International Telecommunication Union

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G.997.1

Amendment 2

(05/2018)

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

Digital sections and digital line system – Metallic access networks

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Physical layer management for digital subscriber line transceivers

Amendment 2

Recommendation ITU-T G.997.1 (2016) – Amendment 2

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ITU-T G-SERIES RECOMMENDATIONS

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DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
ACCESS NETWORKS	G.9000–G.9999

For further details, please refer to the list of ITU-T Recommendations.

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Recommendation ITU-T G.997.1

Physical layer management for digital subscriber line transceivers

Amendment 2

Summary

Recommendation ITU-T G.997.1 specifies the physical layer management for asymmetric digital subscriber line (ADSL) and very high speed digital subscriber line 2 (VDSL2) transmission systems. It specifies means of communication on a transport transmission channel defined in the physical layer Recommendations ITU-T G.992.1, ITU-T G.992.2, ITU-T G.992.3, ITU-T G.992.4, ITU-T G.992.5 and ITU-T G.993.2. It specifies network elements (NE) content and syntax for configuration, fault and performance management.

The revision of this Recommendation includes the management information base (MIB) elements for the physical layer management of Recommendation ITU-T G.993.2 and additional MIB elements for the physical layer management of Recommendations ITU-T G.992.3 and ITU-T G.992.5.

The 2016 edition of this Recommendation integrates ITU-T G.997.1 (2012) and all its amendments and corrigenda. It does not add any new technical material.

Amendment 2 includes:

– addition of loop diagnostic status parameters;

– freezing of performance and monitoring counters when line is forced in L3 state;

– add support for Band plan and Limit PSD masks of profile 35b for the North American region (Annex A).

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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.

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Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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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.997.1

Physical layer management for digital subscriber line transceivers

Amendment 2

Editorial note: This is a complete-text publication. Modifications introduced by this amendment are shown in revision marks relative to Recommendation ITU-T G.997.1 (2016) plus its Amendment 1 and Corrigendum 1.

1 Scope

This Recommendation specifies the physical layer management for asymmetric digital subscriber line (ADSL) and very high speed digital subscriber line 2 (VDSL2) transmission systems based on the usage of indicator bits and embedded operations channel (EOC) messages defined in the ITU-T G.992.x series of ITU-T Recommendations and in [ITU-T G.993.2], and the clear embedded operations channel defined in this Recommendation.

It specifies network management elements content for configuration, fault, and performance management.

The mechanisms to provide operations, administration and maintenance (OAM) functions, and to generate OAM flows F1, F2 and F3, will depend on the transport mechanism of the physical layer transmission system as well as on the supervision functions contained within the physical layer termination functions of equipment. This Recommendation specifies only flow F3 – transmission path level.

For interrelationships of this Recommendation with other Recommendations of the ITU-T G.99x-series, see [ITU-T G.995.1].

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.992.1] Recommendation ITU-T G.992.1 (1999), *Asymmetric digital subscriber line (ADSL) transceivers*.

[ITU-T G.992.2] Recommendation ITU-T G.992.2 (1999), *Splitterless asymmetric digital subscriber line (ADSL) transceivers*.

[ITU-T G.992.3] Recommendation ITU-T G.992.3 (2005), *Asymmetric digital subscriber line transceivers 2 (ADSL2)*.

[ITU-T G.992.4] Recommendation ITU-T G.992.4 (2002), *Splitterless asymmetric digital subscriber line transceivers 2 (splitterless ADSL2)*.

[ITU-T G.992.5] Recommendation ITU-T G.992.5 (2005), *Asymmetric digital subscriber line (ADSL) transceivers – Extended bandwidth ADSL2 (ADSL2plus)*.

[ITU-T G.993.2] Recommendation ITU-T G.993.2 (2011), *Very high speed digital subscriber line transceivers 2 (VDSL2)*.

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[ITU-T G.993.5] Recommendation ITU-T G.993.5 (2010), *Self-FEXT cancellation (vectoring) for use with VDSL2 transceivers*.

[ITU-T G.994.1] Recommendation ITU-T G.994.1 (2003), *Handshake procedures for digital subscriber line (DSL) transceivers*.

[ITU-T G.995.1] Recommendation ITU-T G.995.1 (2001), *Overview of digital subscriber line (DSL) Recommendations*.

[ITU-T G.998.4] Recommendation ITU-T G.998.4 (2010), *Improved impulse noise protection for DSL transceivers*.

[ITU-T I.432.x] Recommendations ITU-T I.432.x-series, *B-ISDN user-network interface – Physical layer specification*.

[ITU-T I.610] Recommendation ITU-T I.610 (1999), *B-ISDN operation and maintenance principles and functions*.

[ITU-T T.35] Recommendation ITU-T T.35 (2000), *Procedure for the allocation of ITU-T defined codes for non-standard facilities*.

[IETF RFC 1157] IETF RFC 1157 (1990), *A Simple Network Management Protocol (SNMP)*.

3 Definitions

This Recommendation defines the following terms:

3.1 accumulation period: Period of time used by the network management system (NMS) to accumulate sufficient number of parameter samples.

3.2 anomaly: An anomaly is a discrepancy between the actual and desired characteristics of an item.

The desired characteristic may be expressed in the form of a specification.

An anomaly may or may not affect the ability of an item to perform a required function.

3.3 bearer channel: As defined in the respective Recommendation (also referred to as "frame bearer" in various digital subscriber line (DSL) Recommendations).

3.4 clear embedded operations channel (EOC): An octet oriented data channel multiplexed in the physical layer transmission frame structure.

3.5 defect: A defect is a limited interruption in the ability of an item to perform a required function. It may or may not lead to maintenance action depending on the results of additional analysis.

Successive anomalies causing a decrease in the ability of an item to perform a required function are considered a defect.

3.6 failure: A failure is the termination of the ability of an item to perform a required function.

NOTE – After failure, the item has a fault. Analysis of successive anomalies or defects affecting the same item can lead to the item being considered as "failed".

3.7 full initialization: Any type of initialization procedure defined in respective Recommendations, except short initialization.

3.8 masked subcarrier: A subcarrier that is not transmitted during initialization and showtime.

3.9 MEDLEY set: A set of subcarriers used during the digital subscriber line (DSL) initialization. This set is defined in the respective Recommendations.

3.10 net data rate: Net data rate is defined in the ITU-T G.992.x-series Recommendations and in [ITU-T G.993.2].

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3.11 short initialization: Shortened type of initialization procedure, as specified in clause 7.2.1.3.3. Short initialization includes fast retrain, as specified in [ITU-T G.992.2], and short initialization, as specified in [ITU-T G.992.3] and [ITU-T G.992.4].

3.12 showtime: As defined in the respective Recommendations.

3.13 xDSL: Any of the various types of digital subscriber line technologies.

3.14 α-interface, β-interface: Interface between the physical media specific-transmission convergence (PMS-TC) and the transport protocol specific-transmission convergence (TPS-TC) sub-layers of the xTU, as defined in [ITU-T G.995.1] and the respective Recommendations.

3.15 γ-interface: Application interface of the xTU, as defined in [ITU-T G.995.1] and the respective Recommendations.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ADSL	Asymmetric Digital Subscriber Line
ADSL2	Asymmetric Digital Subscriber Line 2
AME	ADSL Management Entity
AN	Access Node
ATM	Asynchronous Transfer Mode
ATU	ADSL Transceiver Unit
ATU-C	ADSL Transceiver Unit – Central office end (i.e., network operator)
ATU-R	ADSL Transceiver Unit – Remote side (i.e., subscriber end of the loop)
CRC	Cyclic Redundancy Check
CV	Code Violation
CV-C	Code Violation – Channel
CV-CFE	Code Violation – Channel Far-End
DMT	Discrete MultiTone
DPBO	Downstream Power Back-Off
DSL	Digital Subscriber Line
EOC	Embedded Operations Channel
ES	Errored Second
ES-L	Errored Second – Line
ES-LFE	Errored Second – Line Far-End
FEBE	Far-End Block Error
FEC	Forward Error Correction
FEC-C	Forward Error Correction – Channel
FEC-CFE	Forward Error Correction – Channel Far-End
FECS-L	Forward Error Correction Second – Line
FECS-LFE	Forward Error Correction Second – Line Far-End

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FEXT	Far End Crosstalk
FFEC	Far-end Forward Error Correction
HDLC	High-level Data Link Control
HEC	Header Error Control
IMA	Inverse Multiplexing over ATM
INM	Impulse Noise Monitoring
ISDN	Integrated Services Digital Network
LCD	Loss of Cell Delineation
LCD-FE	Far-End Loss of Cell Delineation
LDSF	Loop Diagnostic mode Forced
LFE	Line Far End
LINIT	Line Initialization
LOF	Loss of Frame
LOF-FE	Far-End Loss of Frame
LOS	Loss of Signal
LOS-FE	Far-End Loss of Signal
LOSS-L	LOS Second-line
LPR	Loss of Power
LPR-FE	Far-End Loss of Power
LSB	Least Significant Bit
ME	Management Entity
MIB	Management Information Base
MINEFTR	Minimum Error-Free Throughput
MSB	Most Significant Bit
NCD	No Cell Delineation
NCD-FE	Far-End No Cell Delineation
NE	Network Element
NEXT	Near End Crosstalk
NMS	Network Management System
NT	Network Termination
OAM	Operations, Administration and Maintenance
OLR	On-Line Reconfiguration
OOS	Out of Sync
OOS-FE	Far-End Out of Sync
PDU	Protocol Data Unit
PM	Performance Monitoring
PMD	Physical Media Dependent

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PMSF	Power Management State Forced
PMS-TC	Physical Media Specific-Transmission Convergence
POTS	Plain Old Telephone Service; one of the services using the voiceband; sometimes used as a descriptor for all voiceband services.
PSD	Power Spectral Density
PSTN	Public Switched Telephone Network
PTM	Packet Transfer Mode
RDI	Remote Defect Indication
RFI	Remote Failure Indication
SEF	Severely Errored Frame
SES	Severely Errored Second
SNMP	Simple Network Management Protocol
SNR	Signal-to-Noise Ratio
STM	Synchronous Transfer Mode
T/S	Interface(s) between ADSL network termination and Customer Installation or home network
TC	Transmission Convergence (layer)
TCM	Time Compression Multiplex
TE	Terminal Equipment
TPS-TC	Transport Protocol Specific-Transmission Convergence
T-R	Interface(s) between ATU-R and switching layer (ATM, STM or PTM)
TR	Threshold Reports
UAS	Unavailable Second
UAS-L	Unavailable Second – Line
U-C	Loop interface-Central office end
U-R	Loop interface-Remote side (i.e., subscriber end of the loop)
V-C	Logical interface between ATU-C and a digital network element, such as one or more switching systems
VDSL2	Very high speed Digital Subscriber Line 2
VME	VDSL2 Management Entity
VTU	VDSL2 Transceiver Unit
VTU-O	VDSL2 Transceiver Unit – central Office or network element end (in the 'ONU' optical network unit per [ITU-T G.993.2] – i.e., network operator.)
VTU-R	VTU at the Remote site (i.e., subscriber end of the loop)
xTU	xDSL Transceiver Unit
xTU-C	xDSL Transceiver Unit – Central office end (i.e., at the network operator), used as a generic term referring to both the ATU-C of the ITU-T G.992.x series of Recommendations and the VTU-O of [ITU-T G.993.2].

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xTU-R xDSL Transceiver Unit at the remote side (i.e., at the subscriber end of the loop), used as a generic term referring to both the ATU-R of the ITU-T G.992.x series of Recommendations and the VTU-R of [ITU-T G.993.2].

5 Overview

Figure 5-1 shows the system reference model for this Recommendation.

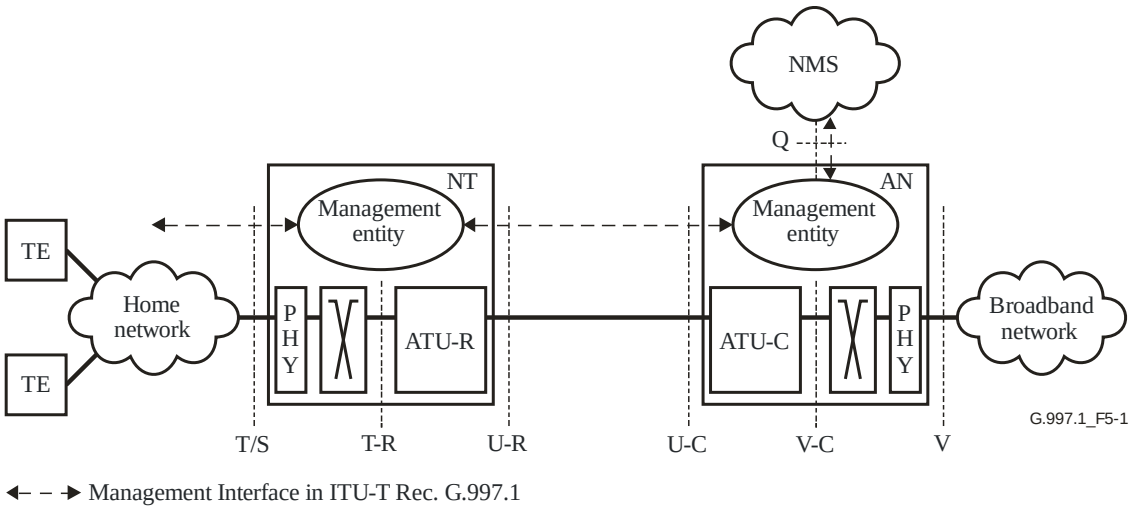

Figure 5-1 – System reference model

There are four management interfaces defined in this Recommendation.

The Q-interface is at the access node (AN) for network management systems (NMS). All the parameters specified in this Recommendation apply at the Q-interface. The Q-interface provides the interface between the NMS of the operator and the management entity (ME) in the access node.

The near-end parameters supported in the management entity (ME) at the access node (AN) are derived from the xTU-C while the far-end parameters (from the xTU-R) can be derived by either of two mechanisms over the U-interface:

- Indicator bits and embedded operations channel (EOC) messages can be used to generate the required xTU-R parameters in the ME of the AN.
- The OAM channel and protocol (specified in clause 6) can be used to retrieve the parameters from the xTU-R, when requested by the ME of the AN.

The definition of the transport of the management instrumentation over the Q-interface is outside the scope of this Recommendation. The coding of the management information transferred over the Q-interface is beyond the scope of this Recommendation.

Two management interfaces U-C at the xTU-C and U-R at the xTU-R, are defined. Their main purposes are to provide:

- At the xTU-C: the xTU-C near-end parameters for the xTU-R to retrieve over the U-interface.
- At the xTU-R: the xTU-R near-end parameters for the xTU-C to retrieve over the U-interface.

