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

Digital sections and digital line system – Access networks

Interface between the link layer and the physical layer for digital subscriber line (DSL) transceivers

Recommendation ITU-T G.999.1

ITU-T

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Recommendation ITU-T G.999.1

Interface between the link layer and the physical layer for digital subscriber line (DSL) transceivers

Summary

Recommendation ITU-T G.999.1 defines a point-to-point interface between the LINK layer device such as a network processor and a PHY device supporting multiple DSL lines, such as VDSL2, ADSL2, and SHDSL.

Source

Recommendation ITU-T G.999.1 was approved on 9 October 2009 by ITU-T Study Group 15 (2009-2012) under Recommendation ITU-T A.8 procedures.

FOREWORD

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CONTENTS

Recommendation ITU-T G.999.1

Interface between the link layer and the physical layer for digital subscriber line (DSL) transceivers

1 Scope

This Recommendation defines an interface between a LINK device and a PHY device. The interface is a single point-to-point interconnection from the LINK layer device to a PHY device, and it is intended for use with all current and developing xDSL Recommendations (e.g., ADSL2, VDSL2, SHDSL, etc.).

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.992.3] Recommendation ITU-T G.992.3 (2009), *Asymmetric digital subscriber line transceivers 2 (ADSL2)*.

[ITU-T G.992.5] Recommendation ITU-T G.992.5 (2009), *Asymmetric digital subscriber line (ADSL) transceivers – Extended bandwidth ADSL2 (ADSL2plus)*.

[IEE 802.3] IEE 802.3-2005, *CSMA/CD Access Method and Physical Layer Specifications*. (http://standards.ieee.org/)

[IEEE 802.3ap] IEEE 802.3ap-2007, *Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications – Amendment 4: Ethernet Operation over Electrical Backplanes*. (http://standards.ieee.org/)

3 Definitions

No definitions are provided for this Recommendation.

4 Abbreviations

This Recommendation uses the following abbreviations:

DEST MAC ADD	Destination MAC Address
DFC	Data Flow Control
EoF	End of Frame
ETH	Ethernet encapsulation function
FCS	Frame Check Sequence
GMII	Gigabit Medium Independent Interface
IFG	Inter-Frame Gap
MAC	Media Access Control

MDI	Media Dependent Interface
MII	Media Independent Interface
PCP	Priority Code Point
PRE	Preamble
RXC_MFS	Maximum Fragment data Size supported by near-end receiver
SFD	Start Frame Delimiter
SID	Stream Identification
SoF	Start of Frame
SOURCE MAC ADD	Source MAC Address
TCI	Tag Control Identifier
TPID	Tag Protocol Identifier
TX_MFS	Maximum Fragment data Size to be used by near-end transmitter
TXC_MFS	Maximum Fragment data Size supported by near-end transmitter
VLAN	Virtual Local Area Network
XOFF	Transmit Off
XON	Transmit On

5 Reference model

The LINK/PHY interface reference model is shown in Figure 5-1. This reference model shows the following primitives defined in Annex K of [ITU-T G.992.3] and Annex K of [ITU-T G.992.5]. Primitives are labelled *n*, where *n* corresponds to an individual stream, with n = 0..N–1 for a LINK/PHY interface transporting N streams.

- Stream(n).request: This primitive is used by the transmit PHY port to request one or more data units from the transmit LINK layer function to be transported. By the interworking of the request and confirm, the data flow is matched to the PHY port configuration (and underlying functions).
- Stream(n).confirm: The transmit LINK layer function passes one or more data units to the PHY port to be transported with this primitive.
- Stream(n).indicate: The transmit PHY port passes one or more data units to the receive LINK layer function that have been transported with this primitive.

The data unit is a block of data consisting of an integer number of octets for transport between a PHY port and a link port. The contents of a data unit is vendor discretionary and outside the scope of this Recommendation. For example, a data unit may contain an Ethernet frame, an Ethernet bonding fragment, one or more ATM cells or an ATM AAL5 PDU.

The LINK/PHY interface reference model adds the following blocks:

- frag: Fragmentation of each data unit, with a tag control identification (TCI) field added to each fragment, and with each fragment not to exceed the configured maximum fragment length;
- tag: Identification of fragments through insertion of a data stream or pause identification tag into the TCI field;
- ETH: Ethernet adaptation by adding fields for compliance with the IEEE 802.3 frame format; the ETH block is configurable to be used or not;

•	FCS: Error detection through addition of frame-check-sequence;

•	PAUSE: Data flow control through a single PAUSE unit containing the data flow control states of all N streams;

•	dec: Decapsulation to recover data units (confirm and indicate primitives) and data flow control states (request primitives), comprising the reverse operation of the frag, tag, and ETH blocks.

