INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.983.1

Amendment 2
(03/2003)

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

Digital sections and digital line system – Optical line systems for local and access networks

Broadband optical access systems based on Passive Optical Networks (PON)

Amendment 2

ITU-T Recommendation G.983.1 (1998) – Amendment 2

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

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

ITU-T Recommendation G.983.1

Broadband optical access systems based on Passive Optical Networks (PON)

Amendment 2

Summary

This amendment describes enhancements to ITU-T Rec. G.983.1 and ITU-T Rec. G.983.1 Amendment 1 to accommodate an optional, improved security mechanism and a 1244.16 Mbit/s downstream line-rate.

Source

Amendment 2 to ITU-T Recommendation G.983.1 (1998) was prepared by ITU-T Study Group 15 (2001-2004) and approved under the WTSA Resolution 1 procedure on 16 March 2003.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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ITU-T Recommendation G.983.1

Broadband optical access systems based on Passive Optical Networks (PON)

Amendment 2

Introduction

The introduction of the BPON Recommendation (ITU-T Rec. G.983.1) in 1998, and the subsequent mass deployment of BPON systems in carrier networks have lead to a much increased understanding of the utility and role of PON technology. It is natural that new requirements have emerged, and this amendment is intended to strengthen BPON by adding two features, namely an optional, improved security mechanism (AES), and a 1244.16 Mbit/s downstream line-rate. The availability of AES will increase the privacy protection of end customers, as well as enhance the ability of service providers to prevent theft-of-service (specifically in residential broadcast digital video applications). Adding the 1244.16 Mbit/s downstream line-rate will increase the value of BPON in VDSL back-haul applications, as it is anticipated that residential entertainment video transport will require more bandwidth than can be supported by current 155.52 or 622.08 Mbit/s systems. Lastly, it is worth noting that the additional functionality of this amendment does not change the fact that BPON and the emerging ITU-T GPON Recommendation will have distinct and complimentary roles; while BPON is optimized for lower line-rate applications and builds on the strengths of ATM for multi-service delivery, GPON represents a progressive effort to more efficiently accommodate the transport of various native protocols (especially Ethernet), and is optimized for gigabit and higher line-rates.

1) Summary

Revise the second sentence in the Summary to read as follows:

This Recommendation describes systems with nominal downstream line rates of 155.52, 622.08, and 1244.16 Mbit/s, and nominal upstream line rates of 155.52 and 622.08. Both symmetrical and asymmetrical systems are defined.

2) Clause 2 – References

Add the following new entry:

[15] Federal Information Processing Standard 197, *Advanced Encryption Standard,* National Institute of Standards and Technology, United States Department of Commerce, November 26, 2001.

3) Clause 3 – Abbreviations

Add the following new entries alphabetically:

AES Advanced Encryption Standard

ECB Electronic Code Book

4) Clause 8.2.1

a) *Replace the first paragraph of 8.2.1 with the following:*

The transmission line rate should be a multiple of 8 kHz. BPON systems will have nominal line rates (downstream/upstream) of:

- 155.52 Mbit/s /155.52 Mbit/s;
- 622.08 Mbit/s /155.52 Mbit/s;
- 622.08 Mbit/s /622.08 Mbit/s;
- 1244.16 Mbit/s /155.52 Mbit/s;
- 1244.16 Mbit/s /622.08 Mbit/s.

b) *Modify Table 3 and the paragraph that follows to read as follows:*

Table 3/G.983.1 – Relation between parameter categories and tables

Transmission direction	Nominal bit rate	Table
Downstream	155.52 Mbit/s	Table 4-b (downstream, 155 Mbit/s)
	622.08 Mbit/s	Table 4-c (downstream, 622 Mbit/s)
	1244.16 Mbit/s	Table VI.4-f (downstream, 1244 Mbit/s)
Upstream	155.52 Mbit/s	Table 4-d (upstream, 155 Mbit/s)
	622.08 Mbit/s	Table V.4-e (upstream, 622 Mbit/s)

"All parameters are specified as follows, and shall be in accordance with Table 4-a (ODN), Table 4-b (downstream, 155 Mbit/s), Table 4-c (downstream, 622 Mbit/s), Table V.4-f (downstream, 1244 Mbit/s), Table 4-d (upstream, 155 Mbit/s), Table V.4-e (upstream 622 Mbit/s). These tables are generally referred to as Table 4 in this Recommendation."