This Recommendation defines (see clause 6) a method for the communication of the xTU parameters defined in clause 7 over the U-interface.

NOTE 1 – In this Recommendation, U-C and U-R refer to the management interfaces that apply to the respective physical reference points defined in respective Recommendations. In Rec. ITU-T G.993.2, the reference point U-C is referred to as U-O.

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At the T-/S-interface a subset of the parameters specified in this Recommendation may apply. The purpose is to indicate the ADSL or VDSL2 link status to the terminal equipment (TE). These parameters are maintained by the ME of the network termination (NT) and are made available over the T-/S-interface.

The G-interface is defined and refers to the management flows from the ME on the NT directly to the NMS when that flow crosses the 'U-C' and 'U-R' interface, but the management flow is not mediated by the ME on the AN. The specification of the protocols to support flows that cross the G-interface is outside the scope of this Recommendation. The parameters supported at the G-interface are a superset of those supported at the S/T interface and they are maintained by the ME of the NT.

The far-end parameters (from the xTU-C) can be derived by either of two mechanisms over the U-interface:

- Indicator bits and EOC messages, which are provided at the physical media dependent (PMD) layer, can be used to generate the required xTU-C parameters in the ME of the NT.
- The OAM channel and protocol (specified in clause 6) can be used to retrieve the parameters from the xTU-C, when requested by the ME of the NT.

The definition of the transport of this management information over the T-/S-interfaces is outside the scope of this Recommendation. The coding of the management information transferred over the T-S-interface is beyond the scope of this Recommendation.

Depending on the transceiver Recommendation (e.g., [ITU-T G.992.1] or [ITU-T G.992.2]), some of the parameters may not apply (i.e., fast data stream parameters for [ITU-T G.992.2]).

Specific parameters may be applicable to specific transceiver Recommendations. Tables in clause 7.6 provide the applicability of any specific parameter to any particular Recommendation in the ITU-T G.992.x series of Recommendations and/or to [ITU-T G.993.2].

NOTE 2 – Throughout this Recommendation, the use of the term xTU-C refers to both ATU-C and VTU-O, while the term xTU-R refers to both ATU-R and VTU-R.

5.1 Physical layer management mechanisms

The general definition of OAM for ATM networks is defined in [ITU-T I.610]. This Recommendation uses this model for both ATM and PTM. The physical layer contains the three lowest OAM levels as outlined in Figure 5-2. The allocation of the OAM flows is as follows:

– F1: regenerator section level;

– F2: digital section level;

– F3: transmission path level.

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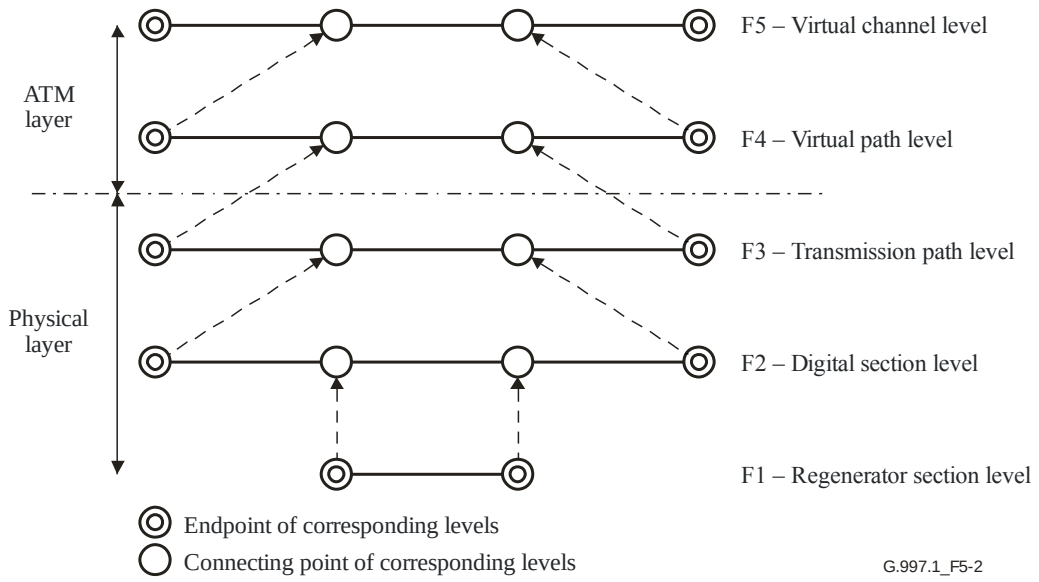

Figure 5-2 – OAM hierarchical levels and their relationship with the ATM layer and physical layer

The physical levels F1-F3 in this Recommendation are coupled with upper levels F4, F5 from the fault management perspective. When an F3 fault (e.g., loss of signal (LOS)) is detected, it is reported to the NMS, but an F4/F5, as defined in [ITU-T I.610], fault is generated as well.

The OAM levels F1-F3 cover the part of the system referred as "xDSL LINE" in Figure 5-3. This part includes analogue processing and digital processing for the metallic transmission medium. Levels F1-F3 provide performance monitoring of both analogue and digital line-related entities. The xDSL LINE is delimited by the two end points V-D (or α) and T-D (or β) as presented in Figure 5-3. The xDSL LINE is defined between the V-D (or α) and the T-D (or β) reference points.

The xDSL ATM PATH is defined between the V-C (or γ_c) and T-R (or γ_r) reference points.

The xDSL PTM PATH is defined between the V-C (or γ_c) and T-R (or γ_r) reference points.

The xDSL STM PATH is for further study.

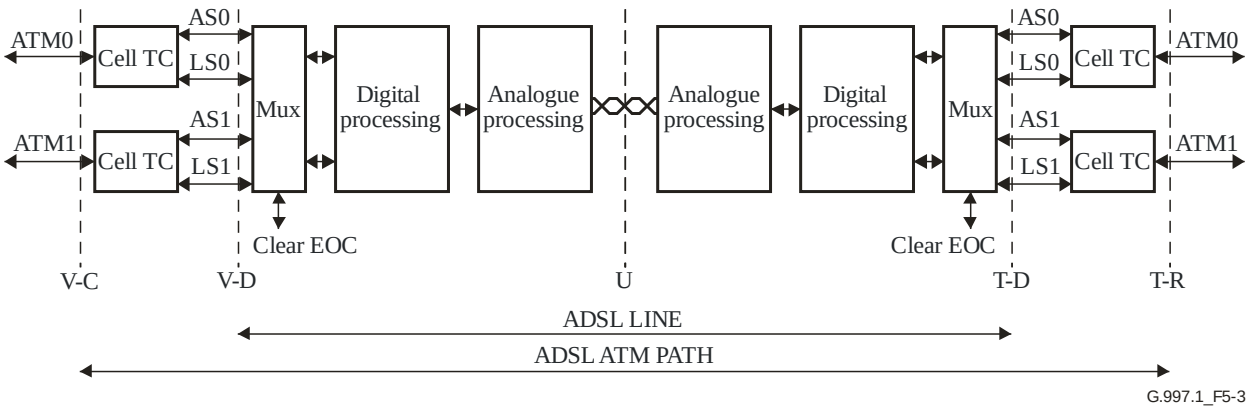

Figure 5-3 – xDSL LINE and xDSL ATM or PTM PATH definition

6 OAM communications channel

This clause specifies an optional OAM communication channel across the U-interface (see Figure 6-1). If this channel is implemented, the xTU-C and the xTU-R may use it for transporting physical layer OAM messages. If either the xTU-C or the xTU-R does not have the capability of this

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OAM channel, the far-end parameters, defined in clause 7, at the xTU-C shall be derived from the indicator bits and EOC messages defined in the ITU-T G.992.x-series of Recommendations and in [ITU-T G.993.2]. Support for the OAM communication channel defined in this clause will be indicated during initialization by messages defined in [ITU-T G.994.1] for ITU-T G.992.1 and ITU-T G.992.2.

NOTE 1 – In those cases where neither the xTU-R nor the xTU-C implements this communication channel, there are some reduced physical layer OAM capabilities (see clause 7).

The ITU-T G.992.x-series of Recommendations and [ITU-T G.993.2] may provide one of two mechanisms to transport physical layer OAM messages.

– For [ITU-T G.992.1] and [ITU-T G.992.2], the mechanism is a bit-oriented clear EOC. For these Recommendations, the channel shall meet the requirements specified in clause 6.1. The data link layer shall be as specified in clause 6.3.

– For [ITU-T G.992.3], [ITU-T G.992.4], [ITU-T G.992.5] and [ITU-T G.993.2], the mechanism is a message-oriented clear EOC. For these Recommendations, the channel shall meet the requirements specified in clause 6.2. The data link layer shall be as specified in clauses 7.8.2.3, 7.8.2.4 and 9.4.1.8 of [ITU-T G.992.3] for [ITU-T G.992.3], [ITU-T G.992.4] and [ITU-T G.992.5]; and as specified in clauses 8.2 and 11.2.3 of [ITU-T G.993.2] for [ITU-T G.993.2].

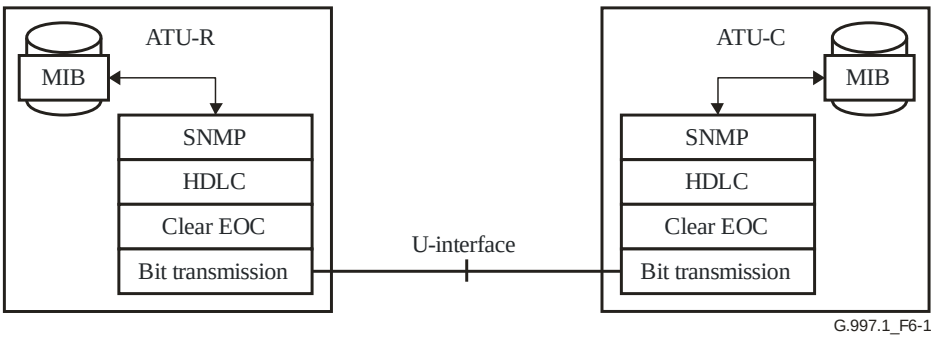

Figure 6-1 – OAM communication channel layers for bit-oriented clear EOC

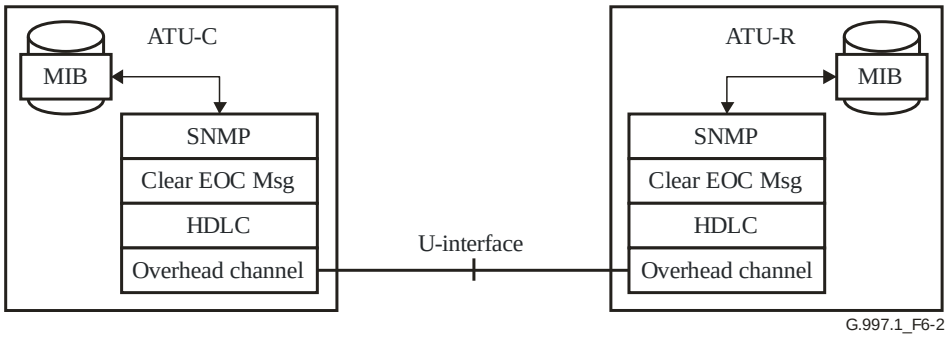

Figure 6-2 – OAM communication channel layers for message-oriented clear EOC

NOTE 2 – In Figures 6-1 and 6-2, MIB represents management information base related to the xTU.

6.1 Requirements on the physical media dependent (PMD) layer for the bit-oriented clear embedded operations channel (EOC)

In order to support the physical layer OAM protocols defined in this Recommendation, a physical layer Recommendation shall provide a full duplex data channel for support of the data link layer defined in clause 6.3.

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The clear EOC serves the function of a physical layer of the protocol stack defined in this Recommendation for [ITU-T G.992.2] and [ITU-T G.992.1].

1) The clear EOC shall be a part of the protocol overhead for the particular xDSL Recommendation.

2) The clear EOC shall be available to carry traffic whenever the xDSL protocol is in a normal transmission mode (e.g., "showtime").

3) The clear EOC shall be available regardless of the specific configuration options or run time adaptation of an ATU-C and ATU-R that are communicating.

4) The clear EOC shall be terminated in the ATU-R and the ATU-C.

5) The clear EOC shall support traffic of at least 4 kbit/s.

6) The clear EOC shall support delineation of individual octets in order to support the link level protocol defined in clause 7.1.

7) The clear EOC should not support error correction or detection. Error correction and detection is supported by use of the OAM stack defined in this Recommendation.

8) The clear EOC should not guarantee the delivery of data carried over the channel.

9) The clear EOC should not support retransmission of data upon error.

10) The clear EOC should not acknowledge the receipt of data by the far end of the link.

11) The clear EOC should not require a specific initialization procedure. It can be assumed to be operational whenever the two modems are in synchronization for "showtime" transport of data.

6.2 Requirements on the PMD layer for the message-oriented clear EOC

In order to support the physical layer OAM protocols defined in this Recommendation, a physical layer Recommendation shall provide a full duplex data channel for support of the SNMP protocol defined in clause 6.4.

1) The clear EOC shall be a part of the protocol overhead for the particular xDSL Recommendation.

2) The clear EOC shall be available to carry traffic whenever the xDSL protocol is in a normal transmission mode (e.g., "showtime").

3) The clear EOC shall be available regardless of the specific configuration of an xTU-C and xTU-R that are communicating.

4) The clear EOC shall be terminated in the xTU-R and the xTU-C.

5) The clear EOC shall support a bit rate of at least 4 kbit/s.

6) The clear EOC shall support delineation of messages through HDLC in order to support the link level protocol defined in clause 7.1.

7) The clear EOC should not support retransmission of data upon error.

8) The clear EOC should not require a specific initialization procedure. It can be assumed to be operational whenever the two modems are in synchronization for "showtime" transport of data.

6.3 Data link layer

For the transport mechanism, an HDLC-like mechanism is defined with the characteristics detailed in the following clauses. The defined method is based on [b-ISO/IEC 13239]. The requirements in the following clauses apply only to the bit-oriented clear EOC.

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NOTE – For [ITU-T G.992.3], [ITU-T G.992.4] and [ITU-T G.992.5], the data link layer uses the clear EOC messages embedded in the overhead channel as defined in clauses 7.8.2.3, 7.8.2.4 and 9.4.1.8 of [ITU-T G.992.3]. For [ITU-T G.993.2], the data link layer uses the clear EOC messages embedded in the overhead channel as defined in clauses 8.2 and 11.2.3 of [ITU-T G.993.2].