Data unit encapsulation is defined as the cascade of the frag, tag, ETH and FCS blocks. Pause init encapsulation is defined as the cascade of the PAUSE, ETH and FCS blocks. Encapsulation overhead depends on whether or not the ETH block is used.

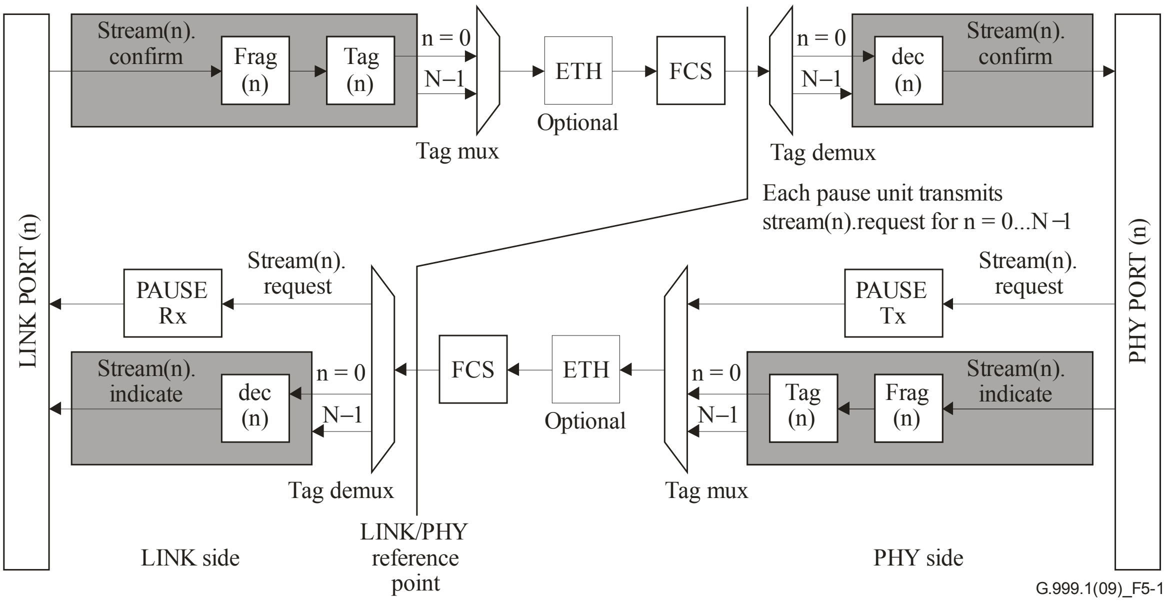

Figure 5-1 – Reference model for the LINK/PHY interface

The LINK device and PHY device shall use a physical point-to-point interconnection. The LINK/PHY interface shall support a data rate of at least 1 Gbit/s for the encapsulated data units. The minimum required bit rate at the LINK/PHY reference point may be higher (e.g., 1.25 Gbit/s if 8B/10B encoding is used).

6 Encapsulation

6.1 Fragmentation

The fragmentation block (see Figure 5-1) shall fragment each data unit as shown in Figure 6-1. The fragment format is shown in Figure 6-2.

