one command of each priority level shall be awaiting a response at any time. Upon reception of the response, a new command of the same priority level may be sent. If the command is segmented, all the segments of the command shall be sent and responses received before the next command is sent.

Accordingly, the VME shall send the message carrying a command or a segment of a command only once and wait for a response message. Upon reception of the response message, a new message may be sent. If a response to a particular message is not received within a specified time period (see Table 11-1), or is received incorrectly, a time-out occurs. After a time-out, the VME ~~may either~~shall re-send the message up until REINIT_TIME_THRESHOLD seconds from the first time-out, after which it shall~~or~~ abandon the message~~it~~.

From all of the messages available for sending at any time, the VME shall always send the message with highest priority first. If a message with a higher priority than the one that is currently being sent becomes available for sending, the VME may abort sending the lower priority message (by setting the *Tx_Stop* signal, as specified in 8.2.4.1). The VME shall re-send the aborted message as the priority rule allows (i.e., when its priority level is the highest among all messages available for sending).

Messages of different priority have different time-out durations, as shown in Table 11-1, except for messages for which a response is not required and hence no timeout period is applicable. Time-outs shall be calculated from the instant the MPS-TC sends the last octet of the message until the instant the VME receives the first octet of the response message. Accordingly, the time-out timer shall be started by the *Sent* signal. If the VME detects an *Rx_RF* signal and a corresponding *Rx_PrF* signal within the relevant time-out value specified in Table 11-1, it shall set a time stamp for the preliminary arrival time of the expected response message, and then wait for the *Rx_Enbl* signal; otherwise the VME shall time-out for the expected response.

If the VME detects the *Rx_Enbl* signal in ≤300 ms after *Rx_RF* and *Rx_PrF* signals are set, the response message is considered to be received; otherwise, the VME shall consider the received

Rx_RF and *Rx_PrF* signals as false, and shall delete the time stamp and wait for the next *Rx_RF* and *Rx_PrF* signals within the rest of the time-out value specified in Table 11-1.

The receiver uses the assigned value specified in 11.2.3.2 to determine the type and priority of the received eoc command (response).

12 Command and response types

Revise clause 11.2.3.2 as follows:

With the exception of control parameter read, which is for further study, the VTU shall support all mandatory eoc command and response types specified in Table 11-2 (high priority commands), Table 11-2.1 (near high priority commands), Table 11-3 (normal priority commands) and Table 11-4 (low priority commands), and their associated commands and responses specified in 11.2.3.3 to 11.2.3.11, inclusive. The VTU should reply with Unable-To-Comply (UTC) response on the optional commands that the VTU cannot recognize the assigned value for the command type. The UTC response shall include two octets: the first octet of the UTC shall be the same as the first octet of the received command, and the second octet shall be FF_{16}. The UTC is a high priority response.

NOTE – If the UTC response is not supported, the command will time out. This would reduce the efficiency of the eoc.

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 11-5

Table 11-2.1 – Near high priority commands and responses

Command type and assigned value	Direction of command	Command content	Response content	Support
Frequency synchronization $0101\ 0000_2$	From VTU-O to VTU-R	The ToD phase difference value to run frequency synchronization: the ns_counter value of the RTC-O mod 125000 ns divided by 2, which shall be represented by a 16 bit value.	No response needed	Optional

Table 11-3 – Normal priority commands and responses

Command type and assigned value	Direction of command	Command content	Response content	Support
Diagnostic $0100\ 0001_2$	From VTU-O to VTU-R	Request to run the self-test, or to update test parameters, or to start and stop transmission of corrupt CRC, or to start and stop reception of corrupt CRC	Acknowledgment	Mandatory
	From VTU-R to VTU-O	Request to update test parameters	Acknowledgment	Mandatory
Time $0100\ 0010_2$	From VTU-O to VTU-R	Set or read out the time	Acknowledgment of the set time command, or a response including the time value	Mandatory
Inventory $0100\ 0011_2$	From either VTU to the other	Identification request, auxiliary inventory information request, and self-test results request	Includes the VTU equipment ID auxiliary inventory information, and self-test results	Mandatory
Management Counter Read $0000\ 0101_2$	From either VTU to the other	Request to read the counters	Includes all counter values	Mandatory
Clear eoc $0000\ 1000_2$	From either VTU to the other	Clear eoc command as defined in Rec. ITU-T G.997.1 [4]	Acknowledgment	Mandatory
Power Management $0000\ 0111_2$	From either VTU to the other	Proposed new power state	An acknowledgement to either reject or grant the new power state	Mandatory
Non-standard Facility (NSF) $0011\ 1111_2$	From either VTU to the other	Non-standard identification field followed by vendor proprietary content	An acknowledgment or a negative acknowledgment indicating that the non-standard identification field is not recognized	Mandatory
Control Parameter Read $0000\ 0100_2$	From either VTU to the other	For further study	For further study	Mandatory
Time synchronization $0101\ 0001_2$	From VTU-O to VTU-R	Includes the time stamps obtained by VTU-O to run time synchronization	Includes either the corresponding time stamp values of events t_2 and t_3 to accept the time synchronization (ACK) or a reject of the time synchronization command with a reason code	Optional

Table 11-4 – Low priority commands and responses

Command type and assigned value	Direction of command	Command content	Response content	Support
PMD Test Parameter Read $1000\ 0001_2$	From either VTU to the other	The identification of test parameters for single read, or for multiple read, or for block read	Includes the requested test parameter values or a negative acknowledgment	See Tables 11-25 and 11-26
INM facility $1000\ 1001_2$	From VTU-O to VTU-R	Set or readout the INM data	An acknowledgment of the INM facility set command, or a response including the INM data	Optional
Non-Standard Facility (NSF) Low Priority $1011\ 1111_2$	From either VTU to the other	Non-standard identification field followed by vendor proprietary content	An acknowledgment or a negative acknowledgment indicating that the non-standard identification field is not recognized	Mandatory

13 OLR commands and responses

Revise Table 11-5 and Table 11-6 as follows:

Table 11-5 – OLR commands sent by the initiating VTU

Name	Length (octets)	Octet number	Content	Support
Request Type 1	$5 + 4 \times N_f$ ($N_f \leq 128$)	2	04_{16} (Note 1)	Mandatory
		3 to 4	2 octets for the number of sub-carriers N_f to be modified	
		5 to $4 + 4 \times N_f$	$4 \times N_f$ octets describing the sub-carrier parameter field for each sub-carrier	
		$5 + 4 \times N_f$	1 octet for SC	

Table 11-5 – OLR commands sent by the initiating VTU

Name	Length (octets)	Octet number	Content	Support
Request Type 2	For further study	2	05_{16} (Note 1)	For further study
		All others	Reserved by ITU-T	
Request Type 3 (SRA) (Note 6)	$5 + 7\ N_{LP} + 4\ N_f$ ($N_f \leq 128$)	2	06_{16} (Note 1)	Optional
		3 to $2 + 2\ N_{LP}$	$2 \times N_{LP}$ octets containing the new L_p values for each of the active latency paths (N_{LP} = number of active latency paths) (Notes 2 and 3)	
		$3 + 2\ N_{LP}$ to $2 + 4\ N_{LP}$	$2 \times N_{LP}$ octets containing the new D_p values for each of the active latency paths (N_{LP} = number of active latency paths) (Note 4)	
		$3 + 4\ N_{LP}$ to $2 + 5\ N_{LP}$	N_{LP} octets containing the new T_p values for each of the active latency paths (N_{LP} = number of active latency paths) (Notes 2, 3, 5)	
		$3 + 5\ N_{LP}$ to $2 + 6\ N_{LP}$	N_{LP} octets containing the new G_p values for each of the active latency paths (N_{LP} = number of active latency paths) (Notes 2, 3, 5)	
		$3 + 6\ N_{LP}$ to $2 + 7\ N_{LP}$	N_{LP} octets containing the new B_{p0} values for each of the active latency paths (N_{LP} = number of active latency paths) (Notes 2, 3, 5)	
		$3 + 7\ N_{LP}$ to $4 + 7\ N_{LP}$	2 octets for the number of sub-carriers N_f to be modified	
		$5 + 7\ N_{LP}$ to $4 + 7\ N_{LP} + 4\ N_f$	$4\ N_f$ octets describing the sub-carrier parameter field for each sub-carrier	
		$5 + 7\ N_{LP} + 4\ N_f$	1 octet for Segment Code (SC)	

Table 11-5 – OLR commands sent by the initiating VTU

<table>
<tr><th>Name</th><th>Length (octets)</th><th>Octet number</th><th colspan="2">Content</th><th>Support</th></tr>
<tr><td rowspan="11">Request Type 4 (SOS)</td><td rowspan="11">N_{TG}/2+11</td><td>2</td><td colspan="2">07_{16} (Note 1)</td><td rowspan="11">Optional</td></tr>
<tr><td>3</td><td colspan="2">Message ID</td></tr>
<tr><td rowspan="4">4 to N_{TG}/2+3</td><td>$\Delta b(2)$</td><td>$\Delta b(1)$</td></tr>
<tr><td>$\Delta b(4)$</td><td>$\Delta b(3)$</td></tr>
<tr><td colspan="2">…</td></tr>
<tr><td>$\Delta b(N_{TG})$</td><td>$\Delta b(N_{TG}$ - 1)</td></tr>
<tr><td>N_{TG}/2+4 to N_{TG}/2+5</td><td colspan="2">New value for L_0</td></tr>
<tr><td>N_{TG}/2+6 to N_{TG}/2+7</td><td colspan="2">New value for L_1</td></tr>
<tr><td>N_{TG}/2+8 to N_{TG}/2+9</td><td colspan="2">New value for D_0</td></tr>
<tr><td>N_{TG}/2+10 to N_{TG}/2+11</td><td colspan="2">New value for D_1</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td rowspan="2">Request Type 5 (SRA/G.998.4)</td><td rowspan="2">See [17]</td><td>2</td><td colspan="2">08_{16} (Note 1)</td><td rowspan="2">Optional</td></tr>
<tr><td>All others</td><td colspan="2">Reserved for ITU-T G.998.4</td></tr>
<tr><td rowspan="2">Request Type 6 (SOS/G.998.4)</td><td rowspan="2">See [17]</td><td>2</td><td colspan="2">09_{16} (Note 1)</td><td rowspan="2">Optional</td></tr>
<tr><td>All others</td><td colspan="2">Reserved for ITU-T G.998.4</td></tr>
<tr><td colspan="6">NOTE 1 – All other values for octet number 2 are reserved by ITU-T.
NOTE 2 – For this command, any change in L_p, T_p, G_p, and B_{p0} values shall be such that the length of the MDF (as defined in Table 9-6) remains unchanged for all active latency paths.
NOTE 3 – To keep the msgp value within its valid range for relatively large changes of L_p, it may be necessary to change all of the T_p, G_p, and B_{p0} values.
NOTE 4 – If a change of D_p is not supported, the value of this parameter shall be identical to that currently used.
NOTE 5 – If a change of T_p, G_p and B_{p0} is not supported, the values of these parameters shall be identical to those currently used.
NOTE 6 – When N_{LP} = 2, the octets associated with latency path 0 are sent first.</td></tr>
</table>

Table 11-6 – OLR responses sent by the responding VTU

<table>
<tr><th>Name</th><th>Length (octets)</th><th>Octet number</th><th>Content</th><th>Support</th></tr>
<tr><td rowspan="2">Defer Type 1 Request</td><td rowspan="2">3</td><td>2</td><td>81_{16} (Note)</td><td rowspan="2">Mandatory</td></tr>
<tr><td>3</td><td>1 octet for reason code (Table 11-7)</td></tr>
<tr><td rowspan="2">Reject Type 2 Request</td><td rowspan="2">3</td><td>2</td><td>82_{16} (Note)</td><td rowspan="2">For further study</td></tr>
<tr><td>3</td><td>1 octet for reason code (Table 11-7)</td></tr>
</table>

Table 11-6 – OLR responses sent by the responding VTU

Name	Length (octets)	Octet number	Content	Support
Reject Type 3 Request	3	2	83_{16} (Note)	Optional
		3	1 octet for reason code (Table 11-7)	
Reject Type 4 Request	3	2	84_{16} (Note)	Optional
		3	1 octet for reason code (Table 11-7)	
Reject Type 5 Request	3	2	85_{16} (Note)	Optional
		3	1 octet for reason code (Table 11-7)	
Reject Type 6 Request	3	2	86_{16} (Note)	Optional
		3	1 octet for reason code (Table 11-7)	
IACK	3	2	$8B_{16}$ (Note)	Mandatory
		3	1 octet for SC	
NOTE – All other values for octet number 2 are reserved by ITU-T.				

14 Inventory commands and responses

Revise clause 11.2.3.6 as follows:

11.2.3.6 Inventory commands and responses

The inventory commands shall be used to determine the identification and capabilities of the VTU at the far end. The inventory commands shown in Table 11-13 may be initiated by either VTU. The Inventory responses shall be as shown in Table 11-14. The first octet of all inventory commands and responses shall be the assigned value for the Inventory command type, as shown in Table 11-3. The second octet of the inventory commands shall be as specified in Table 11-13. The second octet (ACK) and all following octets of the Inventory responses shall be as specified in Table 11-14. The octets shall be sent using the format described in 11.2.3.1.

Table 11-13 – Inventory commands sent by the requesting VTU

Name	Length (Octets)	Octet number	Content
Identification request	2	2	01_{16} (Note)
Auxiliary Inventory Information request	2	2	02_{16} (Note)
Self-test Results Request	2	2	03_{16} (Note)
Inititialization Flags Request	2	2	04_{16} (Note)
Initialization Flags Reset Request	2	2	05_{16} (Note)
NOTE – All other values for octet number 2 are reserved by ITU-T.			

Table 11-14 – Inventory responses sent by the responding VTU

Name	Length (Octets)	Octet number	Contents
ACK (Identification)	58	2	81_{16} (Note)
		3 to 10	8 octets of vendor ID
		11 to 26	16 octets of version number
		27 to 58	32 octets of serial number
ACK (Auxiliary Inventory Information)	variable	2	82_{16} (Note)
		3 to 10	8 octets of vendor ID
		11 +	Multiple octets of auxiliary inventory information
Self-test Results	6	2	83_{16} (Note)
		3 to 6	4 octets of self-test results
Initialization Flags	3	2	84_{16} (Note)
		3	1 octet with the value of the initialization flags.
Initialization Flags Reset	3	2	85_{16} (Note)
		3	1 octet with the value of the initialization flags before the reset.
NOTE – All other values for octet number 2 are reserved by ITU-T.			

Upon reception of one of the Inventory commands, the VTU shall send the corresponding response. Any function of either the requesting or the responding VTU shall not be affected by the command.

The vendor ID in the response identifies the system integrator and shall be formatted according to the vendor ID of Rec. ITU-T G.994.1 [2]. In the context of this request, the system integrator usually refers to the vendor of the smallest field-replaceable unit; thus, the vendor ID in the response may not be the same as the vendor ID indicated during the ITU-T G.994.1 handshake phase of initialization.

The version number, serial number, and auxiliary inventory information shall be assigned with respect to the same system integrator as contained in the vendor ID. The syntax of these fields is beyond the scope of this Recommendation.

The Self-test Results response shall contain the results from the most recent self-test procedure, initiated either at power-up or by the eoc command Perform Self-test. The results shall be formatted as defined in 11.2.3.4.1.