The main differences between the ITU-T G.997.1 data link layer and the ITU-T G.992.3/ITU-T G.993.2 clear EOC protocol are:

– The address field and control field is defined in clause 7.8.2.4 of [ITU-T G.992.3] or clause 8.2.4.1 of [ITU-T G.993.2].

– The two first bytes of the payload are always 08_{16} and 01_{16} to indicate a clear EOC command.

– Each clear EOC command is acknowledged by the far end xTU.

6.3.1 Format convention

The basic format convention used for messages is illustrated in Figure 6-3. Bits are grouped into octets. The bits of each octet are shown horizontally and are numbered from 1 to 8. Octets are displayed vertically and are numbered from 1 to N.

The octets are transmitted in ascending numerical order.

The frame check sequence (FCS) field spans two octets: Bit 1 of the first octet is the MSB and bit 8 of the second octet is the LSB (see Figure 6-4).

8	7	6	5	4	3	2	1	Octet
								1
								2
								...
								N

Figure 6-3 – Format convention

8	7	6	5	4	3	2	1	Octet
2^8							2^{15}	1
2^0							2^7	2

Figure 6-4 – FCS mapping convention

6.3.2 OAM frame structure

The frame structure is as depicted in Figure 6-5.

$7E_{16}$	Opening flag
FF_{16}	Address field
03_{16}	Control field
Information payload	Max 510 bytes
FCS	Frame check sequence (first octet)
FCS	Frame check sequence (second octet)
$7E_{16}$	Closing flag

Figure 6-5 – OAM frame structure

The opening and closing flag sequence shall be the octet $7E_{16}$. The address and control field of the frame shall be coded as FF_{16} and 03_{16}, respectively.

Transparency of the information payload to the flag sequence and the frame check sequence are described below.

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6.3.3 Octet transparency

In this approach, any data that is equal to $7E_{16}$ (01111110_2) (flag sequence) or $7D_{16}$ (control escape) shall be escaped as described below.

After frame check sequence (FCS) computation, the transmitter examines the entire frame between the two flag sequences. Any data octets which are equal to the flag sequence ($7E_{16}$) or the control escape ($7D_{16}$) are replaced by a two-octet sequence consisting of the control escape octet followed by the original octet Exclusive-OR'ed with hexadecimal 0x20 (this is bit 5 complemented, where the bit positions are numbered 76543210). In summary, the following substitutions are made:

- a data octet of $7E_{16}$ is encoded as two octets $7D_{16}$, $5E_{16}$;
- a data octet of $7D_{16}$ is encoded as two octets $7D_{16}$, $5D_{16}$.

On reception, prior to FCS computation, each control escape octet ($7D_{16}$) is removed, and the subsequent octet is exclusive-OR'ed with hexadecimal 20_{16} (unless the following octet is $7E_{16}$, which is the flag, and indicates the end of frame, and therefore an abort has occurred). In summary, the subsequent substitutions are made:

- a sequence of $7D_{16}$, $5E_{16}$ is replaced by the data octet $7E_{16}$;
- a sequence of $7D_{16}$, $5D_{16}$ is replaced by the data octet $7D_{16}$;
- a sequence of $7D_{16}$, $7E_{16}$ aborts the frame.

Note that since octet stuffing is used, the data frame is guaranteed to have an integer number of octets.

6.3.4 Frame check sequence

The FCS field is 16 bits (2 octets) in length. As defined in [b-ISO/IEC 13239], it shall be the one's complement of the sum (modulo 2) of:

a) the remainder of $x^k (x^{15} + x^{14} + x^{13} + x^{12} + x^{11} + x^{10} + x^9 + x^8 + x^7 + x^6 + x^5 + x^4 + x^3 + x^2 + x + 1)$ divided (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$, where k is the number of bits in the frame existing between, but not including, the last bit of the final opening flag and the first bit of the FCS, excluding octets inserted for transparency; and

b) the remainder of the division (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$, of the product of x^{16} by the content of the frame existing between, but not including, the last bit of the final opening flag and the first bit of the FCS, excluding octets inserted for transparency.

As a typical implementation at the transmitter, the initial content of the register of the device computing the remainder of the division is preset to all binary ONEs and is then modified by division by the generator polynomial (as described above) on the information field. The one's complement of the resulting remainder is transmitted as the 16-bit FCS.

As a typical implementation at the receiver, the initial content of the register of the device computing the remainder of the division is preset to all binary ONEs. The final remainder, after multiplication by 16 and then division (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$ of the serial incoming protected bits after removal of the transparency octets and the FCS, will be 0001110100001111_2 (x^{15} through x^0, respectively) in the absence of transmission errors.

The FCS is calculated over all bits of the Address, Control, and Information payload fields of the frame.

The register used to calculate the CRC shall be initialized to the value $FFFF_{16}$, both at the transmitter and the receiver.

The LSB of the FCS is sent first, followed by the MSB.

On the receiver a message received without errors results in a CRC calculation of $F0B8_{16}$.

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6.3.5 Invalid frames

The following conditions result in an invalid frame:

- Frames which are too short (less than 4 octets in between flags, not including transparency octets).
- Frames which contain a control escape octet followed immediately by a flag (i.e., $7D_{16}$, $7E_{16}$).
- Frames which contain control escape sequences other than $7D_{16}$, $5E_{16}$ and $7D_{16}$, $5D_{16}$.

Invalid frames shall be discarded. The receiver shall immediately start looking for the beginning flag of a subsequent frame.

6.3.6 Synchronism

The OAM frame structure transport is octet synchronous. Octet transport and synchronism for this transport is defined in accordance with the TC layer.

6.3.7 Time fill

Inter-frame time fill shall be accomplished by inserting additional flag octets ($7E_{16}$) between the closing and the subsequent opening flag on the EOC transport channel. Inter-octet time fill is not supported.

6.4 The SNMP protocol

If implemented, SNMP messages shall be used as the message encoding over the HDLC data link channel defined in clause 6.2, for [ITU-T G.992.1] and [ITU-T G.992.2]; or over the clear EOC message embedded in the overhead channel for [ITU-T G.992.3], [ITU-T G.992.4], [ITU-T G.992.5] and [ITU-T G.993.2].

6.4.1 SNMP message mapping in HDLC frames

This clause applies only to Recommendations defining a bit-oriented clear EOC (e.g., [ITU-T G.992.1] and [ITU-T G.992.2]).

The SNMP messages are placed directly in HDLC frames together with the protocol identifier (see Figure 6-6). The protocol identifier is two bytes ahead of the SNMP message. The two bytes contain the ethertype SNMP value $814C_{16}$ as defined in [b-IETF RFC 1700]. A single HDLC frame is used to transport each SNMP message.

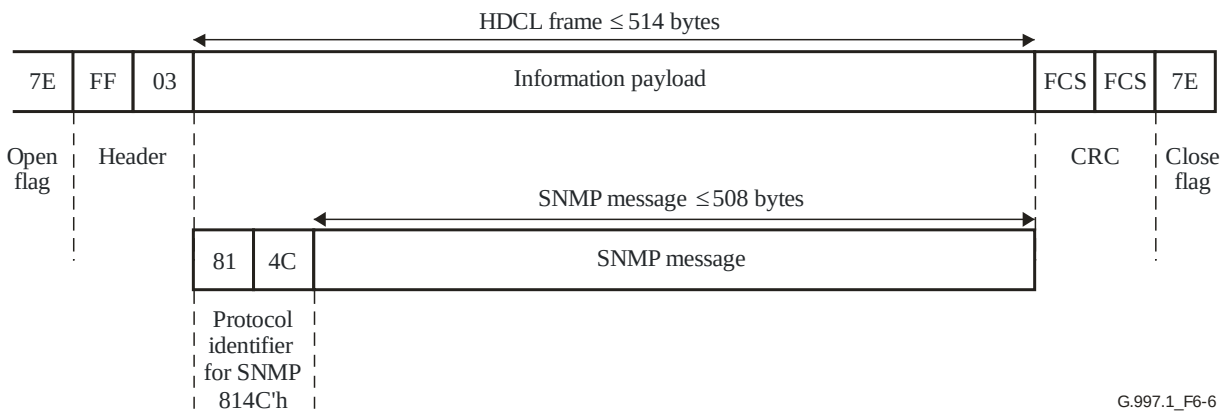

Figure 6-6 – OAM communication channel protocol over the U-interface

The length of an SNMP message shall be less than or equal to 508 bytes.

Due to the transparency mechanism described in clause 6.3.3, the number of bytes actually transmitted between opening and closing flags may be higher than 514.

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6.4.2 SNMP message mapping in clear EOC messages

This clause applies only to Recommendations defining message-oriented clear EOC (e.g., [ITU-T G.992.3], [ITU-T G.992.4], [ITU-T G.992.5] and [ITU-T G.993.2]).

The SNMP messages are placed directly in the clear EOC messages together with the protocol identifier (see Figure 6-7). The protocol identifier is two bytes prepended to the SNMP message. The two bytes contain the ethertype SNMP value $814C_{16}$ as defined in [b-IETF RFC 1700]. A single HDLC frame is used to transport each SNMP message.

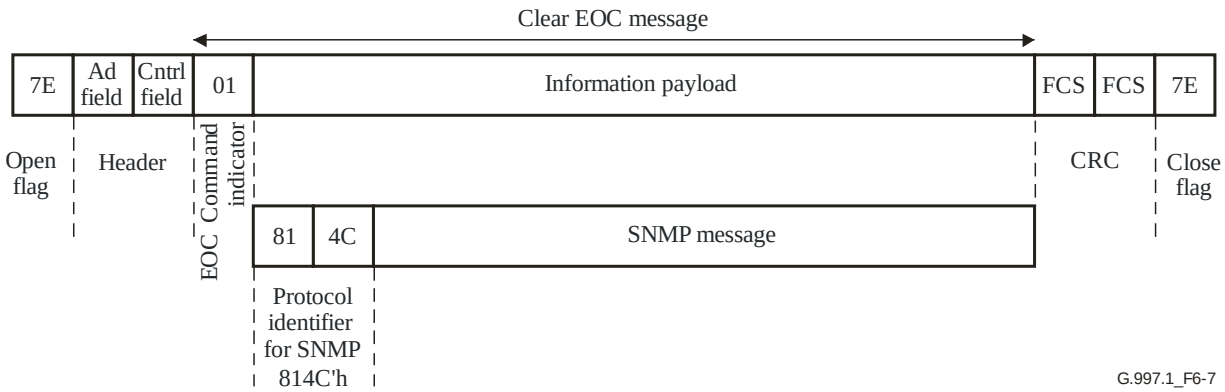

Figure 6-7 – OAM communication channel protocol over the U-interface

The length of an SNMP message shall be less than or equal to 508 bytes.

Due to the transparency mechanism described in clause 6.3.3, the number of bytes actually transmitted between opening and closing flags may be greater than 516.

6.4.3 Protocol based on SNMP

The SNMP protocol as defined in [IETF RFC 1157] consists of four types of operations, which are used to manipulate management information. These are:

Get	Used to retrieve specific management information.
Get-Next	Used to retrieve, via traversal of the MIB, management information.
Set	Used to alter management information.
Trap	Used to report extraordinary events.

The four operations are implemented using five types of protocol data units (PDUs):

GetRequest-PDU	Used to request a Get operation.
GetNextRequest-PDU	Used to request a Get-Next operation.
GetResponse-PDU	Used to respond to a Get, Get-Next, or Set operation.
SetRequest-PDU	Used to request a Set operation.
Trap-PDU	Used to report a Trap operation.

If implemented, SNMP messages shall be used according to the following requirements.

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6.4.3.1 Use of EOC channel

The ADSL or VDSL2 OAM channel will be used for sending HDLC-encapsulated SNMP messages between ADSL management entities (AMEs) or VDSL2 management entities (VMEs) at both sides of the line. An AME or VME residing in the xTU-R and xTU-C will send and interpret these SNMP messages. This ADSL or VDSL2 OAM channel is used for requests, responses, and traps, differentiated according to the SNMP PDU type.

6.4.3.2 Message format

The message format specified in [ITU-T G.992.1] shall be used. That is, messages shall be formatted according to SNMP version 1.

All SNMP messages shall use the community name "ADSL", that is, the OCTET STRING value: "$4144534C_{16}$". This string shall be used for all Recommendations covered by this Recommendation.

In all SNMP Traps, the agent-addr field (which has syntax NetworkAddress), shall always have the IpAddress value: 0.0.0.0.

In all SNMP Traps, the time-stamp field in the Trap-PDU shall contain the value of an AME or VME MIB object at the time of trap generation.

In any standard SNMP Trap, the enterprise field in the Trap-PDU shall contain the value of the agent's sysObjectID MIB object (sysObjectID is defined in the system group of MIB-II).

6.4.3.3 Message sizes

All ADSL and VDSL2 OAM implementations shall be able to support SNMP messages of size up to and including 508 octets.

6.4.3.4 Message response time

Response time refers to the elapsed time from the submission of an SNMP message (e.g., GetRequest, GetNextRequest or SetRequest message) by an AME or VME across an ADSL or VDSL2 Interface to the receipt of the corresponding SNMP message (e.g., GetResponse message) from the adjacent AME or VME. An SNMP GetRequest, GetNextRequest, or SetRequest message is defined in this context as a request concerning a single object.

The AME and VME shall support maximum response times of 1 s for 95% of all SNMP GetRequests, GetNextRequests or SetRequests containing a single object received from an adjacent AME or VME independent of the ADSL or VDSL2 interface's physical line rate.

6.4.3.5 Object value data correctness

Data correctness refers to the maximum elapsed time since an object value in the ADSL or VDSL2 interface MIB was known to be current. The following specifies the requirements on the data correctness of the ADSL or VDSL2 OAM objects and the event notifications.

The ADSL and VDSL2 interface MIB objects shall have the data correctness of a maximum of 30 s.

The AME and VME shall support event notifications (i.e., SNMP Traps) for generic SNMP events within 2 s of the event detection by the AME.

7 Management information base (MIB) elements

The management information base (MIB) contains six types of information:

- Fault monitoring – Failures (alarm indications);
- Fault monitoring – Threshold crossing (alert messages);
- Performance monitoring parameters (counters);
- Configuration parameters;

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- Inventory parameters;
- Test, diagnostic and status parameters.

Figure 7-1 shows the in-service performance monitoring process. The primitives are specified in the physical layer of the ITU-T G.992.x-series of ITU-T Recommendations and [ITU-T G.993.2].