5) Clause 8.2.3.1

Modify the first sentence of 8.2.3.1 to read as follows:

The nominal bit rate of the OLT-to-ONU signal is 155.52, 622.08 or 1244.16 Mbit/s.

6) Clause 8.2.6.6.1

Modify the table in Figure 6 to read as follows:

	155.52 Mbit/s	622.08 Mbit/s	1244.16 Mbit/s
x1/x4	0.15/0.85	0.25/0.75	0.28/0.72
x2/x3	0.35/0.65	0.40/0.60	0.40/0.60
y1/y2	0.20/0.80	0.20/0.80	0.20/0.80

7) Clause 8.2.8

Modify 8.2.8 to read as follows:

All parameters are specified as follows, and shall be in accordance with Table 4 for upstream or downstream bit-rates of 155 Mbit/s or 622 Mbit/s or Table V.4-f for downstream bit-rates of 1244 Mbit/s.

8) Clause 8.2.8.7.1

a) *Modify the table in Figure 8 to read as follows:*

	fc [kHz]	P [dB]
155.52/155.52	130	0.1
155.52/622.08	500	0.1
155.52/1244.16	500	0.1
622.08/622.08	1000	0.1
622.08/1244.16	1000	0.1

b) *Modify the table in Figure 9 to read as follows:*

	ft [kHz]	f0 [kHz]	A1 [Ulp-p]	A1 [Ulp-p]
155.52/155.52	65	6.5	0.075	0.75
155.52/622.08	250	25	0.075	0.75
155.52/1244.16	500	50	0.075	0.75
622.08/622.08	250	25	0.075	0.75
622.08/1244.16	500	50	0.075	0.75

9) Clause 8.2.8.7.3

Replace clause 8.2.8.7.3 with the following:

Jitter generation specification applies only to ONU.

An ONU shall not generate more than 0.2 UI peak to peak jitter, with no jitter applied to the downstream input. The measurement bandwidth for the 155.52 Mbit/s upstream direction has a range from 0.5 kHz to 1.3 MHz. The measurement bandwidth for the 622.08 Mbit/s upstream direction has a range from 2.0 kHz to 5.0 MHz.

10) Clause 8.3.3

Add the following sentence to the end of this clause:

The transfer capacity for the 1244.16 Mbit/s interface is 1199.72 Mbit/s.

11) Clause 8.3.5.1

Modify the first two paragraphs to read as follows:

The downstream interface structures for 155.52 Mbit/s, 622.08 Mbit/s and 1244.16 Mbit/s consist of a continuous stream of timeslots, each timeslot containing 53 octets of an ATM cell or a PLOAM cell.

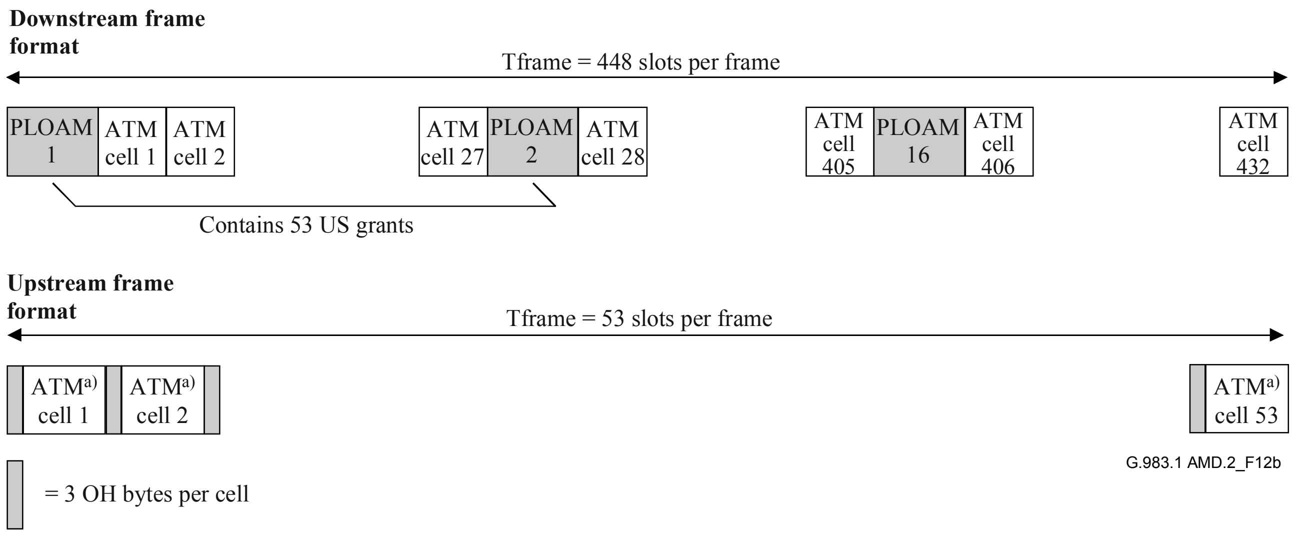
Every 28 time slots a PLOAM cell is inserted. A downstream frame contains two such PLOAM cells and is 56 slots long for the 155 Mbit/s downstream case. For the 622 Mbit/s case, it contains eight PLOAM cells and is 224 slots long. For the 1244 Mbit/s case, it contains sixteen PLOAM cells and is 448 slots long.