The eoc commands Initialization Flags Request and the Initialization Flags Reset Request shall only be supported from the VTU-O to the VTU-R. The responses to those commands are optional.

The Initialization Flags and the Initialization Flags Reset response shall contain the current value of the initialization flags. The following initialization flags are defined:

The "previous-loss-of-power" (PLPR) flag: This flag shall be set to 1 after a power-up of the VTU-R due to an interruption in the VTU-R electrical supply (mains) power. The flag shall be set to 0 after sending the Initialization Flags Reset response.

The "previous host re-init" (PHRI) flag: This flag shall be set to 1 after a power-up of the VTU-R triggered by the CPE host. The flag shall be set to 0 after sending the Initialization Flags Reset response.

The value of the initialization flags shall be formatted as 1 octet [0000 00ba] where "a" is the value of the PLPR flag and "b" is the value of the PHRI flag.

15 Frequency synchronization command and time synchronization command and responses

Add new subclauses 11.2.3.14 and 11.2.3.15 as follows:

11.2.3.14 Frequency synchronization command

The VTU-O shall be capable of sending frequency synchronization command through the eoc if this mechanism is selected during initialization. The command is only in one direction, from VTU-O to VTU-R, and there is no response required.

The ToD phase difference value and corresponding t_1 event number shall be encapsulated in an *eoc* message as follows:

Table 11-34.1 – Frequency synchronization command sent by the VTU-O

Name	Length (Octets)	Octet number	Content
ToD phase difference	5	2	03_{16} (Note)
		3	1 octet representing the index of the t_1 event
		4 to 5	2 octets representing the ToD phase difference in units of 2 nanoseconds
NOTE – All other values for octet number 2 are reserved by ITU-T.			

If the VTU-R selects during initialization that the ToD phase difference values shall be transported through the eoc, then the VTU-O shall generate a ToD phase difference eoc message into the nearly-high priority queue for each superframe. For each superframe, the VTU-O shall send the most recent phase difference eoc message in the queue and shall discard older phase difference eoc messages. If the VTU-R selects during initialization to transport the ToD phase difference values through the OH frame, then the VTU-O shall not send phase difference eoc messages.

11.2.3.15 Time synchronization command and responses

The VTU shall be capable of sending and receiving the time synchronization commands and responses listed in Table 11-34.2 (command sent by VTU-O) and Table 11-34.3 (response sent by VTU-R), respectively. The timestamp command specified in Table 11-34.2 shall only be sent by the VTU-O. The timestamp response specified in Table 11-34.3 shall only be sent by the VTU-R. The VTU-R may reject to run time synchronization procedure using responses listed in Table 11-34.3 with reason codes listed in Table 11-34.4, or positively acknowledge by transmitting an ACK response.

The first octet of all time synchronization commands and responses shall be the assigned value for the time synchronization command type, as shown in Table 11-3. The remaining octets shall be as shown in Table 11-34.2 and Table 11-34.3. The octets of the time synchronization commands and responses shall be set over the link as described in 11.2.3.1.

Table 11-34.2 – Time synchronization commands sent by the VTU-O

Name	Length (Octets)	Octet number	Content
ToD(t_1) ToD(t_4) Timestamps	26	2	01_{16} (Note 1)
		3 to 4	2 octet for the index of time stamp ToD(t_1) in units of a superframe.
		5 to 10	6 octets describing the integer portion of the timestamp ToD(t_1) in units of seconds.
		11 to 14	4 octets describing the fractional portion of the timestamp ToD(t_1) in units of nanoseconds. (Note 2)
		15 to 16	2 octets for the index of time stamp ToD(t_4) in units of a superframe.
		17 to 22	6 octets describing the integer portion of the timestamp ToD(t_4) in units of seconds.
		23 to 26	4 octets describing the fractional portion of the timestamp ToD(t_4) in units of nanoseconds. (Note 2)
NOTE 1 – All other values for octet number 2 are reserved by ITU-T. NOTE 2 – The nanosecond portion is always less than 10^9.			

The octets for the index of time stamp ToD(t_1) contain the value of the downstream superframe counter when ToD(t_1) is taken by the VTU-O (i.e., at the t_1 event). This value shall be a multiple of 16. The octets for the index of time stamp ToD(t_4) contain the value of the upstream superframe counter when ToD(t_4) is taken by the VTU-O (i.e., at t_4 event). The difference between the downstream superframe counter at t_1 event and the upstream superframe counter at t_4 event shall be constant over showtime (i.e., the pairing of the t_1 and t_4 events shall not change over showtime). The t_1 event and the t_4 event shall be less than 1 superframe apart (i.e., 64.25 ms on the PMD sampling clock timebase if the CE length corresponds to m = 5, see clause 10.4.4).The ToD(t_1), ToD(t_2), ToD(t_3), and ToD(t_4) time stamps are described as two parts. One is the integer portion of the timestamp in units of seconds and the other is the fractional portion of the timestamp in units of nanoseconds. The ToD(t_1), and ToD(t_4) time stamps shall represent the time offset between the current time of the real-time clock RTC-O at the VTU-O (i.e., the time elapsed since the epoch) at the t_1 and t_4 events respectively. The ToD(t_2), and ToD(t_3) timestamps shall represent the time of the real-time Clock RTC-R at the VTU-R, (i.e., the time elapsed since the epoch) at the t_2 *and* t_3 events respectively. The epoch shall be the same for the real-time clock RTC-O and the real-time clock RTC-R, where this common epoch is set over the γ-O reference point.

NOTE – If at the t_1 event the real-time clock RTC-O shows +2.000000001 seconds have elapsed since the epoch, this is represented in the ToD(t_1) timestamp by seconds = 0x0000 0000 0002 and nanoseconds = 0x0000 0001. The epoch may be locally set by the DSLAM or may be an absolute instant in time. For example, if the epoch is the PTP epoch, this means that time-of-day = 1 January 1970 00:00:02.000000001.

Table 11-34.3 – Time synchronization responses sent by the VTU-R

Name	Length (Octets)	Octet number	Content
ToD(t_2) ToD(t_3) Timestamps (ACK)	26	2	81_{16} (Note 1)
		3 to 4	2 octets for the index of t_2 time stamp
		5 to 10	6 octets describing the integer portion of the timestamp in units of seconds
		11 to 14	4 octets describing the fractional portion of the timestamp in units of nanoseconds. (Note 2)
		15 to 16	2 octets for the index of t_3 time stamp
		17 to 22	6 octets describing the integer portion of the timestamp in units of seconds
		23 to 26	4 octets describing the fractional portion of the timestamp in units of nanoseconds. (Note 2)
Reject	3	2	82_{16} (Note 1)
		1	1 octet for reason code (see Table 11-34.4)
NOTE 1 – All other values for octet number 2 are reserved by ITU-T. NOTE 2 – The nanosecond portion is always less than 10^9.			

Table 11-34.4 – Reason codes for time synchronization responses

Reason	Octet value
Busy	01_{16}
Invalid parameters	02_{16}
t_2 and t_3 timestamps no longer available at the VTU-R	03_{16}
Still acquiring ToD frequency synchronization	04_{16}

The timestamp command is used to send time stamps ToD(t_1) and ToD(t_4) from the VTU-O to the VTU-R. Upon reception of a timestamp command, the VTU-R shall either send the time stamps ToD(t_2) and ToD(t_3) in an ACK response to indicate that the time synchronization procedure will be performed with the ToD(t_1), ToD(t_2), ToD(t_3) and ToD(t_4) timestamps, or send a reject response with a reason code from those specified in Table 11-34.4.

The VTU-R shall store the t_2 (and related t_3) values for at least the three most recent downstream (and related upstream) reference samples with a t_2 event count that is a multiple of 16. The VTU-O should send the time synchronization command soon enough after the t_1 and t_4 events to assure the related t_2 and t_3 timestamps are still available at the VTU-R.

If the VTU-R accepts the timestamp command, the timestamp response is used to send timestamps ToD(t_2), and ToD(t_3) from the VTU-R to the VTU-O. The ToD(t_1), ToD(t_2), ToD(t_3) and ToD(t_4) timestamps (in conjunction with other information) may be used at the network side to e.g., compensate for propagation delay asymmetry. At the customer premises side, propagation delay asymmetry shall not be compensated for. Other uses of the response reported time stamp values at the network side are for further study.

16 Near-end anomalies

Revise the text of clause 11.3.1.1 as follows:

11.3.1.1 Near-end anomalies

- Forward error correction (*fec-p*): This anomaly occurs when a received FEC codeword in the latency path #*p* indicates that errors have been corrected. This anomaly is not asserted if errors are detected and are not correctable.
- Cyclic redundancy check (*crc-p*): This anomaly occurs when a received CRC byte for the latency path #*p* is not identical to the corresponding locally generated CRC byte.
- Rate adaptation upshift (*rau*)*:* For further study.
- Rate adaptation downshift (*rad*): For further study.
- Loss-of-power interruption (*lpr_intrpt*): Excluding re-initializations triggered by the VTU-O host, this anomaly occurs when the time between the exit from showtime of the VTU-O and first successful reception of an ITU-T G.994.1 message is less than 120 seconds and at least one of the following conditions is met: an LPR-FE (see- clause 7.1.1.2.3 of ITU-T G.997.1) is declared before the exit from showtime or the PLPR flag is set at the entry into showtime.

  This anomaly is only defined at the VTU-O.
- Host-Reinit interruption (*hri_intrpt*)*:* Excluding re-initializations triggered by the VTU-O host, this anomaly occurs when the PHRI flag is set at the entry into showtime.

  This anomaly is only defined at the VTU-O.
- Spontaneous interruption (*spont_intrpt*)*:* Excluding re-initializations triggered by the VTU-O host, this anomaly occurs when the time between the exit from showtime of the VTU-O and the first successful reception of an ITU-T G.994.1 message is less than 120 seconds and neither an *lpr_intrpt* nor a *hri_intrpt* occurs, and the VTU-R supports the initialization flags request and the initialization flags reset request commands.

  This anomaly is only defined at the VTU-O.

17 Near-end defects

Revise the text of clause 11.3.1.3 as follows:

11.3.1.3 Near-end defects

- Loss of signal (*los*): A reference power is established by averaging the VDSL2 receive power over a 0.1 s period and over a subset of sub-carriers used for showtime, and a threshold shall be set 6 dB below this level. An *los* occurs when the level of the VDSL2 receive power averaged over a 0.1 s period and over the same subset of sub-carriers is lower than the threshold, and terminates when this level, measured in the same way, is at or above the threshold. The subset of sub-carriers is implementation dependent.
- Severely errored frame (*sef*): This defect occurs when the content of two consecutively received sync symbols does not correlate with the expected content over a subset of the sub-carriers. An *sef* terminates when the content of two consecutively received sync symbols correlates with the expected content over the same subset of the sub-carriers. The correlation method, the selected subset of sub-carriers, and the threshold for declaring these defect conditions are vendor discretionary.
- Loss of margin (*lom*)*:* This defect occurs when the signal-to-noise ratio margin (SNRM, see 11.4.1.1.6) observed by the near-end receiver is below the minimum signal-to-noise

ratio margin (MINSNRM, see 12.3.5.2.1.1) and an increase of SNRM is no longer possible within the far-end aggregate transmit power and transmit PSD level constraints. This defect terminates when the SNRM is above the MINSNRM. The SNRM measurement update rate shall be at least once every 5 seconds.

18 Re-initialization policy parameters

Add text for new clause 11.4.2.6 as follows:

11.4.2.6 Re-initialization policy parameters

11.4.2.6.1 Re-initialization policy selection (RIPOLICY)

The RIPOLICY configuration parameter (see clause 7.3.1.1.12 of Rec. ITU-T G.997.1 [4]) indicates which policy shall be applied to determine the triggers for re-initialization in a specific direction. The parameter in the downstream direction is RIPOLICYds, and the parameter in the upstream direction is RIPOLICYus.

The control parameter $RIpolicyds_n$ shall have the same value as the configuration parameter RIPOLICYds in the CO-MIB for all downstream bearer channels. However, if configuration parameter RIPOLICYds=1 and the VTU-R indicates during ITU-T G.993.2 initialization in R-MSG 2 (see clause 12.3.5.2.2.1) that $RIpolicyds_n$=1 is not supported for a particular bearer channel, the VTU-O shall fallback to indicate $RIpolicyds_n$=0 in O-TPS (see clause 12.3.5.2.1.2) for that bearer channel.

The control parameter $RIpolicyus_n$ shall have the same value as the configuration parameter RIPOLICYus in the CO-MIB for all upstream bearer channels. However, if $RIpolicyus_n$=1 is not supported by the VTU-O for a particular bearer channel, the VTU-O shall fallback to $RIpolicyus_n$=0 for that bearer channel.

The valid values for RIPOLICY are 0 and 1.

11.4.2.6.2 REINIT_TIME_THRESHOLD

Configuration parameter REINIT_TIME_THRESHOLD (see clause 7.3.1.1.13 of Rec. ITU-T G.997.1 [4]) defines the threshold for re-initialization based on SES, to be used by the VTU receiver when Re-Initialization Policy 1 is used (see clause 12.1.4).

The downstream and upstream values of REINIT_TIME_THRESHOLD shall be configured in the CO-MIB. The parameter in the downstream direction is REINIT_TIME_THRESHOLDds, and the parameter in the upstream direction is REINIT_TIME_THRESHOLDus.

The control parameter *REINIT_TIME_THRESHOLDds* conveyed in O-MSG 1 shall have the same value as the configuration parameter REINIT_TIME_THRESHOLDds in the CO-MIB. The control parameter *REINIT_TIME_THRESHOLDus* shall have the same value as the configuration parameter REINIT_TIME_THRESHOLDus in the CO-MIB.

The value shall be coded as an unsigned integer representing the maximum number of SES. The valid range is from 5 to 31.

19 Link activation methods and procedures

Revise the text of clause 12 as follows:

12 Link activation methods and procedures

12.1 Overview

12.1.1 Link states and ~~timing~~ link state diagram

The VDSL2 link states and activation/deactivation procedures diagram is illustrated in Figure 12-1.

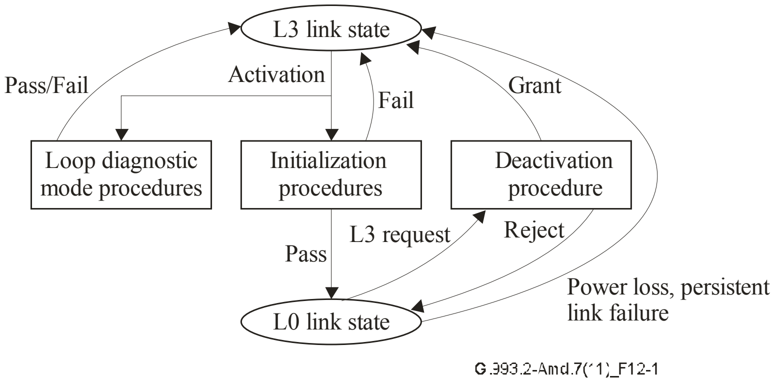


Figure 12-1 – VDSL2 link states and ~~activation/deactivation procedures~~link state diagram

Figure 12-1 has two link states (L0 and L3), and also contains the procedures that allow the ~~modem~~ link to change from one link state to another. The link states are shown in rounded boxes, whilst the procedures are shown as rectangular boxes.