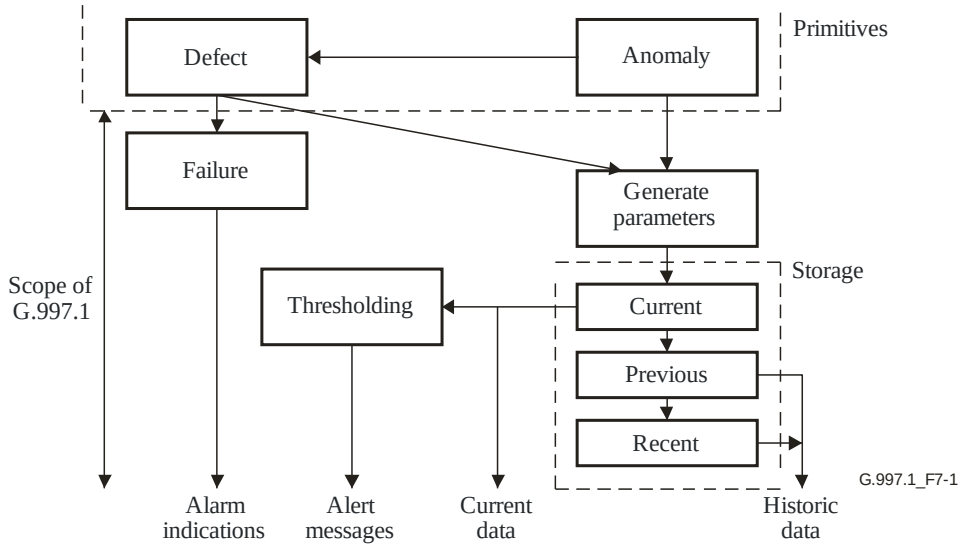

Figure 7-1 – In-service performance monitoring process

As an access node can handle a large number of xTU-Cs (e.g., hundreds or perhaps thousands of ADSL or VDSL2 lines), provisioning every parameter on every xTU-C may become burdensome. In response, two modes have been created to define ADSL and VDSL2 equipment configuration data profiles, as well as a mechanism to associate these profiles to the equipment. Profile tables may be implemented in one of two ways, but not simultaneously:

- MODE-I: Dynamic Profiles – profiles used by one or multiple ADSL/VDSL2 lines.

  Implementations using this mode will enable the operator of the system to dynamically create and delete profiles as needed. One or more ADSL/VDSL2 lines may be configured to share parameters of a single profile (e.g., adslLineConfProfileName = 'silver') by setting its adslLineConfProfile object to the index value of this profile. If a change is made to the profile, all lines that refer to it will be reconfigured to the changed parameters. Before a profile can be deleted or taken out of service, it shall be first unreferenced from all associated lines.

- MODE-II: Static profiles – one profile per ADSL/VDSL2 physical line.

  Implementations with this mode will automatically create a profile one-for-one with each ADSL/VDSL2 line. The name of this profile is a system generated read-only object whose value is equivalent to the index of the line. The management agent in the access node will not allow the operator of the system to create/delete profiles in this mode.

NOTE 1 – For more details on the use of profiles, refer to [b-IETF RFC 2662].

NOTE 2 – The 'data profiles' discussed in this clause are not the 'Profiles' discussed in clause 6 of [ITU-T G.993.2]. This clause discusses the use of a 'profile' for simplifying the configuration of an xDSL transceiver in the field. Clause 6 of [ITU-T G.993.2] is a discussion of a technique for defining the native capabilities (e.g., the particular subset of [ITU-T G.993.2]) supported by a particular VDSL2 transceiver.

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At the Q-interface, a line is configured by linking the following information to the line (see Figure 7-2):

- one line configuration profile (see Table 7-14) for the line;
- one channel configuration profile (see Table 7-16) for each downstream and each upstream bearer channel;
- one data path configuration profile (see Table 7-18) for each downstream and each upstream bearer channel.

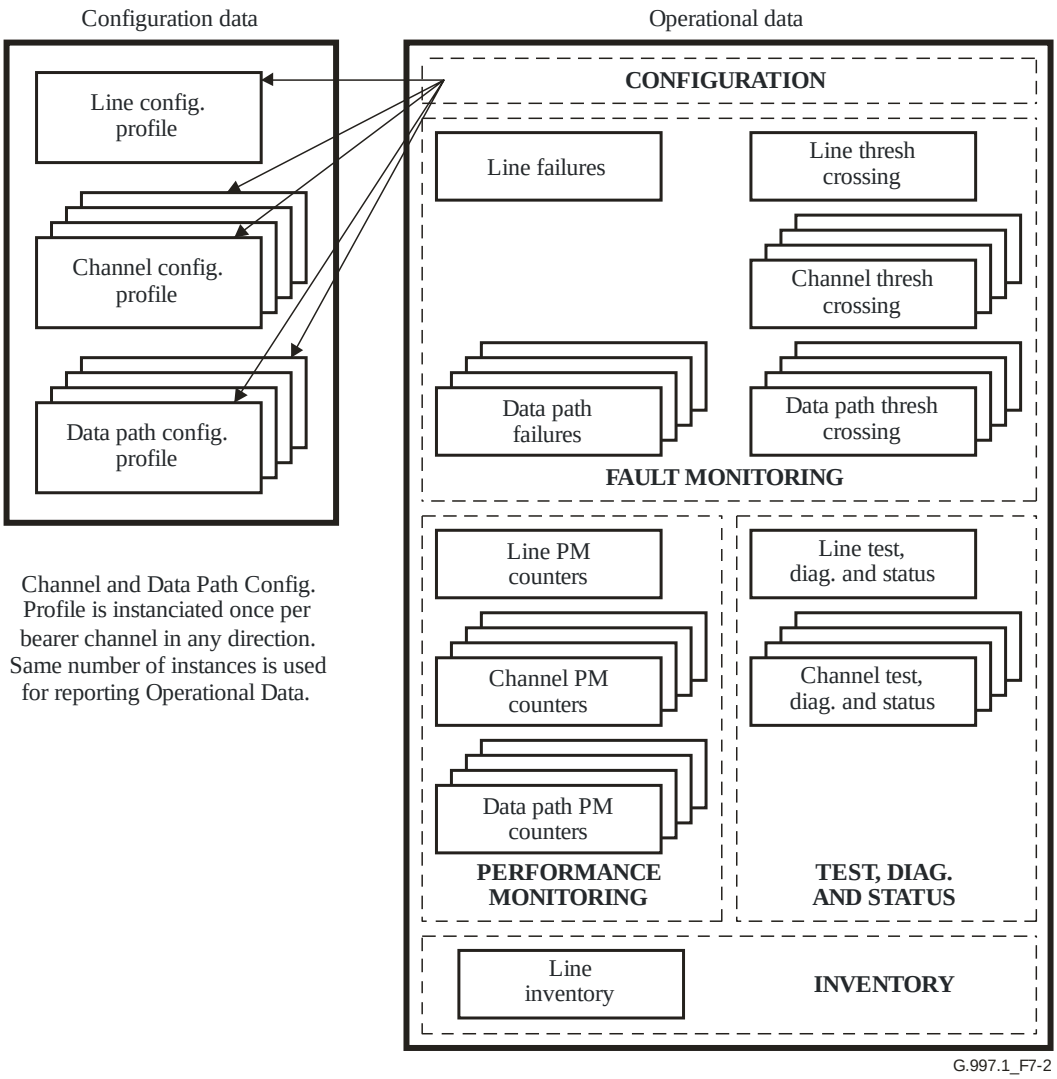

Figure 7-2 – Overview of the MIB elements provided for each line

Some or all of the configuration parameters contained in the line, channel and data path configuration profiles linked to the line may be written and/or read, depending on the interface under consideration:

Q interface: Management interface towards the xTU-C, from the network side perspective.

U-C interface: Management interface towards the xTU-C, from the xTU-R's perspective.

U-R interface: Management interface towards the xTU-R, from the xTU-C's perspective.

T/S interface: Management interface towards the xTU-R, from the premises side perspective.

In clause 7.6, a detailed list is given of the management elements applying to each of these interfaces, with indication whether they are mandatory or optional and whether they can be read, written or both.

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As an access node can handle a large number of lines (e.g., hundreds or perhaps thousands of ADSL or VDSL2 lines), maintaining the performance monitoring and the test, diagnostic and status information (see Figure 7-2) for every line may become burdensome. Although access to all mandatory management elements shall be supported at all times for all ports on the access node at the Q interface (see Figure 5-1), the elements may not be maintained within the management entity of the access node simultaneously for all lines at all times. Although reasonable performance shall be provided at the Q interface for access to the management elements of any line, this Recommendation does not define specific performance requirements at this interface.

7.1 Failures

Any failure defined in this clause shall be conveyed to the NMS by the xTU-C (over the Q-interface) and may be conveyed by the xTU-R over the T-/S-interface after it is detected.

The near-end failure detections shall be provided at the xTU-C and shall be provided at the xTU-R.

The far-end failure detections shall be provided at the xTU-C (xTU-R is at the far-end), and may be provided at the xTU-R (xTU-C is at the far-end).

7.1.1 Line failures

7.1.1.1 Line near-end failures

7.1.1.1.1 Loss-of-signal (LOS) failure

A LOS failure is declared after 2.5 ± 0.5 s of contiguous LOS defect, or, if LOS defect is present when the criteria for LOF failure declaration have been met (see LOF definition below). A LOS failure is cleared after 10 ± 0.5 s of no LOS defect.

7.1.1.1.2 Loss-of-frame (LOF) failure

A LOF failure is declared after 2.5 ± 0.5 s of contiguous SEF defect, except when an LOS defect or failure is present (see LOS definition above). A LOF failure is cleared when LOS failure is declared, or after 10 ± 0.5 s of no SEF defect.

7.1.1.1.3 Loss-of-power (LPR) failure

A LPR failure is declared after 2.5 ± 0.5 s of contiguous near-end LPR primitive presence. An LPR failure is cleared after 10 ± 0.5 s of no near-end LPR primitive presence.

7.1.1.1.4 Loss-of-margin (LOM) failure

A LOM failure is declared when a re-initialization is triggered by a persistent near-end *lom* defect, except when an LOS or LOF defect or failure is present (see LOS and LOF definitions above). A LOM failure is cleared when LOS or LOF failure is declared, or after 10 ± 0.5 s of no LOM defect.

7.1.1.2 Line far-end failures

7.1.1.2.1 Far-end loss-of-signal (LOS-FE) failure

A far-end loss-of-signal – LOS-FE failure is declared after 2.5 ± 0.5 s of contiguous far-end LOS defects, or, if far-end LOS defect is present when the criteria for LOF failure declaration have been met (see LOF definition below). A far-end LOS failure is cleared after 10 ± 0.5 s of no far-end LOS defect.

7.1.1.2.2 Far-end loss-of-frame (LOF-FE) failure

A far-end loss-of-frame – LOF-FE failure is declared after 2.5 ± 0.5 s of contiguous RDI defects, except when a far-end LOS defect or failure is present (see LOS definition above). A far-end LOF failure is cleared when far-end LOS failure is declared, or after 10 ± 0.5 s of no RDI defect.

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7.1.1.2.3 Far-end loss-of-power (LPR-FE) failure

A far-end loss-of-power – LPR-FE failure is declared after the occurrence of a far-end LPR primitive followed by 2.5 ± 0.5 s of contiguous near-end LOS defects. A far-end LPR failure is cleared after 10 ± 0.5 s of no near-end LOS defect.

7.1.1.2.4 Loss-of-margin (LOM-FE) failure

A far-end loss-of-margin – LOM-FE failure is declared when a re-initialization is triggered by a persistent far-end *lom* defect, except when an LOS-FE or LOF-FE defect or failure is present (see LOS and LOF definitions above). A far-end LOM failure is cleared when far-end LOS or LOF failure is declared, or after 10 ± 0.5 s of no far-end LOM defect.

7.1.1.3 Line initialization (LINIT) failure

If the line is forced to the L0 state (or into loop diagnostic mode) and an attempt to reach the L0 state (or to successfully complete the loop diagnostic procedures) fails (after a vendor discretionary number of retries and/or within a vendor discretionary timeout), then an initialization failure occurs. An initialization failure cause and last successful transmitted state are given by the line initialization failure (see clause 7.5.1.6). A line initialization failure shall be conveyed to the NMS by the xTU-C (over the Q-interface) and should be conveyed to the NMS by the xTU-R (over the T-/S-interface) after it is detected.

7.1.2 Channel failures

No channel failures are defined.

7.1.3 STM data path failures

The STM data path failures are for further study.

7.1.4 ATM data path failures

7.1.4.1 ATM data path near-end failures

7.1.4.1.1 No cell delineation (NCD) failure

An NCD failure is declared when an NCD anomaly persists for more than 2.5 ± 0.5 s after the start of showtime. An NCD failure terminates when no NCD anomaly is present for more than 10 ± 0.5 s.

7.1.4.1.2 Loss of cell delineation (LCD) failure

An LCD failure is declared when an LCD defect persists for more than 2.5 ± 0.5 s. An LCD failure terminates when no LCD defect is present for more than 10 ± 0.5 s.

7.1.4.2 Asynchronous Transfer Mode (ATM) data path far-end failures

7.1.4.2.1 Far-end no cell delineation (NCD-FE) failure

An NCD-FE failure is declared when an NCD-FE anomaly persists for more than 2.5 ± 0.5 s after the start of showtime. An NCD-FE failure terminates when no NCD-FE anomaly is present for more than 10 ± 0.5 s.

7.1.4.2.2 Far-end loss of cell delineation (LCD-FE) failure

An LCD-FE failure is declared when an LCD-FE defect persists for more than 2.5 ± 0.5 s. An LCD-FE failure terminates when no LCD-FE defect is present for more than 10 ± 0.5 s.

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7.1.5 PTM data path failures

7.1.5.1 PTM data path near-end failures

7.1.5.1.1 Out of sync (OOS) failure

An OOS failure is declared when an oos-*n* anomaly persists for more than 2.5 ± 0.5 s. An OOS failure terminates when no oos-*n* anomaly is present for more than 10 ± 0.5 s.

7.1.5.2 PTM data path far-end failures

7.1.5.2.1 Far-end out of sync (OOS-FE) failure

An OOS-FE failure is declared when an oos-*f* anomaly persists for more than 2.5 ± 0.5 s. An OOS-FE failure terminates when no oos-*f* anomaly is present for more than 10 ± 0.5 s.

7.2 Performance monitoring functions

Near-end performance monitoring (PM) functions shall be provided at the xTU-C and at the xTU-R. Far-end performance monitoring functions shall be provided at the xTU-C (xTU-R is at the far-end) and are optional at the xTU-R (xTU-C is at the far-end).