12) New clause 8.3.5.1.3 – Frame structure for 1244/155 Mbit/s PON

(The former clause 8.3.5.1.3 will be renumbered 8.3.5.1.5 – see point 14). Add the following new text and figure:

8.3.5.1.3 Frame structure for 1244/155 Mbit/s PON

In this case, the downstream rate is exactly eight times higher than the symmetric 155 Mbit/s case. This is shown in Figure 12b.



a) Any ATM cell slot can contain an upstream PLOAM or divided slot rate controlled by the OLT

NOTE – ATM cells are transmitted in the order of ascending cell numbers.

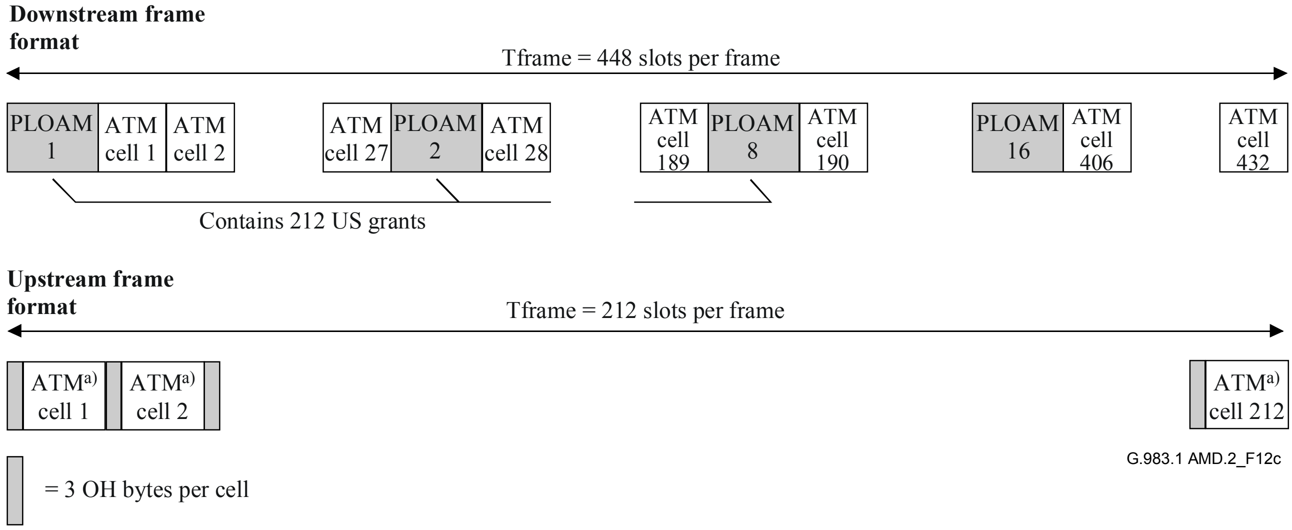
Figure 12b/G.983.1 – Frame format for 1244.16/155.52 Mbit/s PON

13) New clause 8.3.5.1.4 – Frame structure for 1244/622 Mbit/s PON

Add the following new text and figure:

8.3.5.1.4 Frame structure for 1244/622 Mbit/s PON

In this case, the downstream rate is exactly two times higher than the symmetric 622 Mbit/s case. This is shown in Figure 12c.



a) Any ATM cell slot can contain an upstream PLOAM or divided slot rate controlled by the OLT

NOTE – ATM cells are transmitted in the order of ascending cell numbers.