~~**12.1.2 Link states**~~

L3 is the link state where the ~~modem~~ VTU is provisioned through a management interface for the service desired by the operator. In this link state, both the VTU-O and the VTU-R~~modem~~ do~~es~~ not transmit any signal. ~~In the L3 link state, a VTU may determine to use the initialization procedure. A VTU that receives a higher layer signal to activate shall use the initialization procedure defined in 12.3. A VTU that detects the signals of the initialization procedure at the U reference point, if enabled, shall respond by using the initialization procedure. If disabled, the VTU shall remain in the L3 link state.~~

L0 is ~~a~~ the link state achieved after the initialization procedure has completed successfully by both VTUs. In this link state, the link shall transport user information with standard performance characteristics according to the CO-MIB configuration. ~~The modem shall return to L3 state upon guided power removal (L3 Request – see 11.2.3.9), power loss or persistent link failures during showtime.~~

12.1.2 Transceiver states and transceiver state diagram

State diagrams are given in Figure 12-1.1 for the VTU-O, and in Figure 12-1.2 for the VTU-R. States are indicated by ovals, with the name of the state given within the oval. The states are defined in Table 12-0.5 for the VTU-O and in Table 12-0.6 for the VTU-R. Transitions between states are indicated by arrows, with the event causing the transition listed next to the arrow. All states are mandatory.

A variety of "host controller" commands (events preceded by "c:_" and "r:_") are shown as non-mandatory in either state diagram to provide example events and transitions between states. The way in which these events are implemented is left to the vendor since many options are possible.

In the state diagram for the VTU-O, a C-IDLE state would be desired to guarantee a quiet mode, which may be useful to allow certain tests (e.g., MLT), or to discontinue service.

In the state diagram for the VTU-R, a self-test function is desirable, but it may be a vendor/customer option to define when self-test occurs (e.g., always at power-up or only under VTU-O control), and which transition to take after successfully completing self-test (e.g., enter R-IDLE, or enter R-SILENT).

IDLE is the state where the VTU is provisioned through a management interface for the service desired by the operator. In this state, the VTU does not transmit any signal. A VTU that receives a higher layer signal to activate (c:_L0_request for VTU-O or r:_L0_request for VTU-R) shall use the initialization procedure defined in clause 12.3 to transition the link from the L3 to the L0 state. A VTU that detects the signals of the initialization procedure at the U reference point, if enabled, shall respond by using the initialization procedure. If disabled, the VTU shall remain in the IDLE state.

The link transitions to the L0 state once the initialization procedure has completed successfully and both VTUs are in the SHOWTIME state. A VTU-O shall return to the O-SILENT state upon a guided power management (c:_L3_request, see clause 11.2.3.9), or upon a re-initialization triggered by the re-initialization policy (see clause 12.1.4). A VTU-R shall return to the R-SILENT state upon a guided power management (r:_L3_request, see clause 11.2.3.9), or upon a re-initialization triggered by Re-Initialization Policy (see clause 12.1.4). With the former, a VTU-R shall set AUTO_init=OFF to disable autonomous proceeding to the R-INIT/HS state. With the latter, a VTU-R shall set AUTO_init=ON to enable autonomous proceeding to the R-INIT/HS state.

The receiving VTU shall transition state upon persistent LOS and/or LOF failure (see clause 12.1.4). This implies that if no high_BER-hs or high_BER-fs events cause the receiving VTU to transition state earlier, then the persistency allows the transmitting VTU to detect the LOS or LOF failure condition through the indicator bits, before the receiving VTU transitions state (i.e., removes the showtime signal from the line).

NOTE – High_BER-fs event relates to fast startup, which is for further study (see clause 12.5).

The receiving VTU shall also transition state upon a high_BER event (see clause 12.1.4). This event relates to near-end and/or far-end performance primitives and performance counters for which thresholds may be configured through the CO-MIB as to declare a high_BER event upon threshold crossing.

If the VTU-O transitions from O-SHOWTIME to O-SILENT, then the VTU-R shall detect a persistent LOS Failure, shall transition to R-SILENT followed by R-INIT/HS and shall transmit R-TONES-REQ within a maximum of 6 s after the VTU-O transitioning to O-SILENT.

If the VTU-R transitions from R-SHOWTIME to R-SILENT, then the VTU-O shall detect a persistent LOS Failure, shall transition to O-SILENT, either followed by waiting to receive R-TONES-REQ (VTU-R initiated HS) or followed by O-INIT/HS (VTU-O initiated HS).

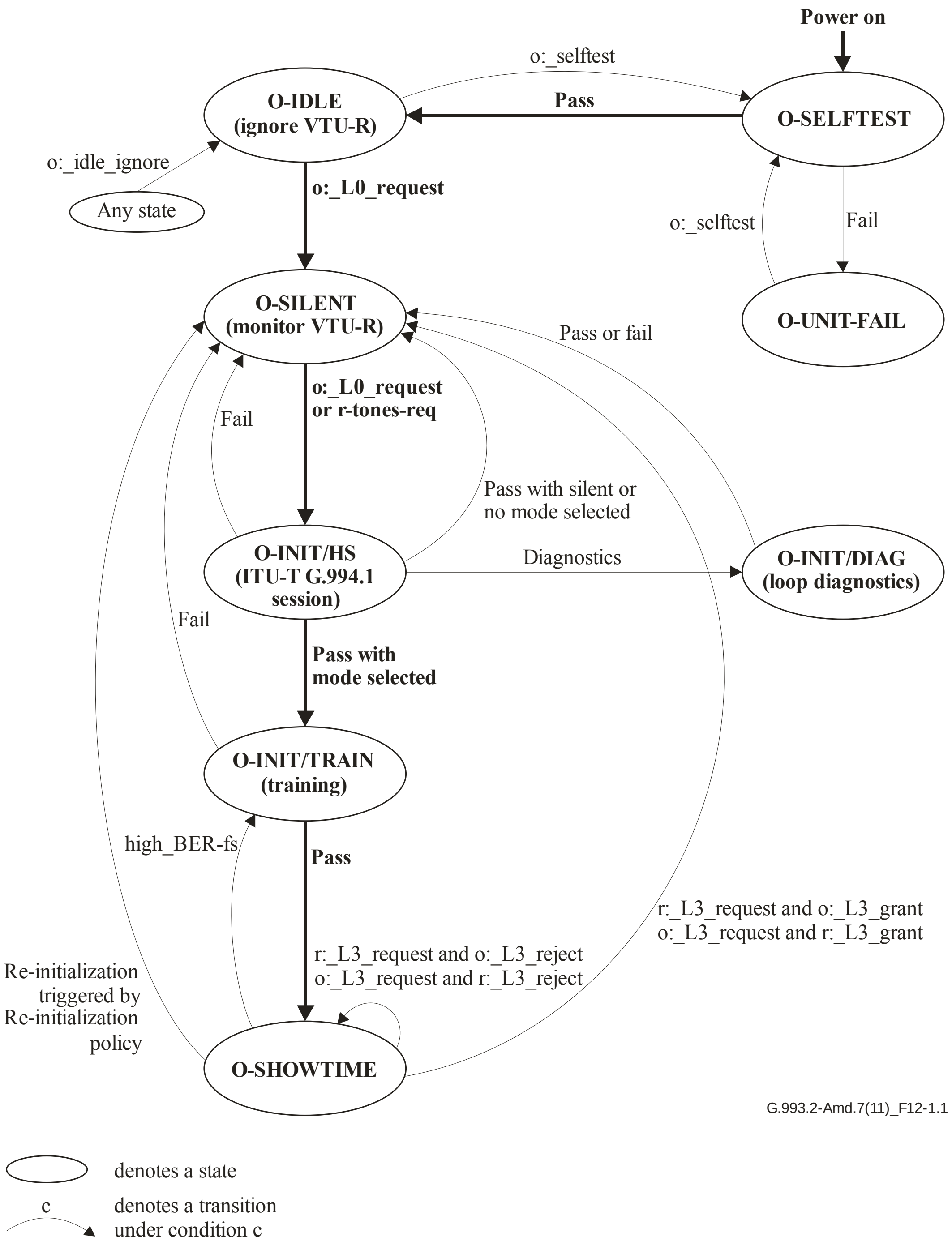


Figure 12-1.1 – State diagram for the VTU-O

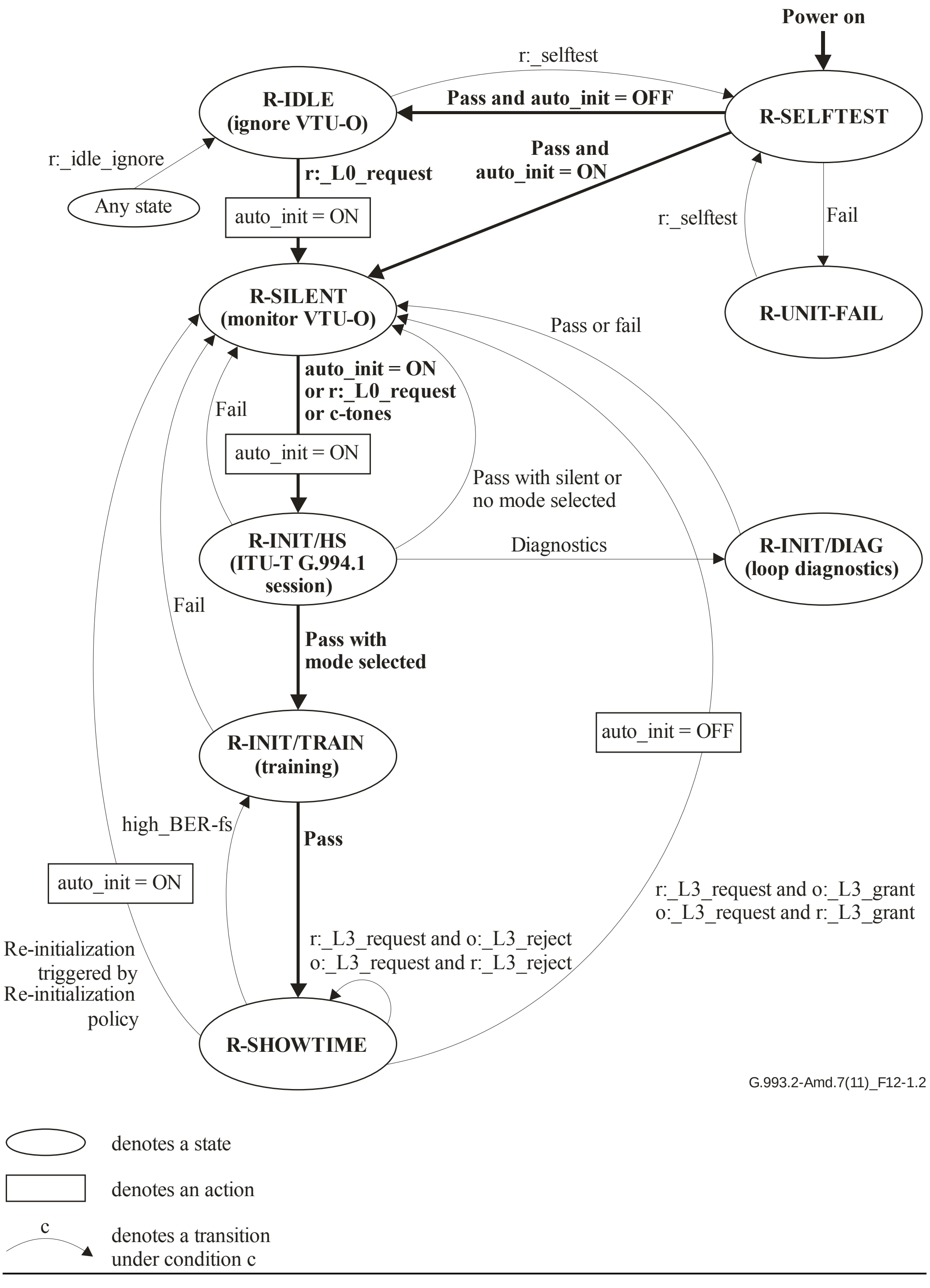


Figure 12-1.2 – State diagram for the VTU-R

Table 12-0.5 – VTU-O state definitions

State name	Description
O-SELFTEST (mandatory)	• Temporary state entered after power-up in which the VTU performs a self test • Transmitter off (QUIET at U-O interface) • Receiver off (no response to R-TONES-REQ signal) • No response to host control channel • If selftest pass then transition to O-IDLE • If selftest fail then transition to O-UNIT-FAIL
O-UNIT-FAIL (mandatory)	• Steady state entered after an unsuccessful VTU self test • Transmitter off (QUIET at U-O interface) • Receiver off (no response to R-TONES-REQ signal) • Monitor host control channel if possible (allows the host controller to retrieve self test results)
O-IDLE (mandatory)	• Steady state entered after successful self test • Transmitter off (QUIET at U-O interface) • Receiver off (no response to R-TONES-REQ signal) • Monitor host control channel
O-SILENT (mandatory)	• Steady state defined in Rec. ITU-T G.994.1 [2], entered upon host controller command • Transmitter off (QUIET at U-O interface) • Receiver on (monitor for R-TONES-REQ signal, if detected, transition to O-INIT/HS state) • Monitor host control channel
O-INIT/HS (mandatory)	• Temporary state entered to perform ITU-T G.994.1 phase of initialization • Transmitter on (start with transmitting C-TONES signal) • Receiver on (start with monitoring for R-SILENT0 signal) • Monitor host control channel • If silent period or no mode selected then transition to O-SILENT1 • If loop diagnostics mode then transition to O-INIT/DIAG • If operating mode selected then transition to O-INIT/TRAIN
O-INIT/TRAIN (mandatory)	• Temporary state entered to perform other phases of initialization • Transmitter on (start with O-P-QUIET1) • Receiver on (start with monitoring for R-P-QUIET1) • If init pass then transition to O-SHOWTIME • If init fail then transition to O-SILENT • Monitor host control channel
O-INIT/DIAG (mandatory)	• Temporary state entered to perform other phases of initialization in loop diagnostics mode • Transmitter on (start with O-P-QUIET1) • Receiver on (start with monitoring for R-P-QUIET1) • Transition to O-SILENT • Monitor host control channel

Table 12-0.5 – VTU-O state definitions

State name	Description
O-SHOWTIME (mandatory)	• Steady state entered to perform bit pump functions (frame bearers active) • On-line reconfigurations occur within this state • Upon conditions satisfying the re-initialization policy ($RIpolicy_n$) then transition to O-SILENT • If link transition to L3 state is granted, then transition to O-SILENT • Monitor host control channel

Table 12-0.6 – VTU-R state definitions

State name	Description
R-SELFTEST (mandatory)	• Temporary state entered after power-up in which the VTU performs a self-test • Transmitter off (QUIET at U-R interface) • Receiver off (no response to C-TONES signal) • No response to host control channel • If selftest pass then transition to R-IDLE if VTU is under host control or transition to R-SILENT if VTU is in automatic training mode • If self-test fail then transition to R-UNIT-FAIL
R-UNIT-FAIL (mandatory)	• Steady state entered after an unsuccessful VTU self-test • Transmitter off (QUIET at U-R interface) • Receiver off (no response to C-TONES signal) • Monitor host control channel if possible (allows the host controller to retrieve self test results)
R-IDLE (mandatory)	• Steady state entered after successful self-test if VTU is under host control • Transmitter off (QUIET at U-R interface) • Receiver off (no response to C-TONES signal) • Monitor host control channel
R-SILENT (mandatory)	• Temporary state defined in Rec. ITU-T G.994.1 [2] entered after self-test pass if VTU is in automatic training mode or with host controller command • Transmitter off (transmit R-SILENT0 signal) • Receiver on (monitor for C-TONES signal, if detected, transition to R-INIT/HS state) • Automatic training: immediate transition to R-INIT/HS (unless delayed for silent period or in orderly shutdown condition) • Monitor host control channel
R-INIT/HS (mandatory)	• Temporary state entered to perform ITU-T G.994.1 phase of initialization • Transmitter on (start with transmitting R-TONES-REQ signal) • Receiver on (start with monitoring for C-TONES signal) • Monitor host control channel • If silent period or no mode selected then transition to R-SILENT • If loop diagnostics mode then transition to R-INIT/DIAG • If operating mode selected then transition to R-INIT/TRAIN

Table 12-0.6 – VTU-R state definitions

State name	Description
R-INIT/TRAIN (mandatory)	• Temporary state entered to perform other phases of initialization • Transmitter on (start with R-P-QUIET1 signal) • Receiver on (start with monitoring for C-P-QUIET1 signal) • If init pass then transition to R-SHOWTIME • If init fail then transition to R-SILENT • Monitor host control channel
R-INIT/DIAG (mandatory)	• Temporary state entered to perform other phases of initialization in loop diagnostics mode • Transmitter on (start with R-P-QUIET1) • Receiver on (start with monitoring for C-P-QUIET1) • Transition to R-SILENT • Monitor host control channel
R-SHOWTIME (mandatory)	• Steady state entered to perform bit pump functions (frame bearers active) • On-line reconfigurations occur within this state • Upon conditions satisfying the re-initialization policy ($RIpolicy_n$) then transition to R-SILENT • If link transition to L3 state is granted, then transition to R-SILENT • Monitor host control channel

12.1.3 Initialization procedures

During the ITU-T G.994.1 handshake phase of the initialization procedure, the VTUs exchange capability lists and agree on a common mode for training and operation using the ITU-T G.994.1 protocol. A successful completion of the ITU-T G.994.1 handshake phase will lead to either the channel discovery phase of initialization or the loop diagnostic mode (depending on which one is selected). Failure of the ITU-T G.994.1 handshake phase leads the VTUs back to the L3 SILENT state and leads the link back to the L3 state. The handshake procedure is described in 12.3.2 and ITU-T Rec. G.994.1 [2].