If the line is forced to the L0 state (see clause 7.3.1.1.3), then performance monitoring counters shall be active, irrespective of the actual power management state of the line (see clause 7.5.1.5). If the line is forced to the L3 state, then all performance monitoring counters shall be frozen, including the UAS counter.

7.2.1 Line performance monitoring parameters

This clause defines a set of line performance monitoring parameters. Support of the performance parameters in a network element is indicated as mandatory (M) or optional (O) in Table 7-1.

7.2.1.1 Near-end line performance monitoring parameters

7.2.1.1.1 Forward error correction second – Line (FECS-L)

This parameter is a count of 1-second intervals with one or more FEC anomalies summed over all received bearer channels.

7.2.1.1.2 Errored second – Line (ES-L)

This parameter is a count of 1-second intervals with one or more CRC-8 anomalies summed over all received bearer channels, or one or more LOS defects, or one or more SEF defects, or one or more LPR defects.

7.2.1.1.3 Severely errored second – Line (SES-L)

This parameter is a count of severely errored seconds (SES). An SES is declared if, during a 1-second interval, there are 18 or more CRC-8 anomalies in one or more of the received bearer channels, or one or more LOS defects, or one or more SEF defects, or one or more LPR defects. If [ITU-T G.998.4] is supported and retransmission is enabled in the near-end received direction, a SES is also declared if, during a 1-second interval, there is one or more severe loss of error-free throughput (*seftr*) defect in the near-end received direction.

If the relevant Recommendation (e.g., [ITU-T G.992.3], [ITU-T G.992.5] and [ITU-T G.993.2]) supports one-second normalized CRC-8 anomaly counter increment, the one-second counter used to declare SES shall increment with this value instead of incrementing by one for each CRC-8 anomaly.

If a common CRC is applied over multiple bearer channels, then each related CRC-8 anomaly shall be counted only once for the whole set of bearer channels over which the CRC is applied.

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7.2.1.1.4 LOS second – Line (LOSS-L)

This parameter is a count of 1-second intervals containing one or more LOS defects.

7.2.1.1.5 Unavailable second – Line (UAS-L)

This parameter is a count of 1-second intervals for which the xDSL line is unavailable.

If RIPOLICY is not supported or is not defined for the mode used, or the actual value of RIPOLICY equals 0, the xDSL line becomes unavailable at the onset of 10 contiguous SES-Ls. These 10 SES-Ls shall be included in unavailable time. Once unavailable, the xDSL line becomes available at the onset of 10 contiguous seconds with no SES-Ls. These 10 seconds with no SES-Ls shall be excluded from unavailable time.

If the actual value of RIPOLICY equals 1, the xDSL line becomes unavailable at the onset of REINIT_TIME_THRESHOLD contiguous SES-Ls. These REINIT_TIME_THRESHOLD SES-Ls shall be included in unavailable time.

Independent of the RIPOLICY, the xDSL line becomes also unavailable when the near-end receiver stops processing showtime symbols, in order to prepare for re-initialization. All contiguous SES-Ls until this moment shall be included in the unavailable time. After initialization or re-initialization, the xDSL line becomes available immediately at the start of showtime.

Some parameter counts are inhibited during unavailability – see clause 7.2.7.13.

7.2.1.1.6 ''leftr'' defects seconds counter

If retransmission is used in a given transmit direction, this parameter is a count of the seconds with a near-end "leftr" defect present (see clause 11.4.1 of [ITU-T G.998.4] for the definition of this counter).

The near-end counter is only defined in upstream.

The management entity shall generate a 15-minute and 24-hour performance history.

7.2.1.1.7 Error-free bits counter

If retransmission is used in a given transmit direction, this parameter is a count of the number of error-free bits passed over the β_1 reference point, divided by 2^{16} (see clause 11.4.2 of [ITU-T G.998.4] for the definition of this counter).

The near-end counter is only defined in upstream.

The management entity shall generate a 15-minute and 24-hour performance history.

7.2.1.1.8 Minimum error-free throughput (MINEFTR)

If retransmission is used in a given transmit direction, this parameter MINEFTR reports the minimum of the EFTR observed over the 15-minute or 24-hour accumulation period (see clause 11.4.3 of [ITU-T G.998.4] for the definition of this parameter).

The value is reported in bit/s.

The near-end value is only defined in upstream.

The management entity shall generate a 15-minute and 24-hour performance history.

The management entity shall read the ITU-T G.998.4 EFTR_min (at least) every 15 minutes to determine the minimum EFTR over the 15-minute and 24-hour intervals.

7.2.1.2 Far-end line performance monitoring parameters

7.2.1.2.1 Forward error correction second – Line far-end (FECS-LFE)

This parameter is a count of 1-second intervals with one or more FFEC anomalies summed over all transmitted bearer channels.

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7.2.1.2.2 Errored second – Line far-end (ES-LFE)

This parameter is a count of one-second intervals with one or more FEBE anomalies summed over all transmitted bearer channels, or one or more LOS-FE defects, or one or more RDI defects, or one or more LPR-FE defects.

7.2.1.2.3 Severely errored second – Line far-end (SES-LFE)

This parameter is a count of severely errored seconds (SES). An SES is declared if, during a 1-second interval, there are 18 or more FEBE anomalies in one or more of the transmitted bearer channels, or one or more far-end LOS defects, or one or more RDI defects, or one or more LPR-FE defects. If [ITU-T G.998.4] is supported and retransmission is enabled in the far-end received direction, a SES-LFE is also declared if, during a 1-second interval, there is one or more severe loss of error-free throughput (*seftr*) defect in the far-end received direction.

If the relevant Recommendation (e.g., [ITU-T G.992.3], [ITU-T G.992.5] or [ITU-T G.993.2]) supports 1-second normalized CRC-8 anomaly counter increment, the one-second counter used to declare SES shall increment with this value instead of incrementing by one for each FEBE anomaly.

If a CRC is applied over multiple bearer channels, then each related FEBE anomaly shall be counted only once for the whole set of related bearer channels.

7.2.1.2.4 LOS second – Line far-end (LOSS-LFE)

This parameter is a count of 1-second intervals containing one or more far-end LOS defects.

7.2.1.2.5 Unavailable seconds – Line far-end (UAS-LFE)

This parameter is a count of 1-second intervals for which the far-end xDSL line is unavailable.

If the actual value of RIPOLICY equals 0, the far-end xDSL line becomes unavailable at the onset of 10 contiguous SES-LFEs. These 10 SES-LFEs shall be included in unavailable time. Once unavailable, the far-end xDSL line becomes available at the onset of 10 contiguous seconds with no SES-LFEs. These 10 seconds with no SES-LFEs shall be excluded from unavailable time.

If the actual value of RIPOLICY equals 1, the xDSL line becomes unavailable at the onset of REINIT_TIME_THRESHOLD contiguous SES-LFEs. These REINIT_TIME_THRESHOLD SES-LFEs shall be included in unavailable time.

Independent of the RIPOLICY, the xDSL line becomes also unavailable when the near-end receiver stops processing showtime symbols, in order to prepare for re-initialization. All contiguous SES-LFEs until this moment shall be included in the unavailable time. After initialization or re-initialization, the xDSL line becomes available immediately at the start of showtime.

Some parameter counts are inhibited during unavailability – see clause 7.2.7.13.

7.2.1.2.6 "leftr" defects seconds counter

If retransmission is used in a given transmit direction, this parameter is a count of the seconds with a near-end "leftr" defect present (see clause 11.4.1 of [ITU-T G.998.4] for the definition of this counter).

The far-end counter is only defined in downstream.

The management entity shall generate a 15-minute and 24-hour performance history.

7.2.1.2.7 Error-free bits counter

If retransmission is used in a given transmit direction, this parameter is a count of the number of error-free bits passed over the β_1 reference point, divided by 2^{16} (see clause 11.4.2 of [ITU-T G.998.4] for the definition of this counter).

The far-end counter is only defined in downstream.

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The management entity shall generate a 15-minute and 24-hour performance history.

7.2.1.2.8 Minimum error-free throughput (MINEFTR)

If retransmission is used in a given transmit direction, this parameter MINEFTR reports the minimum of the EFTR observed over the 15-minute or 24-hour accumulation period (see clause 11.4.3 of [ITU-T G.998.4] for the definition of this parameter).

The value is reported in bit/s.

The far-end value is only defined in downstream.

The management entity shall generate a 15-minute and 24-hour performance history.

The management entity shall read the ITU-T G.998.4 EFTR_min (at least) every 15 minutes to determine the minimum EFTR over the 15-minute and 24-hour intervals.

7.2.1.3 Line initialization performance monitoring parameters

7.2.1.3.1 Full initialization count

This parameter is a count of the total number of full initializations attempted on the line (successful and failed) during the accumulation period. Parameter procedures shall be as defined in clause 7.2.7.

7.2.1.3.2 Failed full initialization count

This performance parameter is a count of the total number of failed full initializations during the accumulation period. A failed full initialization is when showtime is not reached at the end of the full initialization procedure.

Parameter procedures shall be as defined in clause 7.2.7.

7.2.1.3.3 Short initialization count

This parameter is a count of the total number of fast retrains or short initializations attempted on the line (successful and failed) during the accumulation period. Parameter procedures shall be as defined in clause 7.2.7.

Fast retrain is defined in [ITU-T G.992.2].

Short initialization is defined in [ITU-T G.992.3] and [ITU-T G.992.4].

7.2.1.3.4 Failed short initialization count

This performance parameter is a count of the total number of failed fast retrains or short initializations during the accumulation period. A failed fast retrain or short initialization is when showtime is not reached at the end of the fast retrain or short initialization procedure, e.g., when:

- A CRC error is detected.
- A time-out occurs.
- A fast retrain profile is unknown.

Parameter procedures shall be as defined in clause 7.2.7.

7.2.1.4 Near-end impulse noise performance monitoring parameters

7.2.1.4.1 INM INPEQ histogram 1..17 (INMINPEQ$_{1..17}$-L)

This parameter is a count of the near-end INMAINPEQ$_i$ anomalies occurring on the line during the accumulation period. This parameter is subject to inhibiting – see clause 7.2.7.13.

7.2.1.4.2 INM total measurement (INMME-L)

This parameter is a count of the near-end INMAME anomalies occurring on the line during the accumulation period. This parameter is subject to inhibiting – see clause 7.2.7.13.

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7.2.1.4.3 INM IAT histogram 0..7 ($INMIAT_{0..7}$-L)

This parameter is a count of the near-end $INMAIAT_i$ anomalies occurring on the line during the accumulation period. This parameter is subject to inhibiting – see clause 7.2.7.13.

7.2.1.5 Far-end impulse noise performance monitoring parameters

7.2.1.5.1 INM INPEQ histogram 1..17 ($INMINPEQ_{1..17}$-LFE)

This parameter is a count of the far-end $INMAINPEQ_i$ anomalies occurring on the line during the accumulation period. This parameter is subject to inhibiting – see clause 7.2.7.13.

7.2.1.5.2 INM total measurement (INMME-LFE)

This parameter is a count of the far-end INMAME anomalies occurring on the line during the accumulation period. This parameter is subject to inhibiting – see clause 7.2.7.13.

7.2.1.5.3 INM IAT histogram 0..7 ($INMIAT_{0..7}$-LFE)

This parameter is a count of the far-end $INMAIAT_i$ anomalies occurring on the line during the accumulation period. This parameter is subject to inhibiting – see clause 7.2.7.13.

7.2.1.6 Near-end SOS performance monitoring parameters

7.2.1.6.1 Near-end successful SOS count (SOS-SUCCESS-NE)

This parameter is a count of the total number of successful SOS procedures initiated by the near-end xTU on the line during the accumulation period. Parameter procedures shall be as defined in clause 7.2.7.

Successful SOS is defined in clause 12.1.4 of [ITU-T G.993.2].

7.2.1.7 Far-end SOS performance monitoring parameters

7.2.1.7.1 Far-end successful SOS count (SOS-SUCCESS-FE)

This parameter is a count of the total number of successful SOS procedures initiated by the far-end xTU on the line during the accumulation period. Parameter procedures shall be as defined in clause 7.2.7.

Successful SOS is defined in clause 12.1.4 of [ITU-T G.993.2].

7.2.1.8 Short interruption performance monitoring parameters

7.2.1.8.1 Loss-of-power interruption count (LPR_INTRPT)

This parameter is a count of the number of *lpr_intrpt* anomalies occurring during the accumulation period. Those anomalies are defined in clause 11.3.1.1 of [ITU-T G.993.2]. Only the counters on the current and previous 24-hours intervals shall be supported. A special value indicates that this counter is not active on the line. Threshold reports for this counter are not specified.

7.2.1.8.2 Host-Reinit interruption count (HRI_INTRPT)

This parameter is a count of the number of *hri_intrpt* anomalies occurring during the accumulation period. Those anomalies are defined in clause 11.3.1.1 of [ITU-T G.993.2]. Only the counters on the current and previous 24-hours intervals shall be supported. A special value indicates that this counter is not active on the line. Threshold reports for this counter are not specified.

7.2.1.8.3 Spontaneous interruption count (SPONT_INTRPT)

This parameter is a count of the number of *spont_intrpt* anomalies occurring during the accumulation period. Those defects are defined in clause 11.3.1.1 of [ITU-T G.993.2]. Only the counters on the current and previous 24-hours intervals shall be supported. A special value indicates that this counter is not active on the line. Threshold reports are specified for the 24-hour interval counter only.

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7.2.2 Channel performance monitoring parameters

This clause defines a set of channel performance monitoring parameters. Support of the performance parameters in a network element is indicated as mandatory (M) or optional (O) in Table 7-2.

7.2.2.1 Channel near-end performance monitoring parameters

7.2.2.1.1 Code violation – Channel (CV-C)

This parameter is a count of CRC-8 anomalies (the number of incorrect CRC) occurring in the bearer channel during the accumulation period. This parameter is subject to inhibiting – see clause 7.2.7.13.

If the CRC is applied over multiple bearer channels, then each related CRC-8 anomaly shall increment each of the counters related to the individual bearer channels.

7.2.2.1.2 Forward error correction – Channel (FEC-C)

This parameter is a count of FEC anomalies (the number of corrected code words) occurring in the bearer channel during the accumulation period. This parameter is subject to inhibiting – see clause 7.2.7.13.

If FEC is applied over multiple bearer channels, then each related FEC anomaly shall increment each of the counters related to the individual bearer channels.

7.2.2.1.3 Uncorrected DTU – Channel (RTXUC-C)

This parameter is a count of rtx-uc anomalies (the number of uncorrected DTUs) occurring in the bearer channel during the accumulation period.