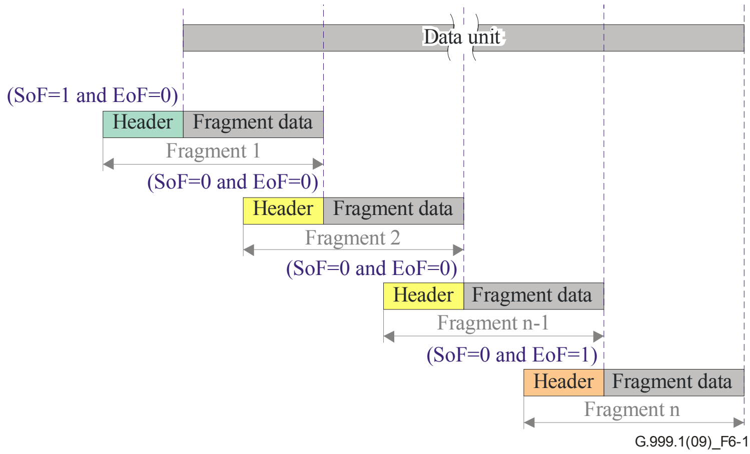

Figure 6-1 – Data unit fragmentation

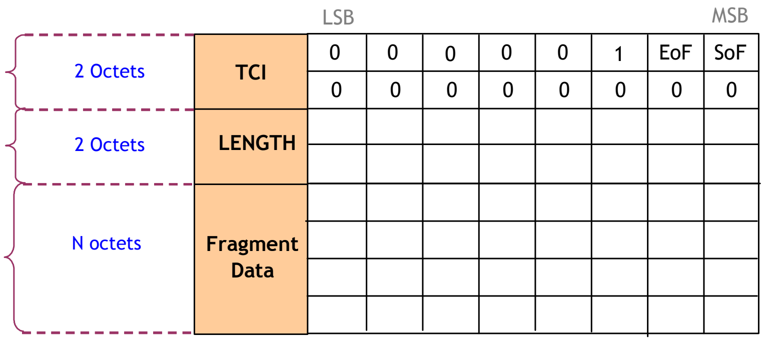

Figure 6-2 – Non-tagged fragment format

The fragment header shall consist of the tag control identifier (TCI) field and the LENGTH field. The capability to insert the LENGTH field is mandatory. When Ethernet encapsulation is enabled, the LENGTH field shall be inserted. When Ethernet encapsulation is disabled, the LENGTH field is configurable to be used or not (see Table 7-1). When the LENGTH MODE is set to 1, the LENGTH field shall be appended; otherwise, the LENGTH field shall not be appended. In the TCI field, the [SoF] and [EoF] bits shall be defined as shown in Table 6-1. The remaining TCI bits shall be as define in Figure 6-2 and partly further defined by the tag function. The LENGTH field shall contain the number of data unit octets in the fragment data field.

Table 6-1 – Definition of the data unit delimiters

[SoF]	[EoF]	Description
0	0	Next fragment of data unit
1	0	First fragment of data unit
0	1	Last fragment of data unit
1	1	Single fragment data unit

For each fragment, the value of the length field shall not exceed the maximum fragment data size (TX_MFS). If the length of a data unit is less than or equal to the TX_MFS value, then that data unit shall be transmitted as a single fragment. If the length of a data unit is higher than the TX_MFS value, then that data unit shall be transmitted in multiple fragments, where fragments may have the same or a different length.

The value of TX_MFS shall be configurable and shall not exceed the near-end maximum transmit fragment data size (TXC_MFS), and it shall not exceed the far-end maximum receive fragment data size (RXC_MFS). If TX_MFS is configured as ZERO, then each data unit shall be transmitted as a single fragment. The valid values of TX_MFS, TXC_MFS, and RXC_MFS are all integers in the range from 0 to 2047 (included).

NOTE – There are no mandatory values defined for the TXC_MFS and RXC_MFS.

6.2 Identification

The tag block (see Figure 5-1) shall tag each data fragment's TCI field with the stream identification (SID) value, resulting in the tagged fragment format shown in Figure 6-3.

		LSB							MSB
2 Octets	TCI	sid_0	sid_1	0	0	0	1	EoF	SoF
		sid_2	sid_3	sid_4	sid_5	sid_6	sid_7	sid_8	sid_9
2 Octets	LENGTH								
N octets	Fragment Data								

Figure 6-3 – Tagged fragment format

The valid SID value is any 10-bit unsigned integer. Up to 1024 data streams can be identified.

The allocation of a SID value to each data stream is technology dependent, and is defined in Annex A for DSL transceivers.

6.3 Data flow control

Data flow control (DFC) is a mechanism that prevents congestion by ensuring that transmitting devices do not overwhelm receiving devices with data. This is achieved by the receiving device informing in advance the transmitting device when no further data can be received (e.g., when the RX-Buffer-Filling becomes critical), after which the transmitter stops transmission (= Transmission-Off = XOFF = Active-Backpressure) until the receiver indicates in the same manner that it has regained ability to receive data (e.g., enough free RX-Buffer-Resources) and transmission may continue (= Transmission-On = XON = Inactive-Backpressure).

For the LINK/PHY interface, data flow control is defined only for the transmission of data from the LINK device to PHY device and is defined per data stream to prevent loss of data units.