During the channel discovery, training, and channel analysis & exchange phases of initialization, the VTUs train their respective transceivers after identifying the common mode of operation. During these phases, the transceivers identify channel conditions, exchange parameters for sShowtime operation, etc. After successful completion of the initialization procedure, the transceivers transition to the L0 SHOWTIME state (sShowtime). Upon unsuccessful completion of the initialization procedure, the VTUs return to the L3 SILENT state and the link returns to the L3 state. The initialization phases are described in 12.3.3 through 12.3.5.

12.1.4 Deactivation, power loss, and persistent link failure and high BER events

The deactivation procedure allows an orderly shutdown of the link. The modem VTUs shall follow the procedures described in 11.2.3.9 to transition the link from the L0 state to the L3 state.

The link is in the L3 state, after both VTU-O and VTU-R have transitioned from the SHOWTIME state to the SILENT state.

Two policies are defined for the VTU to trigger a transition from the SHOWTIME state to the SILENT state. The selection of the policy is controlled via the parameter "Re-initialization policy" ($RIpolicy_n$).

In the first policy (*RIpolicy*$_n$=0) (mandatory), a VTU shall transition from the SHOWTIME state to the SILENT state in the case of

1. loss of receive power (power loss), or
2. persistent link failure, or
3. upon a high_BER-hs event as defined below for *RIpolicy*$_n$=0.

~~the VTU shall transition from L0 state to L3 state.~~

The VTU shall declare a power loss when a persistent LOS failure is declared. Persistent LOS failure is declared after 2.5 ± 0.5 *s* of near-end LOS failure with the *los* (see 11.3.1.3) still present. An LOS failure is declared after 2.5 ± 0.5 s of contiguous *los*, or, if *los* is present when the criteria for LOF failure declaration have been met (see LOF Failure definition below). An LOS failure is cleared after 10 ± 0.5 s of no *los*.

The VTU shall declare a persistent link failure when a persistent LOF failure is declared. A persistent LOF failure is declared after 2.5 ± 0.5 s of near-end LOF failure with the *sef* (see 11.3.1.3) still present. An LOF failure is declared after 2.5 ± 0.5 s of contiguous near-end *sef*, except when an *los* or LOS failure is present (see LOS failure definition above). An LOF failure is cleared when LOS failure is declared, or after 10 ± 0.5 s of no *sef*.

The high_BER-hs event in *RIpolicy*$_n$=0 shall be declared whenever any of the parameters listed in Table 12-0.7 exceeds the listed threshold. Other conditions are vendor-specific and are (but are not required to be) related to near-end and/or far-end performance primitives. As an example, the VTU may also declare a high_BER event after 30 s of persistent near-end or far-end *lom* defect. The VTU should trade-off the persistency in the high_BER events to, on the one hand, quickly recover data integrity, but on the other hand, not to unnecessarily interrupt data transmission. This trade-off may be enhanced if the VTU is able to detect and quantify instantaneous changes in line conditions.

Table 12-0.7 – Conditions for declaring a high_BER-hs event in *RIpolicy*$_n$=0

Parameter	**Threshold**
Number of successful SOS procedures performed within a 120-second interval	MAX-SOS threshold configured in CO-MIB
Number of seconds the actual net data rate (*net_act*$_n$) is below the minimum net data rate (*net_min*$_n$) for any bearer channel after a successful SOS procedure	20 seconds
Duration of time interval with consecutive eoc message time-outs without a single successfull eoc command/ response exchange	Vendor discretionary
NOTE – Other conditions declaring a high_BER event are vendor specific.	

~~If~~ In determining the number of successful SOS procedures performed within a 120-second interval ~~exceeds MAX-SOS~~, the ~~modem shall transition to the L3 state. The~~ 120-second measurement interval shall be started at the first successful SOS procedure after getting into showtime and re-started at the first successful SOS procedure occurring after a previous 120-second period interval has expired with the number of successful SOS procedures being less than MAX-SOS. The 120 second measurement intervals shall be sequential periods, not a sliding window.

The SOS procedure shall be considered as successful when the ~~modem~~ VTU initiating the SOS receives the SyncFlag in response (regardless whether the SyncFlag was received after a single or multiple SOS requests).

~~When the actual net data rate, *net_act*$_n$, remains below the minimum net data rate, *net_min*$_n$, for any bearer channel for more than 20 seconds, the modem shall transition to the L3 state.~~

~~NOTE – From this L3 state a VTU may transition to an initialization procedure.~~

In the second policy (*RIpolicy*$_n$=1) (optional), a VTU shall transition from the SHOWTIME state to the SILENT state in the case of

1. loss of receive power (power loss), or
2. persistent link failure, or
3. persistent near-end loss of margin failure, or
4. persistent TPS-TC out-of-sync failure, or
5. upon a high_BER-hs event as defined below for *RIpolicy*$_n$=1

The VTU shall declare a power loss identical to re-initialization policy 0.

The VTU shall declare a persistent link failure identical to re-initialization policy 0.

The VTU shall declare a persistent loss of margin failure after 60 ± 1 s of contiguous near-end loss of margin defect (*lom*).

The VTU shall declare a persistent TPS-TC out-of-sync failure after 15 ± 1 s of contiguous near-end TPS-TC out-of-sync condition.

In the case that the TPS-TC is ATM, the TPS-TC out-of-sync condition corresponds with near-end loss of cell delineation defect (*lcd-n*). (See clause K.2).

In the case that the TPS-TC is PTM, the the TPS-TC out-of-sync condition corresponds with near-end TC_out_of_sync (*oos-n*) anomaly. (See clause N.4 of Rec. ITU-T G.992.3 [10]).

The high_BER-hs event in *RIpolicy*$_n$=1 shall be declared whenever any of the parameters listed in Table 12-0.8 exceeds the listed threshold.

Table 12-0.8 – Conditions for declaring a high_BER-hs event in *RIpolicy*$_n$=1

Parameter	**Threshold**
Number of contiguous near-end SES	REINIT_TIME_THRESHOLD configured in CO-MIB
Number of successful SOS procedures performed within a 120-second interval	MAX-SOS threshold configured in CO-MIB
Number of seconds the actual net data rate (*net_act*$_n$) is below the minimum net data rate (*net_min*$_n$) for any bearer channel after a successful SOS procedure	20 seconds
Duration of time interval with consecutive eoc message time-outs without a single successfull eoc command/ response exchange	REINIT_TIME_THRESHOLD configured in CO-MIB
NOTE – At the VTU-R, no other conditions shall declare a high_BER-hs event. At the VTU-O, no other near-end conditions shall declare a high_BER-hs event. Declaration of a high_BER-hs event based on far-end conditions are vendor specific.	

12.1.5 Loop diagnostic procedure

Loop diagnostic mode is intended to identify channel conditions at both ends of the loop without transitioning to the ~~L0~~ SHOWTIME state. The ~~modems~~ VTUs will return to ~~L3~~ the SILENT state after completion of the loop diagnostic mode. Loop diagnostic mode is described in 12.4.

…

12.3.2.1.1 CL messages

A VTU-O wishing to indicate ITU-T G.993.2 capabilities in an ITU-T G.994.1 CL message shall do so by setting to ONE the ITU-T G.993.2 SPar(1) bit as defined in Table 11.0.4 of ITU-T G.994.1 [2]. The NPar(2) (Table 11.67 of ITU-T G.994.1 [2]) and SPar(2) (Table 11.68 of ITU-T G.994.1 [2]) fields corresponding to the G.993.2 Spar(1) bit are defined in Tables 12-3 and 12-4, respectively. For each ITU-T G.993.2 SPar(2) bit set to ONE, a corresponding NPar(3) field shall also be present (beginning with Table 11.68.1 in 9.4 of ITU-T G.994.1 [2]). Table 12-5 shows the definitions and coding for the VTU-O CL NPar(3) fields.

Table 12-3 – VTU-O CL message NPar(2) bit definitions

ITU-T G.994.1 NPar(2) Bit	Definition of NPar(2) bit
All-digital mode	If set to ONE, signifies that the VTU-O supports all-digital mode.
Support of downstream virtual noise	If set to ONE, signifies that the VTU-O supports the use of the downstream virtual noise mechanism.
Lineprobe	Always set to ONE in a VTU-O CL message.
Loop diagnostic mode	Set to ONE if the VTU-O requests loop diagnostic mode.
Support of PSD shaping in US0	Always set to ONE in a VTU-O CL message.
Support of equalized FEXT UPBO	If set to ONE, signifies that the VTU-O supports equalized FEXT UPBO.
ITU-T G.993.5-friendly ITU-T G.993.2 operation in the downstream direction	See Annex L, Table L.12-3
Alternative electrical length estimation method	If set to ONE, signifies that the VTU-O supports the alternative electrical length estimation method (ELE-M1)

…

12.3.2.1.2 MS messages

A VTU-O selecting the ITU-T G.993.2 mode of operation in an ITU-T G.994.1 MS message shall do so by setting to ONE the ITU-T G.993.2 SPar(1) bit as defined in Table 11.0.4 of ITU-T G.994.1 [2]. The NPar(2) (Table 11.67 of ITU-T G.994.1 [2]) and SPar(2) (Table 11.68 of ITU-T G.994.1 [2]) fields corresponding to this bit are defined in Tables 12-6 and 12-7, respectively. For each ITU-T G.993.2 SPar(2) bit set to ONE, a corresponding NPar(3) field shall also be present (beginning with Table 11.68.1 in 9.4 of ITU-T G.994.1 [2]). Table 12-8 shows the definitions and coding for the VTU-O MS NPar(3) fields.

Table 12-6 – VTU-O MS message NPar(2) bit definitions

ITU-T G.994.1 NPar(2) Bit	Definition of NPar(2) bit
All-digital mode	Set to ONE if and only if both the last previous CLR and the last previous CL messages have set this bit to ONE. If set to ONE, indicates that both the VTU-O and the VTU-R shall be configured for operation in all-digital mode.

Table 12-6 – VTU-O MS message NPar(2) bit definitions

ITU-T G.994.1 NPar(2) Bit	Definition of NPar(2) bit
Support of downstream virtual noise	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 virtual noise mechanism may be used.
Lineprobe	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 channel discovery phase of initialization shall include a lineprobe stage.
Loop Diagnostic mode	Set to ONE if either the last previous CLR or the last previous CL message has set this bit to ONE. Indicates that both VTUs shall enter loop diagnostic mode.
Support of PSD shaping in US0	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 VTU-R supports PSD shaping in the US0 band.
Support of equalized FEXT UPBO	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 both the VTU-O and the VTU-R shall use equalized FEXT UPBO.
ITU-T G.993.5-friendly ITU-T G.993.2 operation in the downstream direction	See Annex L, Table L.12-6
Alternative electrical length estimation method	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 both the VTU-O and the VTU-R shall use electrical length estimation method ELE-M1.

…

12.3.2.2.1 CLR messages

A VTU-R wishing to indicate ITU-T G.993.2 capabilities in an ITU-T G.994.1 CLR message shall do so by setting to ONE the ITU-T G.993.2 SPar(1) bit as defined in Table 11.0.4 of ITU-T G.994.1 [2]. The NPar(2) (Table 11.67 of ITU-T G.994.1 [2]) and SPar(2) (Table 11.68 of ITU-T G.994.1 [2]) fields corresponding to the ITU-T G.993.2 SPar(1) bit are defined in Tables 12-9 and 12-10, respectively. For each ITU-T G.993.2 SPar(2) bit set to ONE, a corresponding NPar(3) field shall also be present (beginning with Table 11.68.1 in 9.4 of ITU-T G.994.1 [2]). Table 12-11 shows the definitions and coding for the VTU-R CLR NPar(3) fields.

Table 12-9 – VTU-R CLR message NPar(2) bit definitions

ITU-T G.994.1 NPar(2) Bit	Definition of NPar(2) bit
All-digital mode	If set to ONE, signifies that the VTU-R supports all-digital mode.
Support of downstream virtual noise	If set to ONE, signifies that the VTU-R supports the use of the downstream virtual noise mechanism.
Lineprobe	Set to ONE if the VTU-R requests the inclusion of a lineprobe stage in initialization.
Loop diagnostic mode	Set to ONE if the VTU-R requests loop diagnostic mode.

Table 12-9 – VTU-R CLR message NPar(2) bit definitions

ITU-T G.994.1 NPar(2) Bit	Definition of NPar(2) bit
Support of PSD shaping in US0	If set to ONE, signifies that the VTU-R supports PSD shaping in the US0 band.
Support of equalized FEXT	If set to ONE, signifies that the VTU-R supports equalized FEXT UPBO.
ITU-T G.993.5-friendly ITU-T G.993.2 operation in the downstream direction	See Annex X, Table X.12-9
Alternative electrical length estimation method	If set to ONE, signifies that the VTU-R supports the alternative electrical length estimation method (ELE-M1)

…

12.3.2.2.2 MS messages

A VTU-R selecting ITU-T G.993.2 mode of operation in an ITU-T G.994.1 MS message shall do so by setting to ONE the ITU-T G.993.2 SPar(1) bit as defined in Table 11.0.4 of ITU-T G.994.1 [2]. The NPar(2) (Table 11.67 of ITU-T G.994.1 [2]) and SPar(2) (Table 11.68 of ITU-T G.994.1 [2]) fields corresponding to the ITU-T G.993.2 Spar(1) bit are defined in Tables 12-12 and 12-13, respectively. For each ITU-T G.993.2 SPar(2) bit set to ONE, a corresponding NPar(3) field shall also be present (beginning with Table 11.68.1 in 9.4 of ITU-T G.994.1 [2]). Table 12-14 shows the definitions and coding for the VTU-R MS NPar(3) fields.