Figure 12c/G.983.1 – Frame format for 1244.16/622.08 Mbit/s PON

14) Former clause 8.3.5.1.3 – Time relation downstream-upstream frame

a) *Renumber former clause 8.3.5.1.3 as 8.3.5.1.5.*

b) *Modify the first sentence of the first paragraph as follows:*

In Figures 11, 12, 12a, 12b and 12c, the start of the downstream frame and the start of the upstream frame are drawn aligned to each other to indicate the equal duration of the two frames.

c) *Modify the first sentence of the second paragraph as follows:*

For the cases described in Figures 11, 12 and 12b, 53 grants are mapped in the first two PLOAM cells of a frame and are numbered from 1 to 53; for the cases described in Figures 12a and 12c, 212 grants are mapped into the eight PLOAM cells in the frame, and are numbered 1-212.

15) Clause 8.3.5.3.1

Modify the last sentence of this clause as follows:

Any cell, numbered "ATM cell 1" up to "ATM cell 432" in Figures 12b and 12c, that has a header equal to the specified header of a PLOAM cell, is discarded at the ONU in the ATM specific TC layer.

16) New clause 8.3.5.6.7 – Advanced security

Add new clause 8.3.5.6.7 as follows:

8.3.5.6.7 Advanced security

As an option, the Advanced Encryption Standard (AES) may be used instead of churning to provide link security. Although there are several modes of operation for AES, only the Electronic Code Book (ECB) mode shall be used in BPON systems. The algorithm will be applied to the 48 byte payload of the cells. Note that since this payload is always an integral number of code blocks (3), no padding is needed. AES may be used for any of the BPON line-rates.

The format of the new big_key message is given in 8.3.8.2.2. This message is a unicast message, and it carries three information fields: the Key_Index, the Frag_Index, and the KeyBYTEs. This structure allows this message to carry keys of arbitrary size over the channel. The Key_Index field is used as a sequence number to make each set of key transmissions unique. The Frag_Index is used to reassemble the multiple key transmissions. The KeyBYTEs carry 8 bytes of the key in each fragment.

The usage of these fields can be illustrated by the following example. Suppose the ONU is using 128 bit encryption keys, and it receives a New Churning Key Request Message.

The sequence of events at the ONU would include:

ONU creates a new random key: KeyBYTE0 through KeyBYTE15

ONU increments the Key_Index

ONU sends Big_Key message with Frag_Index=0, KeyBYTE0 through KeyBYTE7

ONU sends Big_Key message with Frag_Index=1, KeyBYTE8 through KeyBYTE15

ONU sends Big_Key message with Frag_Index=0, KeyBYTE0 through KeyBYTE7

ONU sends Big_Key message with Frag_Index=1, KeyBYTE8 through KeyBYTE15

ONU sends Big_Key message with Frag_Index=0, KeyBYTE0 through KeyBYTE7

ONU sends Big_Key message with Frag_Index=1, KeyBYTE8 through KeyBYTE15

Note that the details of the key exchange, the key switchover, and alarms associated with churning are all unchanged.

17) Clause 8.3.6.1.6

Modify as follows:

Any cell, numbered "ATM cell 1" up to "ATM cell 432" in Figures 12b and 12c, that has a header equal to the specified header of a PLOAM cell, is discarded at the ONU in the ATM specific TC layer.

18) Table 17

Add the following line to the end of Table 17:

32	Big_Key message (optional)	Carries a large key for use with data encryption Priority level is 1	OLT ←ONU	After the OLT request, the ONU fetches a new key and sends it to the OLT	3 times per fragment	The OLT initializes the encryption logic with this new key if it receives three consecutive identical keys and switches to the new key 48*Tframe after the first churning_key_update message.