To control the data flow from the LINK device to the PHY device, the PHY device may transmit pause units to the LINK device. The format of the pause unit is shown in Figure 6-4.

		LSB							MSB
2 Octets	OPCODE	0	0	0	0	0	0	0	0
		1	0	0	0	0	0	0	0
2 Octets	TIME	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0
N bits, N/8 octets (N multiple of 8)	DFC	fc_0	fc_1	fc_2	fc_3	fc_4	fc_5	fc_6	fc_7
					...				
					...				
		fc_{N-8}	fc_{N-7}	fc_{N-6}	fc_{N-5}	fc_{N-4}	fc_{N-3}	fc_{N-2}	fc_{N-1}

Figure 6-4 – Pause unit format

The OPCODE field shall be set to 0x0001 (i.e., the Ethernet MAC control opcode for pause frame). The OPCODE value allows to uniquely distinguish pause units from tagged data fragments.

The TIME field shall be set to 0x0000 (i.e., the Ethernet pause frame value for immediate resume of transmission).

The DFC field shall contain N/8 octets, where N represents the highest used SID, incremented to the next multiple of 8. The N data flow control bits [$fc_0..fc_{N-1}$] represent the data flow control states for the stream with SID = 0 up to the stream with SID = N–1. A data flow control bit shall be set to 0 to indicate the XON-State and shall be set to 1 to indicate XOFF-State for the respective data stream. A data flow control bit corresponding to an unused SID shall be set to 0.

Upon reception of a pause unit from a PHY-side, the LINK device shall stop transmission within the XOFF-latency of 10 microseconds for the data streams with their flow control bit set to XOFF in this PAUSE unit.

Upon reception of a pause unit from a PHY device, the LINK device shall resume transmission within the XON-latency of 240 microseconds for all the data streams with their flow control bit set to XON in this PAUSE unit and was set to XOFF in the last transmitted PAUSE unit and for which the last transmitted fragment was not the last fragment of a data unit.

The XOFF-latency and XON-latency are referred to the LINK/PHY-reference point (see Figure 5-1). The XOFF-latency shall be measured from the last FCS bit of the PAUSE unit transmitted by the PHY device to the last FCS bit of the last fragment transmitted by the LINK-side for the concerned data stream. The XON-latency shall be measured from the last FCS bit of the PAUSE unit transmitted by the PHY device to the last FCS bit of the first fragment transmitted by the LINK-side for the concerned data stream.

If a data stream is in the XON-state, then the transmitter shall manage the time in-between the transmission of consecutive data fragments belonging to the same data unit, so as to avoid data underflow in the reassembly of the data units at the receiving side.

6.4 Ethernet adaptation

The ETH block shown in Figure 5-1 adds fields to tagged fragments and Pause Units for compliance with [IEEE 802.3] (data and pause) frame format (after addition of FCS, see clause 6.5).

The ETH block shall be supported on the PHY-side and shall be configurable to be used or not. On the LINK-side, support of the ETH block is optional; however, if supported, it shall be configurable to be used or not.

The ETH block shall prepend Source MAC Address field, Destination MAC Address field, VLAN TPID field and MAC TYPE field to tagged fragments and pause units as shown in Figure 6-5.

The ETH block shall append a padding field to guarantee the frame contains at least 64 octets after addition of FCS. Padding octets shall be set to 0x00.

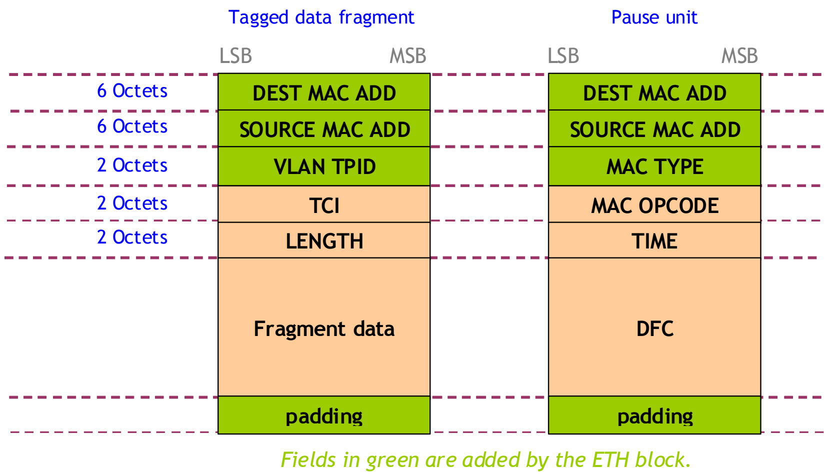

Figure 6-5 – Ethernet adapted format

The destination MAC address shall be set to the MAC address of the far-end device. For pause frames, the destination MAC address may also be set to the globally assigned multicast address 0x0180C2000001. This multicast address has been reserved by [IEEE 802.3] for use in MAC-Control-PAUSE frames.