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

ITU-T G.994.1 NPar(2) Bit	Definition of NPar(2) bit
All-digital mode	Set to ONE if and only if both the last previous CLR and the last previous CL messages have set this bit to ONE. If set to ONE, indicates that both the VTU-O and the VTU-R shall be configured for operation in all-digital mode.
Support of downstream virtual noise	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 virtual noise mechanism may be used.
Lineprobe	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 channel discovery phase of initialization shall include a lineprobe stage.
Loop diagnostic mode	Set to ONE if either the last previous CLR or the last previous CL message has set this bit to ONE. Indicates that both VTUs shall enter loop diagnostic mode.
Support of PSD shaping in US0	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 VTU-R shall support PSD shaping in the US0 band.
Support of equalized FEXT	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 both the VTU-O and the VTU-R shall use equalized FEXT UPBO.

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

ITU-T G.994.1 NPar(2) Bit	Definition of NPar(2) bit
ITU-T G.993.5-friendly ITU-T G.993.2 operation in the downstream direction	See Annex L, Table L.12-12
Alternative electrical length estimation method	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 both the VTU-O and the VTU-R shall use ELE-M1.

…

12.3.3 Channel discovery phase

12.3.3.1 Overview

…

The VTU-R shall start the channel discovery phase with R-P-QUIET 1 (no signal) until it correctly receives the O-SIGNATURE message. During the R-P-QUIET 1 stage, the VTU-R shall complete the timing lock prior to transmitting R-P-CHANNEL DISCOVERY 1. Upon receiving the O-SIGNATURE message, the VTU-R has all of the necessary information needed to perform UPBO (see 7.2.1.3). If AELE-MODE = 1, 2, or 3, UPBO shall be performed according to AELE-MODE=1 until final kl_0 values are provided in the O-UPDATE message. After performing UPBO, the VTU-R shall transmit R-P-CHANNEL DISCOVERY 1. The VTU-R shall transmit R-P-CHANNEL DISCOVERY 1 using the initial timing advance value received in the O-SIGNATURE message. The VTU-R shall send R-IDLE for at least 512 DMT symbols. It shall then send its first message, R-MSG 1, in AR mode. The VTU-R shall send R-MSG 1 until the VTU-O indicates it has correctly received R-MSG 1. The R-MSG 1 message conveys to the VTU-O the upstream PSD and other VTU-R parameters, as presented in Table 12-26.

…

12.3.3.2.1.1 O-SIGNATURE

The full list of parameters carried by the O-SIGNATURE message is shown in Table 12-17.

Table 12-17 – Description of message O-SIGNATURE

	Field name	Format
1	Message descriptor	Message code
2	Supported sub-carriers in the downstream direction (SUPPORTEDCARRIERSds set)	Bands descriptor
3	Supported sub-carriers in the upstream direction (SUPPORTEDCARRIERSus set)	
4	Downstream transmit PSD mask (PSDMASKds)	PSD descriptor
5	Upstream transmit PSD mask (PSDMASKus)	
6	Channel discovery downstream PSD (CDPSDds)	
7	Initial downstream PSD ceiling (CDMAXMASKds)	2 bytes

Table 12-17 – Description of message O-SIGNATURE

	Field name	Format
8	Downstream nominal maximum aggregate transmit power (MAXNOMATPds)	2 bytes
9	Parameters for UPBO reference PSD (UPBOPSD)	UPBOPSD descriptor
10	Maximum target total data rate	2 bytes
11	Downstream maximum SNR margin (MAXSNRMds)	2 bytes
12	Downstream target SNR margin (TARSNRMds)	2 bytes
13	Downstream transmit window length (β_{ds})	1 byte
14	Downstream cyclic prefix	2 bytes
15	Initial value of timing advance	2 bytes
16	Downstream transmitter-referred virtual noise PSD (TXREFVNds)	PSD descriptor
17	SNRM_MODE	1 byte
18	Upstream transmitter-referred virtual noise PSD (TXREFVNus)	PSD descriptor
19	UPBO reference electrical length (UPBOREFEL)	UPBOREFEL descriptor
20	ITU-T G.998.4 parameter field	Variable length
21	ITU-T G.993.5 parameter field	Variable length
22	Alternative electrical length estimation mode control	2 bytes AELE-MODE Control descriptor

…

Field #22 "Alternative electrical length estimation mode control" has 2 bytes containing parameters: Alternative Electrical Length Estimation Mode (AELE-MODE), UPBO Electrical Length Minimum Threshold (UPBOELMT), and RXTHRSHDS, as shown in Table 12-22.1, with the parameters specified in clause 7.2.1.3.2.1.2.

Table 12-22.1 – AELE-MODE Control -Descriptor

Octet	Content of field
1	Bits 0 to 3: UPBOELMT values expressed as a 4-bit unsigned integer in percent (Note). Bits 4 to 5: reserved by ITU and set to 0. Bits 6 to 7: value AELE-MODE expressed as a 2-bit unsigned integer.
2	RXTHRSHDS parameter coded as an eight bit signed integer n, with valid values being all integers in the range from –64 to 0, representing an offset from –100 dBm/Hz as RXTHRSHDS = (−100 + n) dBm/Hz.
NOTE – The only valid value of UPBOELMT is 10. Other values are reserved for future use.	

…

12.3.3.2.1.2 O-UPDATE

The full list of parameters carried by the O-UPDATE message is shown in Table 12-23.

Table 12-23 – Description of message O-UPDATE

	Field name	Format
1	Message descriptor	Message code
2	Final electrical length	2 bytes
3	Updated upstream PSD ceiling (MAXMASKus)	2 bytes
4	Highest allowed upstream sub-carrier	2 bytes
5	Lowest allowed upstream sub-carrier	2 bytes
6	BLACKOUTus set	Bands descriptor
7	Timing advance correction	2 bytes
8	ITU-T G.998.4 parameter field	Variable length
9	ITU-T G.993.5 parameter field	Variable length
10	Extended final electrical length	UPBOXFEL descriptor

…

Field #10 "Extended final electrical length" contains the electrical length. The UPBOXFEL descriptor has the parameter kl_0[*band*] for each upstream band expressed in dB at 1 MHz (see Table 12-23.1, with the parameter specified in clause 7.2.1.3.2.1.2) that the VTU-R shall use to set its upstream PSD starting from the training phase onward. The value shall be coded as a 16-bit number with the LSB weight of 0.1 dB. The valid range of values is from 0 dB to 128 dB with a 0.1 dB step. This value may be different from the value reported by the VTU-R in R-MSG 1 and shall be used by the VTU-R to determine the UPBOMASK, as specified in 7.2.1.3.2.3. This updated UPBOMASK shall be used to form the upstream MEDLEY reference PSD mask (Field #2 of R-PRM).

One value of the parameter kl_0[*band*] is defined per upstream band. The values of kl_0 shall be formatted as shown in Table 12-23.1. If defined with a valid value, this parameter overrides "Final electrical length".

Table 12-23.1 – UPBOXFEL descriptor

Octet	Content of field
1	Number of US bands (nus)
2-3	bits 0-15: value of kl_0[US1] for US1
4-5 (if applicable)	bits 0-15: value of kl_0[US2] for US2
...	
$2 \times n_{us}$, $2 \times n_{us} + 1$	bits 0-15: value of kl_0[US(n_{us})] for US(n_{us})

…

12.3.3.2.2.1 R-MSG 1

…

Table 12-26 – Description of message R-MSG 1

	Field name	Format
1	Message descriptor	Message code
2	Estimate of electrical length	2 bytes
3	Initial upstream PSD ceiling (CDMAXMASKus)	2 bytes
4	Channel discovery upstream PSD (CDPSDus)	PSD descriptor
5	Initialization pilot tones	Tone descriptor
6	Timing advance	2 bytes
7	O-P-PILOT settings	1 byte
8	Upstream transmit window length (β_{us})	1 byte
9	Upstream cyclic prefix length	2 bytes
10	ITU-T G.998.4 parameter field	Variable length
11	ITU-T G.993.5 parameter field	Variable length
12	Extended estimate of electrical length	UPBOXEEL descriptor

…

Field #2 "Estimate of electrical length" shall convey the estimate of the electrical length, expressed in dB at 1 MHz (see 7.2.1.3.2), as determined by the VTU-R. The value shall be coded as a 16-bit number. The value of the electrical length is obtained by multiplying this 16-bit value by 0.1 dB. The valid range of the electrical length is from 0 dB to 128 dB in 0.1 dB steps. Using this estimate of the electrical length, the VTU-R shall derive the upstream power back-off (UPBO) as described in 7.2.1.3. When using the alternative electrical length estimation method (ELE-M1) this parameter contains the value ELEDS.

…

Field #12 "Extended estimated electrical length" contains the estimated electrical length. The UPBOXEEL descriptor has the parameter ELE[*band*] in dB for each downstream band (see Table 12-26.1, with the parameter specified in clause 7.2.1.3.2.1.2). The value shall be coded as a 16-bit number with the LSB weight of 0.1 dB. The valid range of values is from 0 dB to 128 dB with a 0.1 dB step.

Table 12-26.1 – UPBOXEEL descriptor

Octet	Content of field
1	Number of DS bands (n_{ds})
2-3	bits 0-15: value of *ELE*[DS1]
4-5 (if applicable)	bits 0-15: value of *ELE*[DS2]
...	
$2 \times n_{ds}$, $2 \times n_{ds} + 1$	bits 0-15: value of *ELE*[US(n_{ds})]

12.3.5.2 SOC messages exchanged during channel analysis & exchange phase

Figure 12-9 illustrates the SOC message exchange between the VTU-O and VTU-R during the channel analysis & exchange phase. It also summarizes the content of each message.

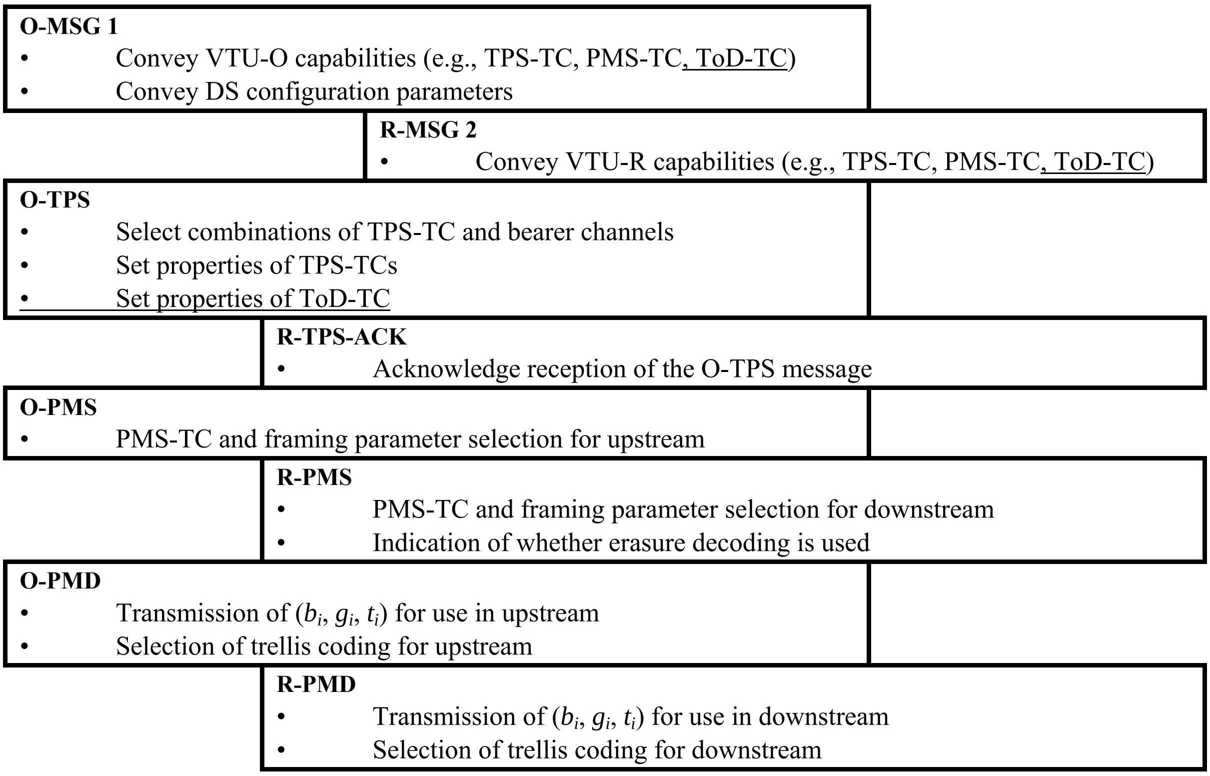


Figure 12-9 – SOC messages exchanged during the channel analysis & exchange phase

12.3.5.2.1 VTU-O messages sent during the channel analysis & exchange phase

12.3.5.2.1.1 O-MSG 1

The O-MSG 1 message contains the capabilities of the VTU-O and the requirements for downstream transmission (such as margin). The full list of parameters carried by the O-MSG 1 message is shown in Table 12-42.

Table 12-42 – Description of message O-MSG 1

	Field name	Format
1	Message descriptor	Message code
2	Downstream target SNR margin (TARSNRMds)	2 bytes
3	Downstream minimum SNR margin (MINSNRMds)	2 bytes
4	Downstream maximum SNR margin (MAXSNRMds)	2 bytes
5	RA-MODE	1 byte
6	NTR	1 byte
7	TPS-TC capabilities	see Table 12-43
8	PMS-TC capabilities	see Table 12-45
9	Downstream rate adaptation downshift SNR margin (RA-DSNRMds)	2 bytes
10	Downstream rate adaptation downshift time interval (RA-DTIMEds)	2 bytes
11	Downstream rate adaptation upshift SNR margin (RA-USNRMds)	2 bytes
12	Downstream rate adaptation upshift time interval (RA-UTIMEds)	2 bytes

Table 12-42 – Description of message O-MSG 1

	Field name	Format
13	Support of "Flexible OH frame type 2" downstream	1 byte
14	SOS Multi-step activation downstream	1 byte
15	SOS Multi-step activation upstream	1 byte
16	MIN-SOS-BR-ds0	2 bytes
17	MIN-SOS-BR-ds1	2 bytes
18	SOS-TIME-ds	1 byte
19	SOS-NTONES-ds	1 byte
20	SOS-CRC-ds	2 bytes
21	MAX-SOS-ds	1 byte
22	SNRMOFFSET-ROC-ds	2 bytes
23	INPMIN-ROC-ds	1 byte
24	ITU-T G.998.4 parameter field	Variable length
25	ITU-T G.993.5 parameter field	Variable length
26	*REINIT_TIME_THRESHOLDds*	1 byte
27	Time synchronization capability	1 byte

…

Field #26 control parameter "*REINIT_TIME_THRESHOLDds*" contains the threshold for re-initialization based on SES as specified in the CO-MIB, to be used in downstream by the VTU-R receiver when Re-initialization policy 1 is used (see clause 12.4.1). The value shall be coded as an unsigned integer representing the maximum number of SES. The valid range is from 5 to 31.

