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G.709/Y.1331

Amendment 2

(04/2011)

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Recommendation ITU-T G.709/Y.1331

Interfaces for the Optical Transport Network (OTN)

Amendment 2

Summary

Amendment 2 to Recommendation ITU-T G.709/Y.1331 (2009) contains extensions related to the addition of Infiniband single, double and quad data rate (IB SDR, IB DDR and IB QDR) client mappings, enhancement of the recommended ODUflex(GFP) bit rate values, modification of the BIP-8 processing in 40GBASE-R and 100GBASE-R, clarification of the ODU maintenance signal (AIS, LCK, OCI) bit rate range, clarification of the number of tributary slots occupied by ODUflex signals transported in OPU2, OPU3 and OPU4, and extension of Table IX.1 with additional clients into LO OPU mapping types and replacement of "n" in C_{nD} by their standardized values.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.709/Y.1331	2001-02-09	15
1.1	ITU-T G.709/Y.1331 (2001) Amd. 1	2001-11-29	15
2.0	ITU-T G.709/Y.1331	2003-03-16	15
2.1	ITU-T G.709/Y.1331 (2003) Amd. 1	2003-12-14	15
2.2	ITU-T G.709/Y.1331 (2003) Cor. 1	2006-12-14	15
2.3	ITU-T G.709/Y.1331 (2003) Amd. 2	2007-11-22	15
2.4	ITU-T G.709/Y.1331 (2003) Cor.2	2009-01-13	15
2.5	ITU-T G.709/Y.1331 (2003) Amd. 3	2009-04-22	15
3.0	ITU-T G.709/Y.1331	2009-12-22	15
3.1	ITU-T G.709/Y.1331 (2009) Cor. 1	2010-07-29	15
3.2	ITU-T G.709/Y.1331 (2009) Amd. 1	2010-07-29	15
3.3	ITU-T G.709/Y.1331 (2009) Amd. 2	2011-04-13	15

FOREWORD

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

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

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Interfaces for the Optical Transport Network (OTN)

Amendment 2

1) Scope

This amendment contains extensions to ITU-T Recommendation G.709/Y.1331 (2009), related to the addition of:

- Addition of Infiniband single data rate (IB SDR), Infiniband double data rate (IB DDR) and Infiniband quad data rate (IB QDR) client mappings (clauses 2, 4, 15.9.2.1.1, 17.9, Appendix IX, Bibliography).
- Enhancement of the recommended ODUflex(GFP) bit rate values (clauses 3.2, 4, 7.3, 12.2.5, Appendix XI).
- Modification of the BIP-8 processing in 40GBASE-R and 100GBASE-R (clauses 17.7.4.1, 17.7.5.1, B.3.1, E.3, E.3.2, E.4.1, E.4.2).
- Clarification of the ODU maintenance signal (AIS, LCK, OCI) bit rate range (clause 7.3).
- Clarification of the number of tributary slots occupied by ODUflex signals transported in OPU2, OPU3 and OPU4 (clauses 7.3, 19.6.1, 19.6.2, 19.6.3, Appendix VIII, Appendix X).
- Extension of Table IX.1 with 40GBASE-R, 100GBASE-R, IB SDR, IB DDR and IB QDR client into LO OPU mapping types and replacement of "n" in C_{nD} by their standardized values (Appendix IX).

2) Additions

2.1) Clause 3.2

Add to clause 3 the following definition:

3.2.1 ODUk.ts: The ODUk.ts is an increment of bandwidth, which, when multiplied by a number of tributary slots, gives the recommended size of an ODUflex(GFP) optimized to occupy a given number of tributary slots of a higher order OPUk.

2.2) Clause 4

Add to clause 4 the following abbreviations:

DDR	Double Data Rate
IB	InfiniBand
ODUk.ts	Optical channel Data Unit k fitting in ts tributary slots
QDR	Quad Data Rate
SDR	Single Data Rate

2.3) Clause 7.3

Modify Tables 7-2 and 7-3 as follows:

Table 7-2 – ODU types and bit rates

ODU type	ODU nominal bit rate	ODU bit-rate tolerance
ODU0	1 244 160 kbit/s	±20 ppm
ODU1	239/238 × 2 488 320 kbit/s	
ODU2	239/237 × 9 953 280 kbit/s	
ODU3	239/236 × 39 813 120 kbit/s	
ODU4	239/227 × 99 532 800 kbit/s	
ODU2e	239/237 × 10 312 500 kbit/s	±100 ppm
ODUflex for CBR client signals	239/238 × client signal bit rate	~~client signal bit rate tolerance, with a maximum of~~ ±100 ppm (Notes 2, 3)
ODUflex for GFP-F mapped client signals	configured bit rate (see Table 7-8)	±~~2~~100 ppm

NOTE 1 – The nominal ODUk rates are approximately: 2 498 775.126 kbit/s (ODU1), 10 037 273.924 kbit/s (ODU2), 40 319 218.983 kbit/s (ODU3), 104 794 445.815 kbit/s (ODU4) and 10 399 525.316 kbit/s (ODU2e).