The source MAC address shall be set to the near-end device MAC address.

The VLAN TPID shall be set to 0x8100. This is the VLAN Tag Protocol Identifier, as defined in [IEEE 802.3].

The MAC TYPE shall be set to 0x8808. This is the MAC Control Type for pause frames, as defined in [IEEE 802.3].

The far-end (i.e., destination) MAC address shall be configurable at the LINK and PHY sides for all frames. For pause frames, it shall be configurable at the LINK side and PHY side whether to use the far-end MAC address or the multicast MAC address.

6.5 Error detection

The FCS block shown in Figure 5-1 shall append a 4-octet frame check sequence to each (Ethernet adapted) tagged data fragment or pause unit. The FCS shall be calculated over all octets in the (Ethernet adapted) tagged data fragment or pause unit. The FCS shall consist of the 32-bit CRC as defined in [IEEE 802.3] clause 3.2.9 for Ethernet frame FCS.

The addition of the FCS field is shown in Figure 6-6.

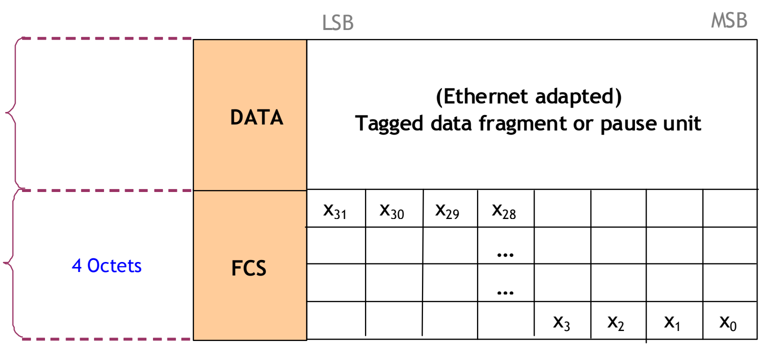

Figure 6-6 – Addition of FCS

6.6 Resulting encapsulation format and bit-ordering

When Ethernet encapsulation is not used, i.e., the ETH block is disabled, the final encapsulation format is shown in Figure 6-7. When Ethernet encapsulation is used, i.e., the ETH block is enabled, the final encapsulation format is shown in Figure 6-8. Octets shall be transmitted top-to-bottom.