Field #27 "Time synchronization capability" indicates the time synchronization capability of the VTU-O. The field shall be coded as a single byte [0000 000t], where:

– t=0 indicates that time synchronization is not supported;

– t=1 indicates that time synchronization is supported.

…

12.3.5.2.1.2 O-TPS

The O-TPS message conveys the TPS-TC configuration for both the upstream and the downstream directions. It is based on the capabilities that were indicated in O-MSG 1 and R-MSG 2. The full list of parameters carried by the O-TPS message is shown in Table 12-46.

Table 12-46 – Description of message O-TPS

	Field name	Format
1	Message descriptor	Message code
2	TPS-TC configuration	See Table 12-47
3	Maximum delay variation	See Table 12-48
4	ROC and SOS enable	1 byte

Table 12-46 – Description of message O-TPS

	Field name	Format
5	ITU-T G.998.4 parameter field	Variable length
6	ITU-T G.993.5 parameter field	Variable length
7	Time synchronization enable	1 byte

…

Field #7 "Time synchronization enable" indicates whether time synchronization is enabled. The field shall be formatted as [0000 00b_1b_0]. The valid values are:

– If b_1b_0=00, time synchronization is not enabled.

– If b_1b_0=01, frequency synchronization with the PMD sampling clock being frequency locked to the ToD network clock is used for time synchronization.

– If b_1b_0=10, frequency synchronization via the processing of ToD phase difference values is used for time synchronization.

– b_1b_0=11 is reserved by ITU-T.

...

For a bearer mapped to an ATM or STM TPS-TC, bits 0 and 1 of the TPS-TC options field are reserved by ITU-T and shall be set to ZERO.

For the upstream bearer channel(s), bits 2-7 shall be set to ZERO.

For the downstream bearer channel(s), bits 2-7 shall be coded as follows:

– Bit 2 contains the selection of the CIpolicy that shall be used in the downstream direction. A value of ZERO indicates that the mandatory CIpolicy shall be used. A value of ONE indicates that the optional CIpolicy 1 (see 12.3.7) shall be used. The CO shall only select optional CIpolicies for which the VTU-R has indicated support (see 12.3.5.2.2.1). A value of ONE can only be selected if no more than one bearer channel is active.

– Bit 3 is reserved by ITU-T and set to ZERO.

– Bit 4 contains the selection of the re-initialization policy that shall be used in the downstream direction for that bearer channel ($RIpolicyds_n$). A value of ZERO indicates that the mandatory re-initialization policy 0 shall be used. A value of ONE indicates that the optional re-initialization policy 1 (see clause 12.1.4) shall be used. The same value shall be indicated for all bearer channels. The CO shall only select optional re-initialization policies for which the VTU-R has indicated support (see clause 12.3.5.2.2.1).

– Bits ~~3~~5-7 are reserved by the ITU-T and shall be set to ZERO.

…

12.3.5.2.2 VTU-R messages sent during the channel analysis & exchange phase

12.3.5.2.2.1 R-MSG 2

The R-MSG 2 message conveys VTU-R information to the VTU-O. The full list of parameters carried by the R-MSG 2 message is shown in Table 12-53.

Table 12-53 – Description of message R-MSG 2

	Field name	Format
1	Message descriptor	Message code
2	TPS-TC capabilities	See Table 12-54
3	PMS-TC capabilities	See Table 12-55
4	Support of "Flexible OH frame type 2" upstream	1 byte
5	SOS Multi-step activation downstream	1 byte
6	SOS Multi-step activation upstream	1 byte
7	ITU-T G.998.4 parameter field	Variable length
8	ITU-T G.993.5 parameter field	Variable length
9	Time synchronization capability	1 byte
10	Time synchronization period (*TSP*)	1 byte

…

Field #9 "Time synchronization capability" indicates the time synchronization capability of the VTU-R. The field shall be coded as a single byte [0000 00pt], where:

– t=0 indicates that time synchronization is not supported;

– t=1 indicates that time synchronization is supported;

– p = 0 indicates that, if time synchronization is enabled, the ToD phase difference values shall be transported through the OH frame;

– p = 1 indicates that, if time synchronization is enabled, the ToD phase difference values shall be transported through the eoc.

NOTE – If time synchronization is not supported, then t=0 and the value of p and the contents of field #10 should be ignored by the VTU-O.

Field #10 indicates the time synchronization period (*TSP*), defined as maximum increment in number of superframes of the t_1 instant number contained in two consecutive transmissions of the time synchronization eoc message. *TSP* is represented in one byte with valid values n = 10…255, indicating $TSP = 16 \times n$.

…

For a bearer mapped to an ATM or STM TPS-TC, bits 0 and 1 shall be set to ZERO at the transmitter and ignored by the receiver.

Bit 2 indicates whether the optional channel initialization policy is supported for that bearer channel. This bit shall be set to ONE to indicate support for this policy.

Bit 3 is reserved by ITU-T and shall be set to ZERO.

Bit 4 indicates whether the optional Re-initialization policy 1 (i.e., $RIpolicyds_n$=1) is supported (see clause 12.1.4) for that bearer channel. This bit shall be set to ONE to indicate support for this policy. This bit shall be set to the same value for all bearer channels.

Bits ~~3~~5-7 are reserved by ITU-T and shall be set to ZERO.

…

20 Region B (Europe)

Revise Annex B as follows:

Annex B

Region B (Europe)

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

B.1 Band plans

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

Plan 997	The original plan 997 (f_{max} = 12 MHz).
Plan 997E17	Plan 997 directly extended to f_{max} = 17.664 MHz.
Plan 997E30	Plan 997 directly extended to f_{max} = 30 MHz.
	NOTE – Plan 997E17 and plan 997 are truncated versions of plan 997E30.
Plan 998	The original plan 998 (f_{max} = 12 MHz).
Plan 998E17	Plan 998 directly extended to f_{max} = 17.664 MHz.
Plan 998E30	Plan 998 directly extended to f_{max} = 30 MHz.
	NOTE – Plan 998E17 and plan 998 are truncated versions of plan 998E30.
Plan 998ADE17	Plan 998 extended to f_{max} = 17.664 MHz (downstream transmission only above 12 MHz)
Plan 998ADE30	Plan 998 extended to f_{max} = 30 MHz.
	NOTE – Plan 998ADE17 and plan 998 are truncated versions of plan 998ADE30.
Plan HPE17	Band plan for operation between 7.05 MHz and 17.664 MHz.
Plan HPE30	Band plan for operation between 7.05 MHz and 30 MHz.
	NOTE – Plan HPE17 is a truncated version of plan HPE30.

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

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

Band plan	Band-edge frequencies (as defined in the generic band plan in 7.1.2)										
	f_{0L} kHz	f_{0H} kHz	f_1 kHz	f_2 kHz	f_3 kHz	f_4 kHz	f_5 kHz	f_6 kHz	f_7 kHz	f_8 kHz	f_9 kHz
	US0		DS1	US1	DS2	US2	DS3	US3	DS4	US4	
997	25	138	138	3000	5100	7050	12000	N/A	N/A	N/A	N/A
	25	276	276								
997E17	25	138	138	3000	5100	7050	12000	14000	17664	N/A	N/A
997E30	N/A	N/A	138	3000	5100	7050	12000	14000	19500	27000	30000
	US0		DS1	US1	DS2	US2	US3	DS3	US4	DS4	
998	25	138	138	3750	5200	8500	12000	N/A	N/A	N/A	N/A
	25	276	276								
	120	276	276								
	N/A	N/A	138								
998E17	N/A	N/A	138	3750	5200	8500	12000	14000	17664	N/A	N/A
	N/A	N/A	276	3750	5200	8500	12000	14000	17664	N/A	N/A
998E30	N/A	N/A	138	3750	5200	8500	12000	14000	21450	24890	30000
	N/A	N/A	276	3750	5200	8500	12000	14000	21450	24890	30000
	US0		DS1	US1	DS2	US2	DS3	US3			
998ADE17	25	138	138	3750	5200	8500	12000	17664	N/A		
	120	276	276								
	25	276	276								
	N/A	N/A	276								

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

Band plan	Band-edge frequencies (as defined in the generic band plan in 7.1.2)										
	f_{0L} kHz	f_{0H} kHz	f_1 kHz	f_2 kHz	f_3 kHz	f_4 kHz	f_5 kHz	f_6 kHz	f_7 kHz	f_8 kHz	f_9 kHz
998ADE30	N/A	N/A	138	3750	5200	8500	12000	24890	30000		
	N/A	N/A	276								
						DS2	US2	US3	DS3	US4	DS4
HPE17	N/A	N/A	N/A	N/A	7050	10125	12000	14000	17664	N/A	N/A
HPE30	N/A	N/A	N/A	N/A	7050	10125	12000	14000	21450	24890	30000

~~NOTE 1 – Flexibility in the bandwidth used for US0 is under study in ETSI TC-TM6.~~

NOTE 1~~2~~ – N/A in the columns f_{0L} and f_{0H} designates a band plan variant that does not use US0.

NOTE 2~~3~~ – The capability to support ~~of~~ US0 together with profile 17a is ~~not~~ required for European VDSL2. ~~This band plan and PSD definitions are given in case profile 17a and US0 are selected during handshake.~~

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

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

B.2 Limit PSD mask options

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

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

Short name	Limit PSD mask (Long name)	Frequency	
		US0 type A/B/M (see Note)	Highest used upstream or downstream frequency (kHz)
B7-1	997-M1c-A-7	A	7050
~~B7-2~~	~~997-M1x-M-8~~	~~M~~	~~8832~~
B7-3	997-M1x-M	M	12000
~~B7-4~~	~~997-M2x-M-8~~	~~M~~	~~8832~~
~~B7-5~~	~~997-M2x-A~~	~~A~~	~~12000~~
~~B7-6~~	~~997-M2x-M~~	~~M~~	~~12000~~
B7-7	HPE17-M1-NUS0	N/A	17664
B7-8	HPE30-M1-NUS0	N/A	30000
B7-9	997E17-M2x-A	A	17664
B7-10	997E30-M2x-NUS0	N/A	30000

NOTE – The US0 types stand for:
- US0 type A corresponds to Annex A of Rec. ITU-T G.992.5 [11];
- US0 type B corresponds to Annex B of Rec. ITU-T G.992.5 [11];
- US0 type M corresponds to Annex M of Recommendations ITU-T G.992.3 [10] or ITU-T G.992.5 [11];
- US0 type N/A designates a band plan variant that does not use US0.

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

Short name	Limit PSD mask (Long name)	Frequency	
		US0 type A/B/M (see Note)	Highest used upstream or downstream frequency (kHz)
B8-1	998-M1x-A	A	12000
B8-2	998-M1x-B	B	12000
B8-3	998-M1x-NUS0	N/A	12000
B8-4	998-M2x-A	A	12000

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

Short name	Limit PSD mask (Long name)	Frequency	
		US0 type A/B/M (see Note)	Highest used upstream or downstream frequency (kHz)
B8-5	998-M2x-M	M	12000
B8-6	998-M2x-B	B	12000
B8-7	998-M2x-NUS0	N/A	12000
B8-8	998E17-M2x-NUS0	N/A	17664
B8-9	998E17-M2x-NUS0-M	N/A	17664
B8-10	998ADE17-M2x-NUS0-M	N/A	17664
B8-11	998ADE17-M2x-A	A	17664
B8-12	998ADE17-M2x-B	B	17664
B8-13	998E30-M2x-NUS0	N/A	30000
B8-14	998E30-M2x-NUS0-M	N/A	30000
B8-15	998ADE30-M2x-NUS0-M	N/A	30000
B8-16	998ADE30-M2x-NUS0-A	N/A	30000
B8-17	998ADE17-M2x-M	M	17664

NOTE – The US0 types stand for:

- US0 type A corresponds to Annex A of Rec. ITU-T G.992.5;
- US0 type B corresponds to Annex B of Rec ITU-T G.992.5;
- US0 type M corresponds to Annex M of Recommendation ITU-T G.992.3 [10] or ITU-T G.992.5 [11];
- US0 type N/A designates a band plan variant that does not use US0;
- 998ADExx-M2x-NUS0-M designate the variants in which DS1 starts at 276 kHz instead of 138 kHz.

B.2.1 General requirements in the band below 4 kHz

The noise in the voice band measured with psophometric weighting according to ITU-T O.41[15] 3.3 shall not exceed –68 dBm. The psophometer shall be used in bridging mode and shall be calibrated for 600 ohm termination.

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

Table B.4 – VTU-R limit PSD masks for band plans 997 (and its extensions), HPE17 and HPE30

Name	B7-1	~~B7-2~~	B7-3	~~B7-4~~	~~B7-5~~	~~B7-6~~	B7-7	B7-8	B7-9	B7-10
Long name	997-M1-c-A-7	~~997-M1-x-M-8~~	997-M1-x-M	~~997-M2x-M-8~~	~~997-M2x-A~~	~~997-M2x-M~~	HPE17-M1-NUS0	HPE30-M1-NUS0	997E17-M2x-A	997E30-M2x-NUS0
kHz	dBm/Hz	~~dBm/Hz~~	dBm/Hz	~~dBm/Hz~~	~~dBm/Hz~~	~~dBm/Hz~~	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz
0	–97.5	~~–97.5~~	–97.5	~~–97.5~~	~~–97.5~~	~~–97.5~~	–100	–100	–97.5	–100
4	–97.5	~~–97.5~~	–97.5	~~–97.5~~	~~–97.5~~	~~–97.5~~	–100	–100	–97.5	–100
4	–92.5	~~–92.5~~	–92.5	~~–92.5~~	~~–92.5~~	~~–92.5~~	–100	–100	–97.5	–100
25.875	–34.5	~~–37.5~~	–37.5	~~–37.5~~	~~–34.5~~	~~–37.5~~	–100	–100	–34.5	–100
50	–34.5	~~–37.5~~	–37.5	~~–37.5~~	~~–34.5~~	~~–37.5~~	–100	–100	–34.5	–100
80	–34.5	~~–37.5~~	–37.5	~~–37.5~~	~~–34.5~~	~~–37.5~~	–100	–100	–34.5	–100
120	–34.5	~~–37.5~~	–37.5	~~–37.5~~	~~–34.5~~	~~–37.5~~	–100	–100	–34.5	–100
138	–34.5	~~–37.5~~	–37.5	~~–37.5~~	~~–34.5~~	~~–37.5~~	–100	–100	–34.5	–100
225	Interp	~~–37.5~~	–37.5	~~–37.5~~	~~Interp~~	~~–37.5~~	–100	–100	Interp	–100
243	−93.2	~~–37.5~~	–37.5	~~–37.5~~	~~–93.2~~	~~–37.5~~	–100	–100	–93.2	–100
276	Interp	~~–37.5~~	–37.5	~~–37.5~~	~~Interp~~	~~–37.5~~	–100	–100	Interp	–100
493.41	Interp	~~–97.9~~	–97.9	~~–97.9~~	~~Interp~~	~~–97.9~~	–100	–100	Interp	–100
686	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–100
2825	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–100
3000	–80	~~–80~~	–80	~~–80~~	~~–80~~	~~–80~~	–100	–100	–80	–80
3000	–56.5	~~–56.5~~	–56.5	~~–50.3~~	~~–50.3~~	~~–50.3~~	–100	–100	–50.3	–50.3
3575	–56.5	~~–56.5~~	–56.5	~~Interp~~	~~Interp~~	~~Interp~~	–100	–100	Interp	Interp
3750	–56.5	~~–56.5~~	–56.5	~~Interp~~	~~Interp~~	~~Interp~~	–100	–100	Interp	Interp
5100	–56.5	~~–56.5~~	–56.5	~~–52.6~~	~~–52.6~~	~~–52.6~~	–100	–100	–52.6	–52.6
5100	–80	~~–80~~	–80	~~–80~~	~~–80~~	~~–80~~	–100	–100	–80	–80
5275	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–100
6875	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–100
7050	–100	~~–80~~	–80	~~–80~~	~~–80~~	~~–80~~	–100	–100	–80	–80
7050	–100	~~–56.5~~	–56.5	~~–54~~	~~–54~~	~~–54~~	–100	–100	–54	–54
8325	–100	~~–56.5~~	–56.5	~~Interp~~	~~Interp~~	~~Interp~~	–100	–100	Interp	Interp
9950	–100	~~–56.5~~	–56.5	~~Interp~~	~~Interp~~	~~Interp~~	–100	–100	Interp	Interp
10125	–100	~~–56.5~~	–56.5	~~–55.5~~	~~–55.5~~	~~–55.5~~	–80	–80	–55.5	–55.5
10125	–100	~~–56.5~~	–56.5	~~–55.5~~	~~–55.5~~	~~–55.5~~	–56.5	–56.5	–55.5	–55.5
12000	–100	~~–56.5~~	–56.5	~~–55.5~~	~~–55.5~~	~~–55.5~~	–56.5	–56.5	–55.5	–55.5
12000	–100	~~–80~~	–80	~~–80~~	~~–80~~	~~–80~~	–56.5	–56.5	–80	–80
12175	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–56.5	–56.5	–100	–100
13825	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–56.5	–56.5	–100	–100
14000	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–56.5	–56.5	–80	–80
14000	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–80	–80	–56.5	–56.5