NOTE 2 – The bit rate tolerance for ODUflex(CBR) signals is specified as ±100 ppm. This value may be larger than the tolerance for the client signal itself (e.g., ±20 ppm). In such cases, the tolerance is determined by the ODUflex(CBR) maintenance signals, which have a tolerance of ±100 ppm.

NOTE 3 – For ODUflex(CBR) signals with nominal bit rates close to the maximum ODTUk.ts payload bit rate and client rate tolerances less than ±100 ppm (e.g., ±10 ppm), the ODUflex(CBR) maintenance signal bit rate may exceed the ODTUk.ts payload bit rate. For such cases either an additional tributary slot may be used (i.e., ODTUk.(ts+1)), or the nominal bit rate of the ODUflex(CBR) signal may be artificially reduced to a value of 100 ppm below the maximum ODUflex(CBR) signal bit rate.

Table 7-3 – OPU types and bit rates

OPU type	OPU payload nominal bit rate	OPU payload bit rate tolerance
OPU0	238/239 × 1 244 160 kbit/s	±20 ppm
OPU1	2 488 320 kbit/s	
OPU2	238/237 × 9 953 280 kbit/s	
OPU3	238/236 × 39 813 120 kbit/s	
OPU4	238/227 × 99 532 800 kbit/s	
OPU2e	238/237 × 10 312 500 kbit/s	±100 ppm
OPUflex for CBR client signals	client signal bit rate	client signal bit rate tolerance, with a maximum of ±100 ppm
OPUflex for GFP-F mapped client signals	238/239 × ODUflex signal rate	±~~2~~100 ppm

Table 7-3 – OPU types and bit rates

OPU type	OPU payload nominal bit rate	OPU payload bit rate tolerance
OPU1-Xv	X × 2 488 320 kbit/s	±20 ppm
OPU2-Xv	X × 238/237 × 9 953 280 kbit/s	
OPU3-Xv	X × 238/236 × 39 813 120 kbit/s	

NOTE – The nominal OPUk payload rates are approximately: 1 238 954.310 kbit/s (OPU0 Payload), 2 488 320.000 kbit/s (OPU1 Payload), 9 995 276.962 kbit/s (OPU2 Payload), 40 150 519.322 kbit/s (OPU3 Payload), 104 355 975.330 (OPU4 Payload) and 10 356 012.658 kbit/s (OPU2e Payload). The nominal OPUk-Xv Payload rates are approximately: X × 2 488 320.000 kbit/s (OPU1-Xv Payload), X × 9 995 276.962 kbit/s (OPU2-Xv Payload) and X × 40 150 519.322 kbit/s (OPU3-Xv Payload).

2.4) Clause 7.3

Replace Table 7-8 with the following:

Table 7-8 – Recommended ODUflex(GFP) bit rates and tolerance

ODU type	Nominal bit-rate	Tolerance
ODU2.ts (Note)	1'249'177.230 kbit/s	
ODU3.ts (Note)	1'254'470.354 kbit/s	
ODU4.ts (Note)	1'301'467.133 kbit/s	
ODUflex(GFP) of n tributary slots, 1 ≤ n ≤ 8	n × ODU2.ts	±100 ppm
ODUflex(GFP) of n tributary slots, 9 ≤ n ≤ 32	n × ODU3.ts	±100 ppm
ODUflex(GFP) of n tributary slots, 33 ≤ n ≤ 80	n × ODU4.ts	±100 ppm

NOTE – The values of ODUk.ts are chosen to permit a variety of methods to be used to generate an ODUflex(GFP) clock. See Appendix XI for the derivation of these values and example ODUflex(GFP) clock generation methods.

2.5) Clause 7.3

Modify Table 7-9 as follows:

Table 7-9 – Number of tributary slots required for ODUj into HO OPUk

	# 2.5G tributary slots		# 1.25G tributary slots			
LO ODU	**OPU2**	**OPU3**	**OPU1**	**OPU2**	**OPU3**	**OPU4**
ODU0	–	–	1	1	1	1
ODU1	1	1	–	2	2	2
ODU2	–	4	–	–	8	8
ODU2e	–	–	–	–	9	8
ODU3	–	–	–	–	–	31
ODUflex(CBR) – ODUflex(IB SDR) – ODUflex(IB DDR) – ODUflex(IB QDR) – ODUflex(FC-400) – ODUflex(FC-800)	– – – – – –	– – – – – –	– – – – – –	Note 1 3 5 – 4 7	Note 2 3 5 9 4 7	Note 3 2 4 8 4 7
ODUflex(GFP)	–	–	–	n	n	n

NOTE 1 – Number of tributary slots = Ceiling(ODUflex(CBR) nominal bit rate/(T×ODTU2.ts nominal bit rate) × (1+ODUflex(CBR) bit rate tolerance)/(1–HO OPU2 bit rate tolerance)).