7.2.2.1.4 Retransmitted DTU – Channel (RTXTX-C)

This parameter is a count of rtx-tx anomalies (the number of retransmitted DTUs, see clause 12 of [ITU-T G.998.4]) occurring in the bearer channel during the accumulation period.

7.2.2.2 Channel far-end performance monitoring parameters

7.2.2.2.1 Code violation – Channel far-end (CV-CFE)

This parameter is a count of far-end block error (FEBE) anomalies occurring in the bearer channel during the accumulation period. This parameter is subject to inhibiting – see clause 7.2.7.13.

If the cyclic redundancy check (CRC) is applied over multiple bearer channels, then each related FEBE anomaly shall increment each of the counters related to the individual bearer channels.

7.2.2.2.2 Forward error correction – Channel far-end (FEC-CFE)

This parameter is a count of far-end forward error correction (FFEC) anomalies occurring in the bearer channel during the accumulation period. This parameter is subject to inhibiting – see clause 7.2.7.13.

If FEC is applied over multiple bearer channels, then each related FFEC anomaly shall increment each of the counters related to the individual bearer channels.

7.2.2.2.3 Uncorrected DTU – Channel far-end (RTXUC-CFE)

This parameter is a count of far-end rtx-uc anomalies (the number of uncorrected DTUs) occurring in the bearer channel during the accumulation period.

7.2.2.2.4 Retransmitted DTU – Channel far-end (RTXTX-CFE)

This parameter is a count of far-end rtx-tx anomalies (the number of retransmitted DTUs, see clause 12 of [ITU-T G.998.4]) occurring in the bearer channel during the accumulation period.

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7.2.3 Synchronous transfer mode (STM) data path performance monitoring parameters

The STM channel performance monitoring parameters are for further study.

7.2.4 ATM data path performance monitoring parameters

This clause defines a set of ATM data path performance monitoring parameters using the cell transfer outcomes. Support of the performance parameters in a network element is indicated as mandatory (M) or optional (O) in Table 7-3.

NOTE – The far-end parameters cannot be supported using only the indicator bits or EOC messages specified in [ITU-T G.992.1] or [ITU-T G.992.2]. They may be provided using the OAM communication channel specified in clause 6.

7.2.4.1 ATM data path near-end performance monitoring parameters

7.2.4.1.1 Near-end header error control (HEC) violation count (HEC-P)

The near-end HEC_violation_count performance parameter is a count of the number of occurrences of a near-end HEC anomaly in the ATM Data Path.

7.2.4.1.2 Near-end delineated total cell count (CD-P)

The near-end delineated_total_cell_count performance parameter is a count of the total number of cells passed through the cell delineation and HEC function process operating on the ATM data path while in the SYNC state.

7.2.4.1.3 Near-end user total cell count (CU-P)

The near-end User_total_cell_count performance parameter is a count of the total number of cells in the ATM data path delivered at the V-C (for the xTU-C) or T-R (for the xTU-R) interface.

7.2.4.1.4 Near-end idle cell bit error count (IBE-P)

The near-end idle_bit_error_count performance parameter is a count of the number of bit errors in the idle cell payload received in the ATM Data Path at the near-end.

NOTE – The idle cell payload is defined in [b-ITU-T I.361] and [ITU-T I.432.x].

7.2.4.2 ATM data path far-end performance monitoring parameters

7.2.4.2.1 Far-end HEC violation count (HEC-PFE)

The far-end HEC_violation_count performance parameter is a count of the number of occurrences of a far-end HEC anomaly in the ATM data path.

7.2.4.2.2 Far-end delineated total cell count (CD-PFE)

The far-end delineated_total_cell_count performance parameter is a count of the total number of cells passed through the cell delineation process and HEC function operating on the ATM data path while in the SYNC state.

7.2.4.2.3 Far-end user total cell count (CU-PFE)

The far-end user_total_cell_count performance parameter is a count of the total number of cells in the ATM data path delivered at the V-C (for the xTU-C) or T-R (for the xTU-R) interface.

7.2.4.2.4 Far-end idle cell bit error count (IBE-PFE)

The far-end idle_bit_error_count performance parameter is a count of the number of bit errors in the idle cell payload received in the ATM data path at the far-end.

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7.2.5 PTM data path performance monitoring parameters

This clause defines a set of PTM data path performance monitoring parameters. Support of the performance parameters in a network element is indicated as mandatory (M) or optional (O) in Table 7-4.

7.2.5.1 PTM data path near-end performance monitoring parameters

7.2.5.1.1 Near-end CRC error count (CRC-P)

The CRC-P performance parameter is a count of the number of occurrences of a CRC-*n* anomaly in the PTM data path at the near-end.

The CRCP-P performance parameter is a count of the number of occurrences of a CRC-*np* anomaly in the PTM data path at the near-end.

7.2.5.1.2 Near-end coding violations Count (CV-P)

The CV-P performance parameter is a count of the number of occurrences of a cv-*n* anomaly in the PTM data path at the near-end.

The CVP-P performance parameter is a count of the number of occurrences of a cv-*np* anomaly in the PTM data path at the near-end.

7.2.5.2 PTM data path far-end performance monitoring parameters

NOTE 1 – The far-end counters are not supported by the indicator bits or EOC messages specified in the ITU-T G.992.x-series of Recommendations or in [ITU-T G.993.2]. They may be provided if the higher layer protocol running over this PTM-TC provides means (outside the scope of this Recommendation) to retrieve far-end PTM-TC surveillance primitives from the far-end, or through the OAM communication channel specified in clause 6.

NOTE 2 – In [b-IEEE 802.3], the Ethernet management function (residing above the γ reference point) maps the near-end surveillance primitives and counters (obtained over the γ-interface through access to clause 45 MDIO registers) into MIB objects defined in clause 30. MIB objects are exchanged with the far-end using the Ethernet OAM PDU format and protocol defined in clause 57.

7.2.5.2.1 Far-end CRC error count (CRC-PFE)

The far-end CRC-PFE performance parameter is a count at the far-end of the number of occurrences of a CRC-*n* anomaly (as observed by the far-end) in the PTM data path.

The far-end CRCP-PFE performance parameter is a count at the far-end of the number of occurrences of a CRC-*np* anomaly (as observed by the far-end) in the PTM data path.

7.2.5.2.2 Far-end coding violations count (CV-PFE)

The far-end CV-PFE performance parameter is a count at the far-end of the number of occurrences of a cv-*n* anomaly (as observed by the far-end) in the PTM data path.

The far-end CVP-PFE performance parameter is a count of the number of occurrences of a cv-*np* anomaly (as observed by the far-end) in the PTM data path.

7.2.6 Performance monitoring data collection

Parameter definitions, failure definitions, and other indications, parameters, and signals are defined above and in Tables 7-1, 7-2, 7-3 and 7-4. Functions are indicated as mandatory (M) or optional (O). Mandatory functions shall be met for performance monitoring. Optional functions should be provided according to the needs of the users.

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Table 7-1 – Line performance monitoring parameter definitions

Name	End	Use at xTU-C	Use at xTU-R	Definition
FECS-L	Near	M	M	FEC ≥ 1 for one or more bearer channels.
FECS-LFE	Far	M	O	FFEC ≥ 1 for one or more bearer channels.
ES-L	Near	M	M	CRC-8 ≥ 1 for one or more bearer channels **OR** LOS ≥ 1 **OR** SEF ≥ 1 **OR** LPR ≥ 1
ES-LFE	Far	M	O	FEBE ≥ 1 for one or more bearer channels **OR** LOS-FE ≥ 1 **OR** RDI ≥ 1 **OR** LPR-FE ≥ 1
SES-L	Near	M	M	CRC-8 ≥ 18 for one or more bearer channels **OR** LOS ≥ 1 **OR** SEF ≥ 1 **OR** LPR ≥ 1 Further conditions see clause 7.2.1.1.3.
SES-LFE	Far	M	O	FEBE ≥ 18 for one or more bearer channels **OR** LOS-FE ≥ 1 **OR** RDI ≥ 1 **OR** LPR-FE ≥ 1 Further condition see clause 7.2.1.2.3
LOSS-L	Near	O	O	LOS ≥ 1
LOSS-LFE	Far	O	O	LOS-FE ≥ 1
UAS-L	Near	M	M	A second of unavailability.
UAS-LFE	Far	M	O	A second of unavailability.
INMINPEQ$_i$-L	Near	O		Count of INMAINPEQ$_i$-L anomalies on the line.
INMINPEQ$_i$-LFE	Far	O		Count of INMAINPEQ$_i$-LFE anomalies on the line.
INMIAT$_i$-L	Near	O		Count of INMAIAT$_i$-L anomalies on the line.
INMIAT$_i$-LFE	Far	O		Count of INMAIAT$_i$-LFE anomalies on the line.
INMME-L	Near	O		Count of INMAME-L anomalies on the line.
INMME-LFE	Far	O		Count of INMAME-LFE anomalies on the line.

NOTE 1 – Note that **OR** represents a logical OR of two conditions.

NOTE 2 – Unavailability definitions are presented in clauses 7.2.1.1.5 and 7.2.1.2.5.

NOTE 3 – If a common CRC or FEC is applied over multiple bearer channels, then each related CRC-8 or FEC anomaly shall be counted only once for the whole set of bearer channels over which the CRC or FEC is applied.

NOTE 4 – If the relevant Recommendation supports one-second normalized CRC counter increments, these increments shall be used instead of an increment of one for each CRC-8 and FEBE anomaly to declare SES.

Table 7-2 – Channel performance monitoring parameter definitions

Name	End	Use at xTU-C	Use at xTU-R	Definition
CV-C	Near	M	M	Count of CRC-8 anomalies in the bearer channel.
CV-CFE	Far	M	O	Count of FEBE anomalies in the bearer channel.
EC-C	Near	M	M	Count of FEC anomalies in the bearer channel.
EC-CFE	Far	M	O	Count of FFEC anomalies in the bearer channel.

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Table 7-3 – ATM data path performance monitoring parameter definitions

Name	End	Use at xTU-C	Use at xTU-R	Definition
HEC-P	Near	M	M	Count of HEC anomalies in the bearer channel.
HEC-PFE	Far	M	O	Count of FHEC anomalies in the bearer channel.
CD-P	Near	M	M	Count of delineated cells in the bearer channel.
CD-PFE	Far	M	O	Count of delineated cells in the bearer channel.
CU-P	Near	M	M	Count of cells to user in the bearer channel.
CU-PFE	Far	M	O	Count of cells to user in the bearer channel.
IBE-P	Near	M	M	Count of idle cell payload bit errors in the bearer channel.
IBE-PFE	Far	M	O	Count of idle cell payload bit errors in the bearer channel.

Table 7-4 – PTM data path performance monitoring parameter definitions

Name	End	Use at xTU-C	Use at xTU-R	Definition
CRC-P	Near	M	M	Count of non pre-emptive packets with CRC error in the bearer channel.
CRC-PFE	Far	M	O	Count of non pre-emptive packets with CRC error in the bearer channel.
CRCP-P	Near	M	M	Count of pre-emptive packets with CRC error in the bearer channel.
CRCP-PFE	Far	M	O	Count of pre-emptive packets with CRC error in the bearer channel.
CV-P	Near	M	M	Count of non pre-emptive packets with coding violation in the bearer channel.
CV-PFE	Far	M	O	Count of non pre-emptive packets with coding violation in the bearer channel.
CVP-P	Near	M	M	Count of pre-emptive packets with coding violation in the bearer channel.
CVP-PFE	Far	M	O	Count of pre-emptive packets with coding violation in the bearer channel.

The line performance monitoring parameters (Table 7-1) are observed for the downstream and upstream directions. In the downstream direction, the near-end line performance monitoring parameters are observed by the xTU-R and far-end line performance monitoring parameters are observed by the xTU-C. In the upstream direction, near-end line performance monitoring parameters are observed by the xTU-C and far-end line performance monitoring parameters are observed by the xTU-R.

For a downstream bearer channel, near-end channel (Table 7-2), ATM data path (Table 7-3, if applicable), and PTM data path (Table 7-4, if applicable) performance monitoring parameters are observed by the xTU-R and far-end performance monitoring parameters are observed by the xTU-C. For an upstream bearer channel, near-end channel and ATM data path performance monitoring parameters are observed by the xTU-C and far-end performance monitoring parameters are observed by the xTU-R.

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7.2.7 Procedures for performance monitoring functions

The functions described in this clause can be performed inside or outside the network element.

7.2.7.1 Line transmission states

A line can be in one of two transmission states:

- unavailable state;
- available state.

The transmission state is determined from filtered SES/non-SES data. The definition of unavailable state is defined in clause 7.2.1.1.5. An xDSL Line is in the available state when it is not in the unavailable state.

7.2.7.2 Threshold reports

A threshold report (TR) is an unsolicited error performance report from a ME over the Q-interface and from the xTU-R over the U-interface with respect to either a 15-minute or 24-hour evaluation period. TRs can only occur when the concerned direction is in the available state. At the Q-interface, TRs for near-end and far-end ES, SES and UAS parameters are mandatory and TRs for the other defined parameters are optional except for INM parameters, LPR_INTRPT, HRI_INTRPT, for which TRs are not defined. Threshold reports are not provided at the T-/S-interface.

TR1s shall occur within 10 seconds after the 15-minute threshold is reached or exceeded.

TR2s shall occur within 10 seconds after the 24-hour threshold is reached or exceeded.

7.2.7.3 Unavailable and available state filters

The unavailable state filter is a 10-second rectangular sliding window with a 1-second granularity of the slide.

The available state filter is also a 10-second rectangular sliding window with a 1-second granularity of the slide.

7.2.7.4 TR1 filter

The TR1 filter is a 15-minute rectangular fixed window. The start and end times for the 15-minute rectangular fixed windows shall fall on the hour and at 15, 30 and 45 minutes after the hour.

7.2.7.5 TR2 filter

The TR2 filter is a 24-hour rectangular fixed window. The start and end times for the 24-hour rectangular fixed windows shall fall on a 15-minute window boundary.

7.2.7.6 Evaluation of TR1

The parameters are counted separately, second by second, over each 15-minute rectangular fixed window period. The threshold values should be programmable over the range 0 to 900 with default values. The default values are given in [b-ITU-T M.2100] and [b-ITU-T M.2101].

A threshold can be crossed at any second within the 15-minute rectangular fixed window. As soon as a threshold is crossed, a TR1 as appropriate should be sent to the NMS together with a date/time-stamp. Moreover, performance events should continue to be counted to the end of the current 15-minute period, at which time the current parameter counts are stored in the history registers and the current parameter registers are reset to zero.