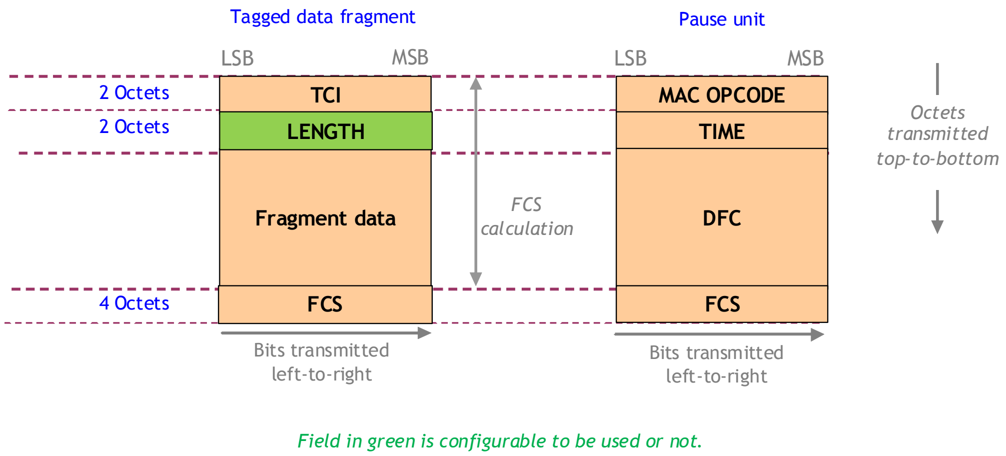

Figure 6-7 – Final encapsulation format without Ethernet encapsulation

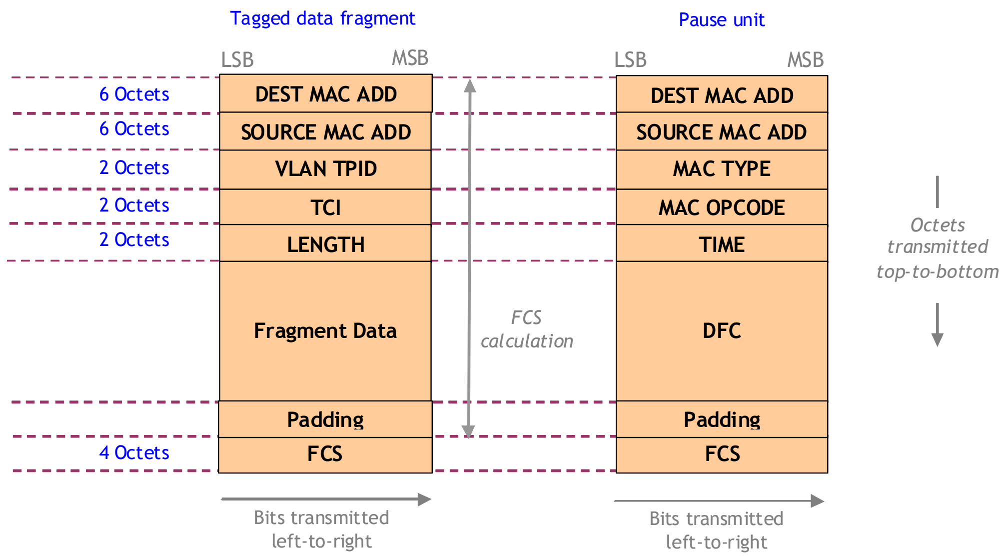

Figure 6-8 – Final encapsulation format with Ethernet encapsulation

7 Configuration parameters

Table 7-1 summarizes the encapsulation configuration parameters defined in clause 6 and defines a detailed format.

Table 7-1 – Configuration parameters for the encapsulation

NAME	SIZE	LINK	PHY	Definition
FRAGMENTATION (clause 6.1)				
TXC_MFS	[10:0]	R	R	Maximum fragment data size supported by near-end transmitter.
RXC_MFS	[10:0]	R	R	Maximum fragment data size supported by near-end receiver.
TX_MFS	[10:0]	R/W	R/W	Maximum fragment data size to be used by near-end transmitter.
LENGTH MODE	[0]	R/W	R/W	0: LENGTH field shall not be appended. 1: LENGTH field shall be appended.
ETHERNET ADAPTATION (clause 6.4)				
ETH	[0]	R/W	R/W	0: Ethernet Adaptation shall not be used. 1: Ethernet Adaptation shall be used.
NE_MAC_ADDRESS	[47:0]	R/W	R/W	Near-end MAC Address
FE_MAC_ADDRESS	[47:0]	R/W	R/W	Far-end MAC Address
PAUSE_MULTICAST	[0]	R/W	R/W	0: Pause frame shall have far-end MAC address as destination MAC address. 1: Pause frame shall have multicast MAC address as destination MAC address.

If the ETH bit is set to ONE, then the LENGTH MODE bit shall also be set to ONE.

Annex A

Stream identification with multi-line DSL PHY devices

(This annex forms an integral part of this Recommendation)

DSL transceivers are based on transparent transport of data streams. A data stream is an input to a TPS-TC, where a data unit equals a 53-octet ATM cell (ATM-TC) or a packet (PTM-TC). A TPS-TC connects to a bearer channel. In the case of PTM-TC with pre-emption, a bearer channel may carry a high priority data stream and low priority data stream. Hence, for DSL transceivers, the stream identification (SID) shall identify a particular DSL line, a particular bearer channel and a particular priority within the bearer in the DSL line.

NOTE – The three primitives defined in clause 5 correspond to the TPS-TC primitives defined in the ADSL2 [ITU-T G.992.3] and VDSL2 [b-ITU-T G.993.2] Recommendations.

This annex defines a mapping of the stream identifier (SID) for a multi-line DSL PHY device, with up to 256 DSL lines/transceivers, up to 2 bearer channels and possible use of pre-emption.