19) Clause 8.3.8.2.2

Add the following table to the end of this clause:

Big_Key Message (optional)		
Octet	**Content**	**Description**
2	PON_ID	Indicates the ONU sourcing this message
3	0000 0110	Message identification "Big Churning Key message"
4	Key_Index	Index indicating which ONU key this message carries
5	Frag_Index	Index indicating which part of the key this message carries
6	KeyBYTE0	Byte 0 of fragment (Frag_Index) of Key (Key_Index)
7	KeyBYTE1	Byte 1 of fragment (Frag_Index) of Key (Key_Index)
8	KeyBYTE2	Byte 2 of fragment (Frag_Index) of Key (Key_Index)
9	KeyBYTE3	Byte 3 of fragment (Frag_Index) of Key (Key_Index)
10	KeyBYTE4	Byte 4 of fragment (Frag_Index) of Key (Key_Index)
11	KeyBYTE5	Byte 5 of fragment (Frag_Index) of Key (Key_Index)
12	KeyBYTE6	Byte 6 of fragment (Frag_Index) of Key (Key_Index)
13	KeyBYTE7	Byte 7 of fragment (Frag_Index) of Key (Key_Index)

20) Appendix V

In Table V.4-e replace:

"Jitter generation from 0.5 kHz to 1.3 MHz"

with

"Jitter generation from 2.0 kHz to 5.0 MHz".

21) New Appendix VI

Add the following new appendix:

Appendix VI

Optical parameters for 1244.16 Mbit/s Downstream

Introduction

Table IV.4-f is an extension of Table 4 in the main body of this Recommendation. This table describes the operation of the downstream link at 1244.16 Mbit/s. All specifications are the same for both single- and dual-fibre cases.

Table VI.4-f/G.983.1 – Optical interface parameters of 1244.16 Mbit/s downstream direction

Items	Unit	Single fibre			Dual fibre		
		OLT Transmitter (optical interface O_{ld})					
Nominal bit rate	Mbit/s	1244.16			1244.16		
Operating wavelength	nm	1480-1500			1260-1360		
Line code	–	Scrambled NRZ			Scrambled NRZ		
Mask of the transmitter eye diagram	–	Figure 6			Figure 6		
Maximum reflectance of equipment, measured at transmitter wavelength	dB	NA			NA		
Minimum ORL of ODN at O_{lu} and O_{ld} (Notes 1 and 2)	dB	more than 32			more than 32		
ODN Class		Class A	Class B	Class C	Class A	Class B	Class C
Mean launched power MIN	dBm	–4	+1	+5	–4	+1	+5
Mean launched power MAX	dBm	+1	+6	+9	+1	+6	+9
Launched optical power without input to the transmitter	dBm	NA			NA		
Extinction ratio	dB	more than 10			more than 10		
Tolerance to the transmitter incident light power	dB	more than –15			more than –15		
If MLM Laser – Maximum RMS width	nm	NA			NA		
If SLM Laser – Maximum –20 dB width (Note 3)	nm	1			1		
If SLM Laser – Minimum side mode suppression ratio	dB	30			30		
		ONU Receiver (optical interface O_{rd})					
Maximum reflectance of equipment, measured at receiver wavelength	dB	less than –20			less than –20		
Bit error ratio	–	less than 10^{-10}			less than 10^{-10}		
ODN Class		Class A	Class B	Class C	Class A	Class B	Class C
Minimum sensitivity	dBm	–25	–25	–26	–25	–25	–25
Minimum overload	dBm	–4	–4	–4 (Note 4)	–4	–4	–4

Table VI.4-f/G.983.1 – Optical interface parameters of 1244.16 Mbit/s downstream direction

Items	Unit	Single fibre	Dual fibre
Consecutive identical digit immunity	bit	more than 72	more than 72
Jitter tolerance	–	Figure 9	Figure 9
Tolerance to the reflected optical power	dB	less than 10	less than 10
NOTE 1 – The value of "minimum ORL of ODN at point O_{ru} and O_{rd}, and O_{lu} and O_{ld}" should be more than 20 dB in optional cases which are described in Appendix I. NOTE 2 – The values on ONU transmitter reflectance for the case that the value of "minimum ORL of ODN at point O_{ru} and O_{rd}, and O_{lu} and O_{ld}" is 20 dB are described in Appendix II. NOTE 3 – Values of maximum –20 dB width, and minimum side mode suppression ratio are referred to in ITU-T Rec. G.957. NOTE 4 – While only –6 dBm overload is required to support the class C ODN, a –3 dBm overload value has been chosen here for ONU receiver uniformity across all ODN classes.			

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Printed in Switzerland
Geneva, 2003