7.2.7.7 Evaluation of TR2

The parameters are counted separately over each 24-hour period. The threshold values should be programmable over the range 0 to 86400 with default values.

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The network element shall recognize a 24-hour threshold crossing within 15 minutes of its occurrence. The threshold crossing shall be given the date/time-stamp of the moment of recognition. A TR2 as appropriate should be sent to the NMS with the date/time-stamp. Moreover, performance events should continue to be counted to the end of the current 24-hour period, at which time the parameter counts are stored in the history registers and the current parameter registers are reset to zero.

7.2.7.8 Threshold report evaluation during transmission state changes

Care should be taken to ensure that threshold reports are correctly generated and parameter counters are correctly processed during changes in the transmission state. This implies that all threshold reports should be delayed by 10 seconds (see [b-ITU-T M.2120]).

7.2.7.9 Performance history storage in network elements

The parameters for ME performance history storage at the Q-interface that shall be supported are ES, SES and UAS. Performance history storage for the other defined parameters is optional.

There shall be a current 15-minute register (which can also facilitate the TR1 filter) plus a further *N* 15-minute history registers for each parameter in each ME. The *N* 15-minute history registers are used as a stack, i.e., the value held in each register is pushed down the stack one place at the end of each 15-minute period, and the oldest register value at the bottom of the stack is discarded.

The value of *N* for the parameters ES, SES and UAS shall be at least 16. For the other parameters, the value of *N* shall be at least 1 (i.e., only current and previous values are required). If INM parameters are supported, the value of *N* for those parameters shall be 1.

There shall be a current 24-hour register (which can also facilitate the TR2 filter) plus one previous 24-hour register for each parameter.

As a minimum, an invalid data flag shall be provided for each stored interval for each direction for each monitored transmission entity. For example:

An invalid data flag is set to indicate that the data stored is incomplete or otherwise invalid when:

- The data in the previous and recent intervals has been accumulated over a period of time that is greater or less than the nominal accumulation period duration.
- The data in the current interval is suspect because a terminal is restarted or a register is reset in the middle of an accumulation period.
- The data is incomplete in an accumulation period. For example, an incoming transmission failure or defect may prevent complete collection of far-end performance reports.

The invalid data flag is not set as a result of register saturation.

7.2.7.10 Register size

The minimum register size is 16 bits. The maximum register sizes are vendor discretionary. When the maximum value of a register is reached, the register shall remain at that maximum value until it is reset, or the value is transferred or discarded, as described in this clause.

7.2.7.11 Parameter counts

All parameter counts shall be actual counts for the 15-minute filtering period.

Although all parameter counts should (ideally) also be actual for the 24-hour filtering periods, it is recognized that it might be desirable to limit register sizes. In such cases register overflow may occur. Should register overflow occur, the registers shall hold their maximum value for the parameter considered until the registers are read and reset at the end of the 24-hour period. An implementation involving setting and resetting an overflow bit may be used.

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If the AN-ME does not force the line into the L3 state, then performance monitoring counters shall be active, irrespective of the actual link state of the line.

If the AN-ME forces the line into the L3 state, then all performance monitoring counters shall be frozen, including the UAS counter.

The time when the PM counters are frozen shall be excluded from the accumulation period (see clause 7.2.7.9).

NOTE – The AN-ME may force the line into the L3 state, e.g., when the line is configured with AdminStatus="down", during loop diagnostics mode (see clause 7.3.1.1.8), or during a single-ended line test (SELT) measurement (see ITU-T G.996.2).

7.2.7.12 Date/time-stamping of reports

The date/time-stamping accuracy of reports, together with the method of maintaining the accuracy, is under study.

The format for date/time-stamps is as follows:

- 15-minute window will be stamped Year, Month, Day, Hour, Minute;
- 24-hour window will be stamped Year, Month, Day, Hour;
- Unavailable Time events will be stamped Year, Month, Day, Hour, Minute, Second;
- Alarms will be stamped either at the declaration of the alarm by the equipment or at the exact time of the event (to be decided) with Year, Month, Day, Hour, Minute, Second.

Equipment clock accuracy requirements are for further study.

7.2.7.13 Inhibiting performance monitoring parameters

For a given monitored entity, the accumulation of certain performance parameters is inhibited during periods of unavailability, during SESs or during seconds containing defects on that monitored entity. Inhibiting on a given monitored entity (e.g., ADSL ATM data path) is not explicitly affected by conditions on any other monitored entity (xDSL line). The inhibiting rules are as follows:

- UAS and failure count parameters shall not be inhibited.
- *leftr* defect seconds counter and MINEFTR shall not be inhibited.
- INM parameters shall be inhibited during a 1-second interval, if it contains one or more LOS defects, or one or more SEF defects, or one or more LPR defects.

  SES-L, SES-LFE, ES-L, ES-LFE, LOSS-L and LOSS-LFE counters shall be inhibited only during unavailable time even if the unavailable time is declared retroactively.

  NOTE – An implementation may count the SES-L, ES-L and LOSS-L during the contiguous SES-L leading to the declaration of UAS-L and substract them at the onset of the declaration of UAS-L. The same may apply for the LOSS-LFE. See illustration in Figure 4 of [b-ITU-T M.2100].
- All other performance parameter counts shall be inhibited during UAS and SES. Inhibiting shall be retroactive to the onset of unavailable time and shall end retroactively to the end of unavailable time.

7.3 Configuration functions

7.3.1 Line configuration parameters

7.3.1.1 State configuration parameters

7.3.1.1.1 xTU transmission system enabling (XTSE)

This configuration parameter defines the transmission system types to be allowed by the near-end xTU on this line. This parameter only applies to the Q-interface. It is coded in a bit-map representation (0 if not allowed, 1 if allowed), with following definition:

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Bit	Representation
Octet 1	
1	Regional standards (see Note).
2	Regional standards (see Note).
3	ITU-T G.992.1 operation over POTS non-overlapped spectrum (Annex A of [ITU-T G.992.1]).
4	ITU-T G.992.1 operation over POTS overlapped spectrum (Annex A of [ITU-T G.992.1]).
5	ITU-T G.992.1 operation over ISDN non-overlapped spectrum (Annex B of [ITU-T G.992.1]).
6	ITU-T G.992.1 operation over ISDN overlapped spectrum (Annex B of [ITU-T G.992.1]).
7	ITU-T G.992.1 operation in conjunction with TCM-ISDN non-overlapped spectrum (Annex C of [ITU-T G.992.1]).
8	ITU-T G.992.1 operation in conjunction with TCM-ISDN overlapped spectrum (Annex C of [ITU-T G.992.1]).
Octet 2	
9	ITU-T G.992.2 operation over POTS non-overlapped spectrum (Annex A of [ITU-T G.992.2]).
10	ITU-T G.992.2 operation over POTS overlapped spectrum (Annex B of [ITU-T G.992.2]).
11	ITU-T G.992.2 operation in conjunction with TCM-ISDN non-overlapped spectrum (Annex C of [ITU-T G.992.2]).
12	ITU-T G.992.2 operation in conjunction with TCM-ISDN overlapped spectrum (Annex C of [ITU-T G.992.2]).
13	Reserved.
14	Reserved.
15	Reserved.
16	Reserved.
Octet 3	
17	Reserved.
18	Reserved.
19	ITU-T G.992.3 operation over POTS non-overlapped spectrum (Annex A of [ITU-T G.992.3]).
20	ITU-T G.992.3 operation over POTS overlapped spectrum (Annex A of [ITU-T G.992.3]).
21	ITU-T G.992.3 operation over ISDN non-overlapped spectrum (Annex B of [ITU-T G.992.3]).
22	ITU-T G.992.3 operation over ISDN overlapped spectrum (Annex B of [ITU-T G.992.3]).
23	ITU-T G.992.3 operation in conjunction with TCM-ISDN non-overlapped spectrum (Annex C of [ITU-T G.992.3]).
24	ITU-T G.992.3 operation in conjunction with TCM-ISDN overlapped spectrum (Annex C of [ITU-T G.992.3]).
Octet 4	
25	ITU-T G.992.4 operation over POTS non-overlapped spectrum (Annex A of [ITU-T G.992.4]).
26	ITU-T G.992.4 operation over POTS overlapped spectrum (Annex A of [ITU-T G.992.4]).

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27 Reserved.

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29 ITU-T G.992.3 all digital mode operation with non-overlapped spectrum (Annex I of [ITU-T G.992.3]).

30 ITU-T G.992.3 all digital mode operation with overlapped spectrum (Annex I of [ITU-T G.992.3]).

31 ITU-T G.992.3 all digital mode operation with non-overlapped spectrum (Annex J of [ITU-T G.992.3]).

32 ITU-T G.992.3 all digital mode operation with overlapped spectrum (Annex J of [ITU-T G.992.3]).

Octet 5

33 ITU-T G.992.4 all digital mode operation with non-overlapped spectrum (Annex I of [ITU-T G.992.4]).

34 ITU-T G.992.4 all digital mode operation with overlapped spectrum (Annex I of [ITU-T G.992.4]).

35 ITU-T G.992.3 reach extended operation over POTS, Mode 1 (non-overlapped, wide upstream) (Annex L of [ITU-T G.992.3]).

36 ITU-T G.992.3 reach extended operation over POTS, Mode 2 (non-overlapped, narrow upstream) (Annex L of [ITU-T G.992.3]).

37 ITU-T G.992.3 reach extended operation over POTS, Mode 3 (overlapped, wide upstream) (Annex L of [ITU-T G.992.3]).

38 ITU-T G.992.3 reach extended operation over POTS, Mode 4 (overlapped, narrow upstream) (Annex L of [ITU-T G.992.3]).

39 ITU-T G.992.3 extended upstream operation over POTS non-overlapped spectrum (Annex M of [ITU-T G.992.3]).

40 ITU-T G.992.3 extended upstream operation over POTS overlapped spectrum (Annex M of [ITU-T G.992.3]).

Octet 6

41 ITU-T G.992.5 operation over POTS non-overlapped spectrum (Annex A of [ITU-T G.992.5]).

42 ITU-T G.992.5 operation over POTS overlapped spectrum (Annex A of [ITU-T G.992.5]).

43 ITU-T G.992.5 operation over ISDN non-overlapped spectrum (Annex B of [ITU-T G.992.5]).

44 ITU-T G.992.5 operation over ISDN overlapped spectrum (Annex B of [ITU-T G.992.5]).

45 ITU-T G.992.5 operation in conjunction with TCM-ISDN non-overlapped spectrum (Annex C of [ITU-T G.992.5]).

46 ITU-T G.992.5 operation in conjunction with TCM-ISDN overlapped spectrum (Annex C of [ITU-T G.992.5]).

47 ITU-T G.992.5 all digital mode operation with non-overlapped spectrum (Annex I of [ITU-T G.992.5]).

48 ITU-T G.992.5 all digital mode operation with overlapped spectrum (Annex I of [ITU-T G.992.5]).

Octet 7

49 ITU-T G.992.5 all digital mode operation with non-overlapped spectrum (Annex J of [ITU-T G.992.5]).

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50 ITU-T G.992.5 all digital mode operation with overlapped spectrum (Annex J of [ITU-T G.992.5]).

51 ITU-T G.992.5 extended upstream operation over POTS non-overlapped spectrum (Annex M of [ITU-T G.992.5]).

52 ITU-T G.992.5 extended upstream operation over POTS overlapped spectrum (Annex M of [ITU-T G.992.5]).

53 Reserved.

54 Reserved.

55 Reserved.

56 Reserved.

Octet 8

57 ITU-T G.993.2 Region A (North America) (Annex A of [ITU-T G.993.2]).

58 ITU-T G.993.2 Region B (Europe) (Annex B of [ITU-T G.993.2]).

59 ITU-T G.993.2 Region C (Japan) (Annex C of [ITU-T G.993.2]).

60 Reserved.

61 Reserved.

62 Reserved.

63 Reserved.

64 Reserved.

NOTE – It is recommended that bit 1 be used for [b-ATIS 0600413]. It is recommended that bit 2 be used for Annex C of [b-ETSI TS 101 388].

7.3.1.1.2 ADSL transceiver unit (ATU) impedance state forced (AISF)

This configuration parameter defines the impedance state to be forced on the near-end ATU. It applies only to the T-/S-interface. It is coded as an integer value with the following definition:

1 Force the near-end ATU to the disabled state.

2 Force the near-end ATU to the inactive state.

3 Force the near-end ATU to the active state.

Impedance states apply only to Annex A of [ITU-T G.992.3] operation mode and are defined in clause A.4.1 of [ITU-T G.992.3].

7.3.1.1.3 Power management state forced (PMSF)

This configuration parameter defines the line states to be forced by the near-end xTU on this line. It is coded as an integer value with the following definition:

0 Force the line to transition from the L3 idle state to the L0 full-on state (i.e., both xTUs are in showtime). This transition requires the (short or full) initialization procedures. After reaching the L0 state, the line may transition into or exit from the L2 low power state (if L2 state is defined and enabled). If the L0 state is not reached (after a vendor discretionary number of retries and/or within a vendor discretionary timeout), then an Initialization failure occurs. Whenever the line is in the L3 state, attempts shall be made to transition to the L0 state until it is forced into another state through this configuration parameter.

2 Force the line to transition from L0 full on to L2 low power state. This transition requires the entry into L2 mode. This is an out-of-service test value for triggering the L2 mode and is valid only for Recommendations supporting L2 mode.

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3 Force the line to transition from the L0 full-on or L2 low power state to the L3 idle state. This transition requires the (orderly) shutdown procedure. After reaching the L3 state, the line shall remain in the L3 idle state until it is forced into another state through this configuration parameter.

Forced line state transitions require the line to enter or exit the L3 idle state. These transitions are not restricted by the power management state enabling parameter value.

NOTE – This configuration parameter maps to the AdminStatus of the line, which is part of the GeneralInformationGroup object group specified in [b-IETF RFC 2233], and may not need to be duplicated in the ADSL MIB. See also [b-IETF RFC 2662]. The administrative status of the line is UP when the line is forced to the L0 state and is DOWN when the line is forced to the L3 state.

7.3.1.1.4 Power management state enabling (PMMode)

This configuration parameter defines the line states the xTU-C or xTU-R may autonomously transition to on this line. It is coded in a bit-map representation (0 if not allowed, 1 if allowed) with following definition:

Bit 0 L3 state (idle state)

Bit 1 L1/L2 state (low power state)

NOTE – L1/L2 state may not be defined in some ITU-T Recommendations.