The line/transceiver number (line[7:0], values 0 to 255), the bearer channel (BC, values 0 or 1), and the priority (PR, values 0 = low or 1 = high) shall be mapped into the stream identification (SID[9:0], values 0 to 1024) as shown in Figure A.1.

sid_9	sid_8	sid_7	sid_6	sid_5	sid_4	sid_3	sid_2	sid_1	sid_0
$line_7$	$line_6$	$line_5$	$line_4$	$line_3$	$line_2$	$line_1$	$line_0$	BC	PR

Figure A.1 – Mapping of line, bearer and priority into the SID

In general, for a PHY device supporting N transceivers, there are N*4 SIG values and N/2 octets in the DFC field of the pause unit. For example:

– If the PHY device has 256 DSL transceivers, then the DFC field in the pause unit (see Figure 6-4) contains 128 octets.

– If the PHY device has 84 DSL transceivers, then the DFC field in the pause unit (see Figure 6-4) contains 42 octets. This is the maximum number of transceivers that keeps the encapsulated pause unit (including Ethernet adaptation) at the IEEE 802.3 pause frame length of 64 octets.

– If the PHY device has only 12 DSL transceivers, then the DFC field in the pause unit (see Figure 6-4) contains only 6 octets. If Ethernet adaptation is used, the Ethernet frame contains 36 padding octets.

Annex B

LINK/PHY physical interface

(This annex forms an integral part of this Recommendation)

This annex defines the LINK/PHY physical interface, based on [IEEE 802.3ap] 1000BASE-KX Ethernet (also known as Backplane Ethernet). Compliance to this annex requires support of a relevant subset of [IEEE 802.3ap] 1000BASE-KX Ethernet (clause 70) below the GMII, which include the PCS, PMA, and PMD layers (see Table B.1 for relevant sections of 1000Base-KX). The sections of [IEEE 802.3ap] 1000Base-KX Ethernet (clause 70) that are not identified in Table B.1 are vendor discretionary.

Note that the GMII is an optional interface. However, if the GMII is not implemented, a conforming implementation must behave functionally as though the GMII is present.

Figure B.1 shows the LINK/PHY interface based on 1000BASE-KX. The encapsulation block is defined in the main body of this Recommendation.