Table B.4 – VTU-R limit PSD masks for band plans 997 (and its extensions), HPE17 and HPE30

Name	B7-1	~~B7-2~~	B7-3	~~B7-4~~	~~B7-5~~	~~B7-6~~	B7-7	B7-8	B7-9	B7-10
Long name	**997-M1-c-A-7**	~~**997-M1-x-M-8**~~	**997-M1-x-M**	~~**997-M2x-M-8**~~	~~**997-M2x-A**~~	~~**997-M2x-M**~~	**HPE17-M1-NUS0**	**HPE30-M1-NUS0**	**997E17-M2x-A**	**997E30-M2x-NUS0**
kHz	**dBm/Hz**	~~**dBm/Hz**~~	**dBm/Hz**	~~**dBm/Hz**~~	~~**dBm/Hz**~~	~~**dBm/Hz**~~	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**
14175	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	Interp	Interp
17664	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–56.5	–56.5
19500	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–80	–56.5
19500	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–80	–80
19675	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–100
21275	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–100
21450	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–80	–100	–100
21450	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–56.5	–100	–100
24890	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–56.5	–100	–100
24890	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–80	–100	–100
25065	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–100
26825	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–100
27000	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–80
27000	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–56.5
30000	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–56.5
30000	110	~~110~~	110	~~110~~	~~110~~	~~110~~	110	110	110	–80
30175	110	~~110~~	110	~~110~~	~~110~~	~~110~~	110	110	110	110
≥30175	–110	~~–110~~	–110	~~–110~~	~~–110~~	~~–110~~	–110	–110	–110	–110

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

– below 2825 kHz on a dB/log(*f*) basis; and
– above 2825 kHz on a dB/*f* basis.

~~NOTE – In the limit PSD masks B7-2 and B7-4, the PSD above 8832 kHz should be considered preliminary. Reduction in the mask in the band from 8832 kHz to 12000 kHz is for further study. The minimum roll-off of the anti-alias filter should be specified to limit unnecessary FEXT to full bandwidth solutions sharing the same cable, to protect the amateur radio band (10.10 MHz to 10.15 MHz), and to provide flexibility for future band plan evolution.~~

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

Table B.5 – VTU-O limit PSD masks for band plans 997 (and its extensions), HPE17 and HPE30

Name	B7-1	~~B7-2~~	B7-3	~~B7-4~~	~~B7-5~~	~~B7-6~~	B7-7	B7-8	B7-9	B7-10
Long name	997-M1c-A-7	~~997-M1x-M-8~~	997-M1x-M	~~997-M2x-M-8~~	~~997-M2x-A~~	~~997-M2x-M~~	HPE17-M1-NUS0	HPE30-M1-NUS0	997E17-M2x-A	997E30-M2x-NUS0
kHz	dBm/Hz	~~dBm/Hz~~	dBm/Hz	~~dBm/Hz~~	~~dBm/Hz~~	~~dBm/Hz~~	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz
0	–97.5	~~–97.5~~	–97.5	~~–97.5~~	~~–97.5~~	~~–97.5~~	–97.5	–97.5	–97.5	–97.5
4	–97.5	~~–97.5~~	–97.5	~~–97.5~~	~~–97.5~~	~~–97.5~~	–97.5	–97.5	–97.5	–97.5
4	–92.5	~~–92.5~~	–92.5	~~–92.5~~	~~–92.5~~	~~–92.5~~	–97.5	–97.5	–92.5	–92.5
80	–72.5	~~–92.5~~	–92.5	~~–92.5~~	~~–72.5~~	~~–92.5~~	–97.5	–97.5	–72.5	–72.5
101.2	Interp	~~–92.5~~	–92.5	~~–92.5~~	~~Interp~~	~~–92.5~~	–97.5	–97.5	Interp	Interp
138	–49.5	~~Interp~~	Interp	~~Interp~~	~~–44.2~~	~~Interp~~	–100	–100	–44.2	–44.2
138	–49.5	~~Interp~~	Interp	~~Interp~~	~~–36.5~~	~~Interp~~	–100	–100	–36.5	–36.5
227.11	–49.5	~~–62~~	–62	~~–62~~	~~–36.5~~	~~–62~~	–100	–100	–36.5	–36.5
276	–49.5	~~–48.5~~	–48.5	~~–48.5~~	~~–36.5~~	~~–48.5~~	–100	–100	–36.5	–36.5
276	–49.5	~~–36.5~~	–36.5	~~–36.5~~	~~–36.5~~	~~–36.5~~	–100	–100	–36.5	–36.5
1104	–49.5	~~–36.5~~	–36.5	~~–36.5~~	~~–36.5~~	~~–36.5~~	–100	–100	–36.5	–36.5
1622	–49.5	~~–46.5~~	–46.5	~~–46.5~~	~~–46.5~~	~~–46.5~~	–100	–100	–46.5	–46.5
2208	–49.5	~~–48~~	–48	~~Interp~~	~~Interp~~	~~Interp~~	–100	–100	Interp	Interp
2236	–49.5	~~Interp~~	Interp	~~Interp~~	~~Interp~~	~~Interp~~	–100	–100	Interp	Interp
2249	–49.5	~~–49.5~~	–49.5	~~Interp~~	~~Interp~~	~~Interp~~	–100	–100	Interp	Interp
2423	–56.5	~~Interp~~	Interp	~~Interp~~	~~Interp~~	~~Interp~~	–100	–100	Interp	Interp
2500	–56.5	~~–56.5~~	–56.5	~~Interp~~	~~Interp~~	~~Interp~~	–100	–100	Interp	Interp
3000	–56.5	~~–56.5~~	–56.5	~~–49.6~~	~~–49.6~~	~~–49.6~~	–100	–100	–49.6	–49.6
3000	–80	~~–80~~	–80	~~–80~~	~~–80~~	~~–80~~	–100	–100	–80	–80
3175	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–100
4925	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–100
5100	–80	~~–80~~	–80	~~–80~~	~~–80~~	~~–80~~	–100	–100	–80	–80
5100	–56.5	~~–56.5~~	–56.5	~~–52.6~~	~~–52.6~~	~~–52.6~~	–100	–100	–52.6	–52.6
5200	–56.5	~~–56.5~~	–56.5	~~Interp~~	~~Interp~~	~~Interp~~	–100	–100	Interp	Interp
6875	–56.5	~~–56.5~~	–56.5	~~Interp~~	~~Interp~~	~~Interp~~	–100	–100	Interp	Interp
7050	–56.5	~~–56.5~~	–56.5	~~–54~~	~~–54~~	~~–54~~	–80	–80	–54	–54
7050	–80	~~–80~~	–80	~~–80~~	~~–80~~	~~–80~~	–56.5	–56.5	–80	–80
7225	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–56.5	–56.5	–100	–100
10125	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–56.5	–56.5	–100	–100
10125	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–80	–80	–100	–100
10300	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–100
11825	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–100
12000	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–80	–80
12000	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–56.5	–56.5
13825	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–56.5	–56.5

Table B.5 – VTU-O limit PSD masks for band plans 997 (and its extensions), HPE17 and HPE30

Name	B7-1	~~B7-2~~	B7-3	~~B7-4~~	~~B7-5~~	~~B7-6~~	B7-7	B7-8	B7-9	B7-10
Long name	**997-M1c-A-7**	~~**997-M1x-M-8**~~	**997-M1x-M**	~~**997-M2x-M-8**~~	~~**997-M2x-A**~~	~~**997-M2x-M**~~	**HPE17-M1-NUS0**	**HPE30-M1-NUS0**	**997E17-M2x-A**	**997E30-M2x-NUS0**
kHz	**dBm/Hz**	~~**dBm/Hz**~~	**dBm/Hz**	~~**dBm/Hz**~~	~~**dBm/Hz**~~	~~**dBm/Hz**~~	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**
14000	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–80	–80	–56.5	–56.5
14000	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–56.5	–56.5	–80	–80
14175	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–56.5	–56.5	–100	–100
17664	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–56.5	–56.5	–100	–100
19325	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	Interp	–56.5	–100	–100
19500	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	Interp	–56.5	–100	–80
19500	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	Interp	–56.5	–100	–56.5
21000	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–80	–56.5	–100	–56.5
21450	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–56.5	–100	–56.5
21450	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–80	–100	–56.5
21625	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–56.5
24715	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–100	–100	–56.5
24890	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–80	–100	–56.5
24890	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–56.5	–100	–56.5
27000	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–56.5	–100	–56.5
27000	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–56.5	–100	–80
27175	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–56.5	–100	–100
30000	–100	~~–100~~	–100	~~–100~~	~~–100~~	~~–100~~	–100	–56.5	–100	–100
30000	–110	~~–110~~	–110	~~–110~~	~~–110~~	~~–110~~	–110	–80	–110	–110
30175	–110	~~–110~~	–110	~~–110~~	~~–110~~	~~–110~~	–110	–110	–110	–110
≥30175	–110	~~–110~~	–110	~~–110~~	~~–110~~	~~–110~~	–110	–110	–110	–110

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

– below f_1 on a dB/log(f) basis; and

– above f_1 on a dB/f basis,

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

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

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

– above 138 kHz on a dB/f basis.

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

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

Name	B8-1	B8-2	B8-3	B8-4	B8-5	B8-6	B8-7	B8-8	B8-9	B8-10	B8-11	B8-12	B8-13	B8-14	B8-15	B8-16	B8-17
Long name	998-M1x-A	998-M1x-B	998-M1x-NUS0	998-M2x-A	998-M2x-M	998-M2x-B	998-M2x-NUS0	998E17-M2x-NUS0	998E17-M2x-NUS0-M	998ADE17-M2x-NUS0-M	998ADE17-M2x-A	998ADE17-M2x-B	998E30-M2x-NUS0	998E30-M2x-NUS0-M	998ADE30-M2x-NUS0-M	998ADE30-M2x-NUS0-A	998ADE17-M2x-M
kHz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz
0	–97.5	–97.5	–100	–97.5	–97.5	–97.5	–100	–100	–100	–100	–97.5	–97.5	–100	–100	–100	–100	–97.5
4	–97.5	–97.5	–100	–97.5	–97.5	–97.5	–100	–100	–100	–100	–97.5	–97.5	–100	–100	–100	–100	–97.5
4	–92.5	–92.5	–100	–92.5	–92.5	–92.5	–100	–100	–100	–100	–92.5	–92.5	–100	–100	–100	–100	–92.5
25.875	–34.5	–92.5	–100	–34.5	–37.5	–92.5	–100	–100	–100	–100	–34.5	–92.5	–100	–100	–100	–100	–37.5
50	–34.5	–90	–100	–34.5	–37.5	–90	–100	–100	–100	–100	–34.5	–90	–100	–100	–100	–100	–37.5
80	–34.5	–81.8	–100	–34.5	–37.5	–81.8	–100	–100	–100	–100	–34.5	–81.8	–100	–100	–100	–100	–37.5
120	–34.5	–34.5	–100	–34.5	–37.5	–34.5	–100	–100	–100	–100	–34.5	–34.5	–100	–100	–100	–100	–37.5
138	–34.5	–34.5	–100	–34.5	–37.5	–34.5	–100	–100	–100	–100	–34.5	–34.5	–100	–100	–100	–100	–37.5
225	Interp	–34.5	–100	Interp	–37.5	–34.5	–100	–100	–100	–100	Interp	–34.5	–100	–100	–100	–100	–37.5
243	–93.2	–34.5	–100	–93.2	–37.5	–34.5	–100	–100	–100	–100	–93.2	–34.5	–100	–100	–100	–100	–37.5
276	Interp	–34.5	–100	Interp	–37.5	–34.5	–100	–100	–100	–100	Interp	–34.5	–100	–100	–100	–100	–37.5
307	Interp	Interp	–100	Interp	Interp	Interp	–100	–100	–100	–100	Interp	Interp	–100	–100	–100	–100	Interp
493.41	Interp	Interp	–100	Interp	–97.9	Interp	–100	–100	–100	–100	Interp	Interp	–100	–100	–100	–100	–97.9
508.8	Interp	–98	–100	Interp	Interp	–98	–100	–100	–100	–100	Interp	–98	–100	–100	–100	–100	Interp
686	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100
3575	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100
3750	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80
3750	–56.5	–56.5	–56.5	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2

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

Name	B8-1	B8-2	B8-3	B8-4	B8-5	B8-6	B8-7	B8-8	B8-9	B8-10	B8-11	B8-12	B8-13	B8-14	B8-15	B8-16	B8-17
Long name	998-M1x-A	998-M1x-B	998-M1x-NUS0	998-M2x-A	998-M2x-M	998-M2x-B	998-M2x-NUS0	998E17-M2x-NUS0	998E17-M2x-NUS0-M	998ADE17-M2x-NUS0-M	998ADE17-M2x-A	998ADE17-M2x-B	998E30-M2x-NUS0	998E30-M2x-NUS0-M	998ADE30-M2x-NUS0-M	998ADE30-M2x-NUS0-A	998ADE17-M2x-M
kHz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz
5100	–56.5	–56.5	–56.5	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp
5200	–56.5	–56.5	–56.5	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7
5200	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80
5375	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100
8325	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100
8500	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80
8500	–56.5	–56.5	–56.5	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8
10000	–56.5	–56.5	–56.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5
12000	–56.5	–56.5	–56.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5	–55.5
12000	–80	–80	–80	–80	–80	–80	–80	–56.5	–56.5	–80	–80	–80	–56.5	–56.5	–80	–80	–80
12175	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–100	–100	–100	–56.5	–56.5	–100	–100	–100
14000	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–100	–100	–100	–56.5	–56.5	–100	–100	–100
14000	–100	–100	–100	–100	–100	–100	–100	–80	–80	–100	–100	–100	–80	–80	–100	–100	–100
14175	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100
21275	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100
21450	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–80	–80	–100	–100	–100
21450	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–100	–100	–100
24715	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–100	–100	–100
24890	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–80	–80	–100
24890	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–80	–80	–56.5	–56.5	–100

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

Name	B8-1	B8-2	B8-3	B8-4	B8-5	B8-6	B8-7	B8-8	B8-9	B8-10	B8-11	B8-12	B8-13	B8-14	B8-15	B8-16	B8-17
Long name	998-M1x-A	998-M1x-B	998-M1x-NUS0	998-M2x-A	998-M2x-M	998-M2x-B	998-M2x-NUS0	998E17-M2x-NUS0	998E17-M2x-NUS0-M	998ADE17-M2x-NUS0-M	998ADE17-M2x-A	998ADE17-M2x-B	998E30-M2x-NUS0	998E30-M2x-NUS0-M	998ADE30-M2x-NUS0-M	998ADE30-M2x-NUS0-A	998ADE17-M2x-M
kHz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz	dBm/Hz
25065	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–100
30000	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–100
30000	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–80	–80	–110
30175	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110
≥30175	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110

NOTE – The PSD values between breakpoints including the values marked by "Interp" shall be obtained by interpolation between adjacent breakpoints as follows:
- below 3575 kHz on a dB/log(*f*) basis; and
- above 3575 kHz on a dB/*f* basis.