7.3.1.1.5 Minimum L0 time interval between L2 exit and next L2 entry (L0-TIME)

This parameter represents the minimum time (in seconds) between an exit from the L2 state and the next entry into the L2 state. It ranges from 0 to 255 seconds.

7.3.1.1.6 Minimum L2 time interval between L2 entry and first L2 trim (L2-TIME)

This parameter represents the minimum time (in seconds) between an entry into the L2 state and the first power trim in the L2 state and between two consecutive power trims in the L2 state. It ranges from 0 to 255 seconds.

7.3.1.1.7 Maximum aggregate transmit power reduction per L2 request or L2 power trim (L2-ATPR)

This parameter represents the maximum aggregate transmit power reduction (in dB) that can be performed in the L2 request (i.e., at transition of L0 to L2 state) or through a single power trim in the L2 state. It ranges from 0 dB to 31 dB in steps of 1 dB.

7.3.1.1.8 Loop diagnostic mode forced (LDSF)

This configuration parameter defines whether the line should be forced into the loop diagnostic mode by the near-end xTU on this line. It is coded as an integer value with the following definition:

0 Inhibits the near-end xTU from performing loop diagnostic mode procedures on the line. Loop diagnostic mode procedures may still be initiated by the far-end xTU.

1 Forces the near-end xTU to perform the loop diagnostic procedures.

Upon the NMS forcing the loop diagnostics mode on the line, the access node shall ~~The line needs to be~~ force~~d~~ the line to the L3 state ~~(see clause 7.3.1.1.3)~~ before it forces the near-end xTU ~~can be forced~~ to perform the loop diagnostic mode procedures. Only while the line power management state is the L3 state (see clause 7.5.1.5), ~~can~~ the near-end xTU can be ~~line be~~ forced ~~into~~ to perform the loop diagnostic mode procedures.

If the loop diagnostics mode status and results status (LDS and LDR, see clauses 7.5.1.44 and 7.5.1.45) MIB elements are not supported, then u~~U~~pon successful completion of the loop diagnostic mode procedures, the access node shall set the LDSF MIB element to 0, and the xTUs shall return to the ~~L3~~ IDLE state. The loop diagnostic data shall be available at least until the NMS no longer forces the loop diagnostic mode~~line is forced to the L0 state (see clause 7.3.1.1.3)~~. If the loop diagnostic

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mode procedures cannot be completed successfully (after a vendor discretionary number of retries and/or within a vendor discretionary timeout), then an initialization failure shall occur~~s~~.

If the loop diagnostics mode status and results status (LDS and LDR, see clauses 7.5.1.44 and 7.5.1.45) MIB elements are supported, then upon successful completion of the loop diagnostic mode procedures, the access node shall set the LDS to “inactive” and the LDR to ”loop-diagnostics-succeeded-results-valid”, and the xTUs shall return to the IDLE state. The loop diagnostic mode data shall be available at least until the NMS no longer forces the loop diagnostic mode. If the loop diagnostic mode procedures cannot be completed successfully (after a vendor discretionary number of retries and/or within a vendor discretionary timeout), then the access node shall set the LDS to ”inactive” and the LDR to ”loop diagnostics failed results invalid”, and the xTUs shall return to the ~~idle~~IDLE state.~~ As long as loop diagnostic procedures are not completed successfully, attempts shall be made to do so, until the loop diagnostic mode is no longer forced on the line through this configuration parameter.~~

7.3.1.1.9 Total maximum aggregate transmit power reduction in L2 (L2-ATPRT)

This parameter represents the total maximum aggregate transmit power reduction (in dB) that can be performed in an L2 state. This is the sum of all reductions of L2 Request (i.e., at transition of L0 to L2 state) and power trims. It ranges from 0 dB to 31 dB in steps of 1 dB.

7.3.1.1.10 Automode cold start forced

This parameter is defined in order to improve testing of the performance of xTUs supporting automode when it is enabled in the MIB. The valid values are 0 and 1. A change in value of this parameter indicates a change in loop conditions applied to the devices under test. The xTUs shall reset any historical information used for automode, for shortening ITU-T G.994.1 handshake, or for shortening the initialization procedure.

Automode is defined as the case where multiple operation-modes are enabled in the MIB in the ITU-T G.997.1 "xTU Transmission System Enabling (XTSE)" table and where the selection of the operation-mode to be used for transmission does not only depend on the common capabilities of both xTUs (as exchanged in [ITU-T G.994.1]), but depends also on achievable data rates under given loop conditions.

This parameter is mandatory at the Q interface for modems supporting automode.

7.3.1.1.11 VDSL2 profiles enabling (PROFILES)

This configuration parameter contains the ITU-T G.993.2 profiles to be allowed by the near-end xTU on this line. It is coded in a bit-map representation (0 if not allowed, 1 if allowed) with the following definition:

Bit	**Representation**
Octet 1	
1	ITU-T G.993.2 profile 8a.
2	ITU-T G.993.2 profile 8b.
3	ITU-T G.993.2 profile 8c.
4	ITU-T G.993.2 profile 8d.
5	ITU-T G.993.2 profile 12a.
6	ITU-T G.993.2 profile 12b.
7	ITU-T G.993.2 profile 17a.
8	ITU-T G.993.2 profile 30a.

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Octet 2

1 ITU-T G.993.2 profile 35b.

2 reserved by ITU-T.

3 reserved by ITU-T.

4 reserved by ITU-T.

5 reserved by ITU-T.

6 reserved by ITU-T.

7 reserved by ITU-T.

8 reserved by ITU-T.

7.3.1.1.12 Re-Initialization policy selection (RIPOLICY)

7.3.1.1.12.1 Downstream re-initialization policy selection (RIPOLICYds)

The RIPOLICYds parameter indicates which policy shall be applied to determine the triggers for re-initialization in the downstream direction (see clause 12.1.4 of [ITU-T G.993.2] and clauses 7.3.1.1.13 and 7.2.1.1.5 of this Recommendation).

If RIPOLICYds=1 is configured and it is detected during ITU-T G.993.2 initialization that RIPOLICYds=1 is not supported in the downstream direction by either XTU's, the XTU's shall fallback to RIPOLICYds=0.

The valid values for RIPOLICYds are 0 and 1.

7.3.1.1.12.2 Upstream re-initialization policy selection (RIPOLICYus)

The RIPOLICYus parameter indicates which policy shall be applied to determine the triggers for re-initialization in the upstream direction (see clause 12.1.4 of [ITU-T G.993.2] and clauses 7.3.1.1.13 and 7.2.1.1.5 of this Recommendation).

If RIPOLICYus=1 is configured and it is detected during ITU-T G.993.2 initialization that RIPOLICYus=1 is not supported in the upstream direction by either XTU's, the XTU's shall fallback to RIPOLICYus=0.

The valid values for RIPOLICYus are 0 and 1.

7.3.1.1.13 REINIT_TIME_THRESHOLDds

7.3.1.1.13.1 Downstream REINIT_TIME_THRESHOLDds

The parameter REINIT_TIME_THRESHOLDds defines the downstream threshold for re-initialization based on SES, to be used by the VTU receiver when re-initialization policy 1 is used in downstream (see clause 12.1.4 of [ITU-T G.993.2]).

The valid range is from 5 to 31.

7.3.1.1.13.2 Upstream REINIT_TIME_THRESHOLDus

The parameter REINIT_TIME_THRESHOLDus defines the upstream threshold for re-initialization based on SES, to be used by the VTU receiver when re-initialization policy 1 is used in upstream (see clause 12.1.4 of [ITU-T G.993.2]).

The valid range is from 5 to 31.

7.3.1.2 Power/PSD configuration parameters

7.3.1.2.1 Downstream maximum nominal power spectral density (MAXNOMPSDds)

This parameter represents the maximum nominal transmit PSD in the downstream direction during initialization and showtime (in dBm/Hz). A single MAXNOMPSDds parameter is defined per mode

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enabled in the XTSE line configuration parameter. It ranges from –60 to –30 dBm/Hz, with 0.1 dB steps.

7.3.1.2.2 Upstream maximum nominal power spectral density (MAXNOMPSDus)

This parameter represents the maximum nominal transmit PSD in the upstream direction during initialization and showtime (in dBm/Hz). A single MAXNOMPSDus parameter is defined per mode enabled in the XTSE line configuration parameter. It ranges from –60 to –30 dBm/Hz, with 0.1 dB steps.

7.3.1.2.3 Downstream maximum nominal aggregate transmit power (MAXNOMATPds)

This parameter represents the maximum nominal aggregate transmit power in the downstream direction during initialization and showtime (in dBm). It ranges from 0 to 25.5 dBm, with 0.1 dB steps.

7.3.1.2.4 Upstream maximum nominal aggregate transmit power (MAXNOMATPus)

This parameter represents the maximum nominal aggregate transmit power in the upstream direction during initialization and showtime (in dBm). It ranges from 0 to 25.5 dBm, with 0.1 dB steps.

7.3.1.2.5 Upstream maximum aggregate receive power (MAXRXPWRus)

This parameter represents the maximum upstream aggregate receive power over a set of subcarriers (in dBm) as specified in the relevant Recommendation. The xTU-C shall request an upstream power cutback such that the upstream aggregate receive power over that set of subcarriers is at or below the configured maximum value. It ranges from –25.5 to 25.5 dBm, with 0.1 dB steps. A special value is used to indicate that no upstream maximum aggregate receive power limit is to be applied (i.e., the maximum value is infinite).

7.3.1.2.6 Downstream subcarrier masking (CARMASKds)

This configuration parameter is an array of boolean values sc(i). Each entry sc(i) defines whether subcarrier with index i is masked on this line in the downstream direction, for i ranging from 0 to NSCds-1. It is coded as 1 if the subcarrier is masked and 0 if the subcarrier is not masked.

NSCds is the highest subcarrier index that can be transmitted in the downstream direction. For [ITU-T G.992.3], [ITU-T G.992.4], and [ITU-T G.992.5], it is defined in the corresponding Recommendations. For [ITU-T G.992.1], NSCds = 256 and for [ITU-T G.992.2], NSCds = 128.

7.3.1.2.7 Upstream subcarrier masking (CARMASKus)

This configuration parameter is an array of Boolean values sc(i). Each entry sc(i) defines whether transmission of subcarrier with index i is masked on this line in the upstream direction, for i ranging from 0 to NSCus-1. It is coded as 1 if subcarrier is masked and 0 if the subcarrier is not masked.

NSCus is the highest subcarrier index that can be transmitted in the upstream direction. For [ITU-T G.992.3], [ITU-T G.992.4] and [ITU-T G.992.5], it is defined in the corresponding Recommendation. For Annex A of [ITU-T G.992.1] and [ITU-T G.992.2], NSCus = 32 and for Annex B of [ITU-T G.992.1], NSCus = 64.

7.3.1.2.8 VDSL2 subcarrier masking (VDSL2-CARMASK)

This configuration parameter defines the restrictions, additional to the band plan, to determine the set of subcarriers allowed for transmission in both upstream and downstream directions.

The VDSL2-CARMASK shall describe the not masked subcarriers as one or more frequency bands. Each band is represented by start and stop subcarrier indices with a subcarrier spacing of 4.3125 kHz. The valid range of subcarrier indices specifying the VDSL2-CARMASK is from 0 to at least the index of the highest allowed subcarrier in both transmission directions among all profiles enabled by

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the parameter PROFILES (see clause 7.3.1.1.11). Up to 32 bands may be specified. Other subcarriers shall be masked.

For profiles using 8.625 kHz tone spacing, the odd subcarrier indices $i_{4.3125}$ in VDSL2-CARMASK shall be transformed into actual subcarrier indices $i_{8.625}$ using the following rule:

– for the start frequency of each band: $i_{8.625} = (i_{4.3125} + 1)/2$

– for the stop frequency of each band: $i_{8.625} = (i_{4.3125} – 1)/2$.

7.3.1.2.9 Downstream PSD Mask (PSDMASKds)

This configuration parameter defines the downstream PSD mask applicable at the U-C2 reference point as defined in the respective Recommendation. A modified PSD mask, as defined in clause 7.3.1.2.13, may apply at the U-C2 reference point. This MIB PSD mask may impose PSD restrictions in addition to the Limit PSD mask defined in the relevant Recommendation (e.g., [ITU-T G.992.5] and [ITU-T G.993.2]).

NOTE – In [ITU-T G.993.2], the PSDMASKds parameter is referred to as MIBMASKds.

The downstream PSD mask in the CO-MIB shall be specified through a set of breakpoints. Each breakpoint shall consist of a subcarrier index t, with a subcarrier spacing of 4.3125 kHz, and a MIB PSD mask level (expressed in dBm/Hz) at that subcarrier. The set of breakpoints can then be represented as $[(t_1, PSD_1), (t_2, PSD_2), \ldots , (t_N, PSD_N)]$. The subcarrier index shall be coded as an unsigned integer. The MIB PSD mask level shall be coded as an unsigned integer representing the MIB PSD mask levels 0 dBm/Hz to –127.5 dBm/Hz, in steps of 0.5 dBm/Hz, with valid range from 0 to –95 dBm/Hz. The maximum number of breakpoints is 32.

The requirements for a valid set of breakpoints are defined in the relevant Recommendations (e.g., [ITU-T G.992.5] and [ITU-T G.993.2]).

7.3.1.2.10 RFI bands (RFIBANDS)

For [ITU-T G.992.5], this configuration parameter defines the subset of downstream PSD mask breakpoints, as specified in PSDMASKds, that shall be used to notch an RFI band. This subset consists of couples of consecutive subcarrier indices belonging to breakpoints: [ti; ti + 1], corresponding to the low level of the notch. The specific interpolation around these points is defined in the relevant Recommendations (e.g., [ITU-T G.992.5]). The CO-MIB shall define the RFI notches using breakpoints in PSDMASKds as specified in the relevant Recommendations (e.g., [ITU-T G.992.5]).

For [ITU-T G.993.2], this configuration parameter defines the bands where the PSD shall be reduced as specified in clause 7.2.1.2 of [ITU-T G.993.2]. Each band shall be represented by a start and stop subcarrier indices with a subcarrier spacing of 4.3125 kHz. Up to 16 bands may be specified. This parameter defines the RFI bands for both upstream and downstream directions.

7.3.1.2.11 Upstream PSD mask selection

This configuration parameter defines which upstream PSD mask is enabled. This parameter is used only for Annexes J and M of [ITU-T G.992.3] and [ITU-T G.992.5]. As only one selection parameter is defined in the MIB, the same selection value applies to all relevant modes enabled in the XTSE line configuration parameter. It ranges from 1 to 9 and selects the mask with the definitions of Table 7-5.

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