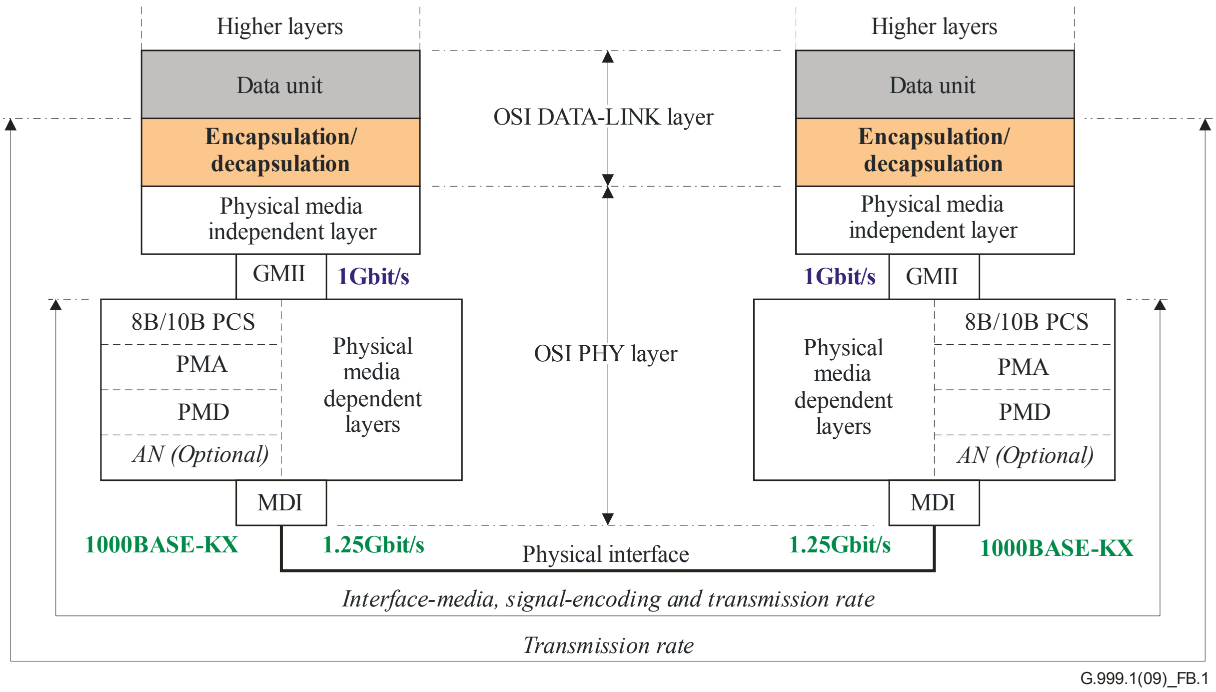

Figure B.1 – LINK/PHY interface based on 1000BASE-KX

The OSI's PHY-Layer part of the LINK/PHY interface (see Figure B.1):

- Shall be compliant with a relevant subset of [IEEE 802.3ap] 1000BASE-KX standard clause 70 per Table B.1. Note that Table B.1 lists the relevant section headings of [IEEE 802.3ap] clause 70 for which compliance is required: 'Req' means that full support of mandatory items in the section is required, and 'Partial' means partially supported with identification in the comment column of the appropriate elements required. Compliance to the other sections of [IEEE 802.3ap] clause 70 is optional.
- Shall operate in Full-Duplex mode and at 1 Gbit/s data rate at the GMII or equivalent interface (which is 1.25 Gbit/s at the MDI interface). The Auto-Negotiation capability is not necessary and therefore not required.
- The interface between the physical media independent layer and the physical media dependent layers (MII) is vendor discretionary.

- Shall use PREamble (PRE), start frame delimiter (SFD) and inter-frame-gaps (IFG) for detecting byte and (Ethernet adapted) fragment boundaries; the following Ethernet CSMA/CD MAC parameters (clauses 3 and 4 of [IEEE 802.3], 2005) shall be applied:
  – PRE: 7 octets (clause 3.2.1)
  – SFD: 1 octets (clause 3.2.2)
  – IFG: 12 octets (clause 4.4.2)
- Optionally, the minimum number of IFG octets may be reduced to 3. If Ethernet adaptation is not used, then PREamble octets may optionally be reduced to 2.
- In general, all options can be used when both the LINK and the PHY devices are configured to support it; the means for enabling each option in the LINK and PHY devices are vendor discretionary.

Table B.1 – Subset of 1000Base-KX for Annex B compliance

Section #	Section Title	Support	Comment
70.1	Overview	Partial	w/o clause 45
70.2	Physical media dependent (PMD) service interface	Req.	w/o Signal Detect
70.4	Delay constraints	Req.	
70.6	PMD functional specifications	Partial	w/o Signal Detect
70.6.1	Link block diagram	Partial	w/o Signal Detect
70.6.2	PMD transmit function	Req.	
70.6.3	PMD receive function	Req.	
70.6.6	Loopback Mode	Req.	w/o clause 45
70.7.1	Transmitter characteristics	Req.	
70.7.1.1	Test fixtures	Req.	
70.7.1.2	Test fixture impedance	Req.	
70.7.1.3	Signaling speed	Req.	
70.7.1.4	Differential output eye mask	Req.	
70.7.1.5	Output amplitude	Req.	–
70.7.1.6	Differential output return loss	Req.	
70.7.1.7	Transition time	Req.	
70.7.1.8	Transmit jitter	Req.	
70.7.1.9	Transmit jitter test requirements	Req.	
70.7.2	Receiver characteristics	Req.	
70.7.2.1	Receiver interference tolerance	Req.	
70.7.2.2	Signaling speed range	Req.	
70.7.2.3	AC-coupling	Req.	
70.7.2.4	Input signal amplitude	Req.	
70.7.2.5	Differential input return loss	Req.	
70.9	Environmental specifications	Req.	–
70.10	Protocol implementation conformance statement (PICS) proforma for clause 70, physical media dependent (PMD) sublayer and baseband medium, type 1000BASE-KX		
70.10.1	Introduction	Req.	–

Table B.1 – Subset of 1000Base-KX for Annex B compliance

Section #	Section Title	Support	Comment
70.10.3	Major capabilities/options	Partial	only PCS, FD, and DC
70.10.4.2	PMD functional specifications	Partial	only FS1, FS2, FS3, FS4, FS8, and FS9
70.10.4.4	Transmitter electrical characteristics	Req.	–
70.10.4.5	Receiver electrical characteristics	Req.	–
70.10.4.6	Environmental and safety specifications	Req.	–

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