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

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

Name	B8-1	B8-2	B8-3	B8-4	B8-5	B8-6	B8-7	B8-8	B8-9	B8-10	B8-11	B8-12	B8-13	B8-14	B8-15	B8-16	B8-17
Long name	**998-M1x-A**	**998-M1x-B**	**998-M1x-NUS0**	**998-M2x-A**	**998-M2x-M**	**998-M2x-B**	**998-M2x-NUS0**	**998E17-M2x-NUS0**	**998E17-M2x-NUS0-M**	**998ADE17-M2x-NUS0-M**	**998ADE17-M2x-A**	**998ADE17-M2x-B**	**998E30-M2x-NUS0**	**998E30-M2x-NUS0-M**	**998ADE30-M2x-NUS0-M**	**998ADE30-M2x-NUS0-A**	**998ADE17-M2x-M**
kHz	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**
0	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5
4	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5	–97.5
4	–92.5	–92.5	–92.5	–92.5	–92.5	–92.5	–92.5	–92.5	–92.5	–92.5	–92.5	–92.5	–92.5	–92.5	–92.5	–92.5	–92.5
80	–72.5	–92.5	–72.5	–72.5	–92.5	–92.5	–72.5	–72.5	–92.5	–92.5	–72.5	–92.5	–72.5	–92.5	–92.5	–72.5	–92.5
101.2	Interp	–92.5	Interp	Interp	–92.5	–92.5	Interp	Interp	–92.5	–92.5	Interp	–92.5	Interp	–92.5	–92.5	Interp	–92.5
138	–44.2	Interp	–44.2	–44.2	Interp	Interp	–44.2	–44.2	Interp	Interp	–44.2	Interp	–44.2	Interp	Interp	–44.2	Interp
138	–36.5	Interp	–36.5	–36.5	Interp	Interp	–36.5	–36.5	Interp	Interp	–36.5	Interp	–36.5	Interp	Interp	–36.5	Interp
227.11	–36.5	–62	–36.5	–36.5	–62	–62	–36.5	–36.5	–62	–62	–36.5	–62	–36.5	–62	–62	–36.5	–62
276	–36.5	–48.5	–36.5	–36.5	–48.5	–48.5	–36.5	–36.5	–48.5	–48.5	–36.5	–48.5	–36.5	–48.5	–48.5	–36.5	–48.5
276	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5
1104	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5	–36.5
1622	–46.5	–46.5	–46.5	–46.5	–46.5	–46.5	–46.5	–46.5	–46.5	–46.5	–46.5	–46.5	–46.5	–46.5	–46.5	–46.5	–46.5
2208	–48	–48	–48	–48	–48	–48	–48	–48	–48	–48	–48	–48	–48	–48	–48	–48	–48
2249	–49.5	–49.5	–49.5	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp
2500	–56.5	–56.5	–56.5	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp
3750	–56.5	–56.5	–56.5	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2	–51.2
3750	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80
3925	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100
5025	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100
5200	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80

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

Name	B8-1	B8-2	B8-3	B8-4	B8-5	B8-6	B8-7	B8-8	B8-9	B8-10	B8-11	B8-12	B8-13	B8-14	B8-15	B8-16	B8-17
Long name	**998-M1x-A**	**998-M1x-B**	**998-M1x-NUS0**	**998-M2x-A**	**998-M2x-M**	**998-M2x-B**	**998-M2x-NUS0**	**998E17-M2x-NUS0**	**998E17-M2x-NUS0-M**	**998ADE17-M2x-NUS0-M**	**998ADE17-M2x-A**	**998ADE17-M2x-B**	**998E30-M2x-NUS0**	**998E30-M2x-NUS0-M**	**998ADE30-M2x-NUS0-M**	**998ADE30-M2x-NUS0-A**	**998ADE17-M2x-M**
kHz	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**
5200	–56.5	–56.5	–56.5	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7	–52.7
7050	–56.5	–56.5	–56.5	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp
7225	–56.5	–56.5	–56.5	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp	Interp
8500	–56.5	–56.5	–56.5	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8	–54.8
8500	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80	–80
8675	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100
11825	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100
12000	–100	–100	–100	–100	–100	–100	–100	–100	–100	–80	–80	–80	–100	–100	–80	–80	–80
12000	–100	–100	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–56.5	–100	–100	–56.5	–56.5	–56.5
13825	–100	–100	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–56.5	–100	–100	–56.5	–56.5	–56.5
14000	–100	–100	–100	–100	–100	–100	–100	–80	–80	–56.5	–56.5	–56.5	–80	–80	–56.5	–56.5	–56.5
14000	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–56.5	–56.5	–56.5	–56.5	–56.5	–56.5	–56.5	–56.5
17664	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–56.5	–56.5	–56.5	–56.5	–56.5	–56.5	–56.5	–56.5
21000	–100	–100	–100	–100	–100	–100	–100	–80	–80	–80	–80	–80	–56.5	–56.5	–56.5	–56.5	–80
21450	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–56.5	–56.5	–100
21450	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–80	–80	–56.5	–56.5	–100
21625	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–100
24715	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–100
24890	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–80	–80	–56.5	–56.5	–100
24890	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–80	–80	–100
25065	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–100	–100	–100

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

Name	B8-1	B8-2	B8-3	B8-4	B8-5	B8-6	B8-7	B8-8	B8-9	B8-10	B8-11	B8-12	B8-13	B8-14	B8-15	B8-16	B8-17
Long name	**998-M1x-A**	**998-M1x-B**	**998-M1x-NUS0**	**998-M2x-A**	**998-M2x-M**	**998-M2x-B**	**998-M2x-NUS0**	**998E17-M2x-NUS0**	**998E17-M2x-NUS0-M**	**998ADE17-M2x-NUS0-M**	**998ADE17-M2x-A**	**998ADE17-M2x-B**	**998E30-M2x-NUS0**	**998E30-M2x-NUS0-M**	**998ADE30-M2x-NUS0-M**	**998ADE30-M2x-NUS0-A**	**998ADE17-M2x-M**
kHz	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**	**dBm/Hz**
30000	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–100	–56.5	–56.5	–100	–100	–100
30000	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–80	–80	–110	–110	–110
30175	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110
≥30175	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110	–110

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

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

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

B.3 UPBO reference PSDs

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

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

B.4 Template PSD

B.4.1 Definition

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

B.4.2 Narrow-band PSD verification

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

B.4.3 Use in simulation (Informative)

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

B.5 Compliance

Compliance requires conformance with at least one limit PSD mask.

21 Time-of-day distribution over VDSL2 link

Add new Annex M as follows:

Annex M

Time-of-day distribution over VDSL2 links

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

This annex defines the procedure for distribution of time-of-day across a VDSL2 link. Each clause in this annex identifies the corresponding clause in the main body for which supplements or amendments are made in support of time-of-day distribution over VDSL2 links.

M.1 Time-of-day distribution operational overview

See clause 8.4.1.

M.2 Definitions

See clause 3.

M.3 Abbreviations

See clause 4.

M.4 VTU functional model

See clause 5.1.

M.5 TPS-TC function

See clause 8 (i.e., text between headings of clause 8 and clause 8.1).

M.6 eoc communication protocol

See clause 8.2.4.1.

M.7 ToD TPS-TC (ToD-TC)

See clause 8.4.

M.8 Mapping of OH data

See clause 9.5.2.2.1.

M.9 eoc transmission protocol

See clause 11.2.2 (transmission protocol).

See clause 11.2.3.2 (Command and response types).

M.10 Frequency synchronization command

See clause 11.2.3.14.

M.10.1 The eoc data rate to transport the ToD phase difference values (informative)

This informative clause contains a calculation of the required eoc data rate to transport the ToD phase difference values.

The model of the eoc transmitter is shown in Figure M.1. Two cases are illustrated in Figure M.2.

– Case 1: Transfer of high priority message ongoing when ToD frequency synchronization message is to be sent.

– Case 2: Transfer of lower priority message ongoing when ToD frequency synchronization message is to be sent.

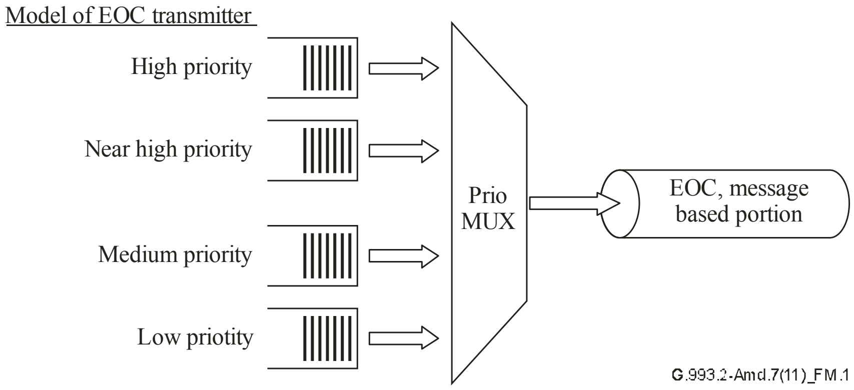


Figure M.1 – Model of the eoc transmitter

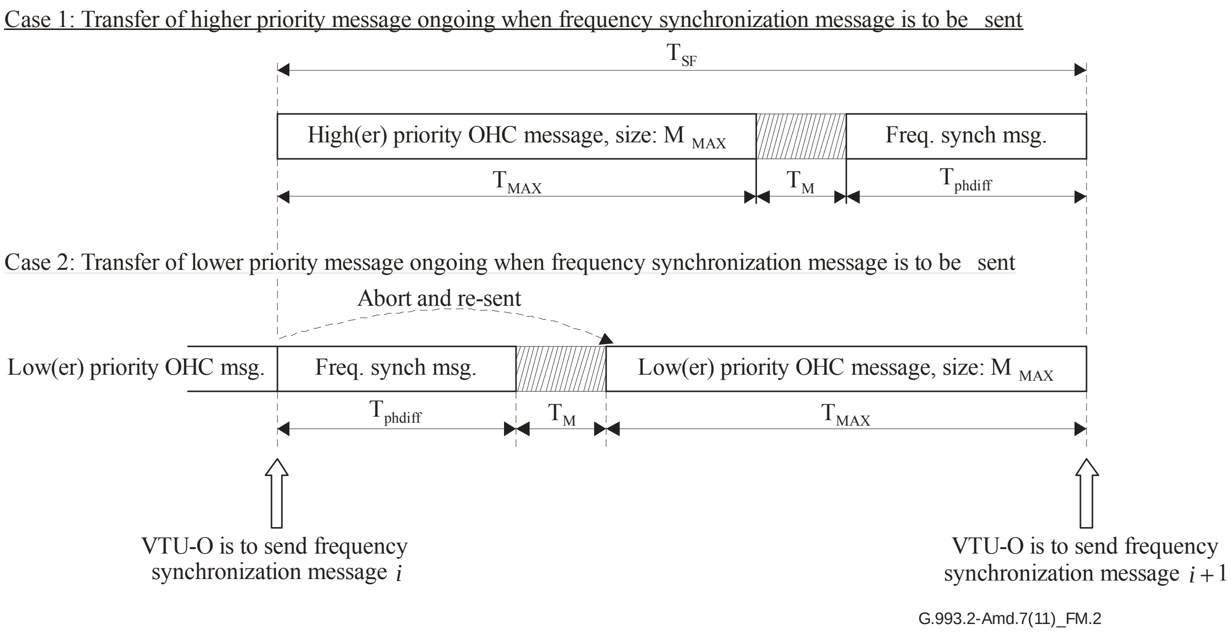


Figure M.2 – Two cases of ongoing transfers

Variables and Calculation:

msg_p	[kbit/s]	message overhead data rate (see Table 9-6)
M_{max}	[Octets]	maximum size of any eoc message fragment (1024 octets, see clause 11.2.3.1)
M_{phdiff}	[Octets]	size of periodic ToD frequency synchronization message
T_{SF}	[s]	repetition period of time synchronization messages
f_{DMT}	[kHz]	DMT symbol rate (see clause 10.4.4.)

$T_{SF} = \dfrac{n \times 257}{f_{DMT}}$ with *n* being agreed between VTUs during initialization

(n = 1, 2 … 255)

T_{max} [s] time required for transmission of message of size M_{max}

T_{phdiff} [s] time required for transmission of message of size M_{phdiff}

$T_m = \alpha \times T_{max}$ α denoting a percentage of T_{max} to be considered as margin T_m. The margin takes care for HDLC framing overhead and software reaction times when scheduling OHC messages.

Condition for deterministic exchange of periodic message along with maximum sized messages:

$$T_{SF} \geq T_{max} + T_{phdiff} + T_m$$

with $msg_p \times T_{max} = M_{max}$ and equivalent for the other contributors, the condition is expressed as

$$msg_p \geq \frac{8}{T_{SF}} \times \left(M_{phdiff} + (1+\alpha) \times M_{max}\right)$$

considering the operator configured parameter msg_{min} in addition:

$$msg_p \geq \min\left\{\frac{8}{T_{SF}} \times \left(M_{phdiff} + (1+\alpha) \times M_{max}\right); msg_{min}\right\} \quad \text{(M-1)}$$

Using typical values for the aforementioned parameters, the following table can be generated:

n	f_s [kHz]	T_{SF} [s]	M_{phdiff}	M_{max} [Oct]	α	msg_{min} [kbit/s]	msg_p [bit/s]	msg_p [kbit/s]	percentage of eoc bandwidth for phase difference [%]
1	4	0.06425	5	512	0.1	16	70749	71	0.9

M.11 Time synchronization command and responses

See clause 11.2.3.15.

M.12 Updates to initialization

See clause 12.3.5.2 (SOC messages exchanged during channel analysis & exchange phase).

See 12.3.5.2.1.1 (O-MSG 1 field #27).

See 12.3.5.2.1.2 (O-TPS field #7).

See 12.3.5.2.2.1 (R-MSG 2 fields #9 and #10).

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