NOTE 2 – Number of tributary slots = Ceiling(ODUflex(CBR) nominal bit rate/(T×ODTU3.ts nominal bit rate) × (1+ODUflex(CBR) bit rate tolerance)/(1–HO OPU3 bit rate tolerance)).

NOTE 3 – Number of tributary slots = Ceiling(ODUflex(CBR) nominal bit rate/(T×ODTU4.ts nominal bit rate) × (1+ODUflex(CBR) bit rate tolerance)/(1–HO OPU4 bit rate tolerance)).

NOTE 4 – T represents the transcoding factor. Refer to clauses 17.7.3, 17.7.4 and 17.7.5.

2.6) Clause 12.2.5

Modify the text in clause 12.2.5 as follows:

ODUflex(GFP) signals are generated using a local clock. This clock may be the local HO ODUk (or OTUk) clock, or an equipment internal clock of the signal over which the ODUflex is carried through the equipment.

Any bit rate is possible for an ODUflex(GFP) signal, however it is suggested for maximum efficiency that the ODUflex(GFP) will ~~occupy a fixed number of ODTUk.ts payload bytes (in the initial ODTUk.ts)~~fill an integral number of tributary slots of the smallest HO ODUk path over which the ODUflex(GFP) may be carried. The recommended bit-rates to meet this criteria are specified in Table 7-8. The derivation of the specific values is provided in Appendix XI.

~~NOTE – Such ODUflex(GFP) may be transported through more than one HO ODUk path. The C_m value will be fixed in the first HO ODUk path; it will not be fixed in the other HO ODUk paths.~~

~~This fixed number of bytes per ODTUk.ts is controlled by configuration of the value C_m (refer to Annex D). The value of C_m should be selected such that the ODUflex signal can be transported over "n" OPUk tributary slots under worst-case conditions (i.e., maximum ODUflex bit rate and minimum HO OPUk bit rates). The ODUflex signal may be transported over a series of HO ODUk paths; the following are some example sequences: HO ODU2; HO ODU2 – ODU3; HO ODU2 – ODU4; HO ODU2 – ODU3 – ODU4; HO ODU3; HO ODU3 – ODU4; HO ODU4.~~

~~The ODUflex(GFP) has a bit rate tolerance of ±20 ppm. This tolerance requires that the maximum value of C_m is 15230 for ODTU2.ts and ODTU3.ts, and 15198 for ODTU4.ts.~~

~~These C_m values are to be reduced when the ODUflex(GFP) signal is generated by, e.g., a HO ODUk clock while the signal has to be transported also over a HO ODUj (j<k). The reduction factors are presented in Table 12-2. Note that these reduction factors are to be applied to the higher set of C_m values as indicated in Table 12-2.~~

~~Table 12-1 – OPUk tributary slot (TS) payload bandwidth ratios~~

	~~OPU2-TS~~	**~~OPU3-TS~~**	**~~OPU4-TS~~**
~~OPU2-TS~~	–	~~237/236 ≈ 1.0042~~	~~237/227 × 475/476~~ ~~≈ 1.0419~~
~~OPU3-TS~~	~~236/237 ≈ 0.9958~~	–	~~236/227 × 475/476~~ ~~≈ 1.0375~~
~~OPU4-TS~~	~~227/237 × 476/475~~ ~~≈ 0.9598~~	~~227/236 × 476/475~~ ~~≈ 0.9639~~	–

~~Table 12-2 – C_m reduction factors~~

	~~Passing over HO ODU2, 3 and 4~~	**~~Passing over HO ODU3 and 4~~**	**~~Passing over HO ODU4~~**
~~ODUflex with ODU2 base clock~~	–	~~N/A~~	~~N/A~~
~~ODUflex with ODU3 base clock~~	~~236/237 ≈ 0.99578~~ ~~Applied to~~ ~~15165 ≤ C_m ≤ 15230~~	–	~~N/A~~
~~ODUflex with ODU4 base clock~~	~~227/237 ≈ 0.95781~~ ~~Applied to~~ ~~14587 ≤ C_m ≤ 15198~~	~~227/236 ≈ 0.96186~~ ~~Applied to~~ ~~14649 ≤ C_m ≤ 15198~~	–

2.7) Figure 12-3

Replace Figure 12-3 with the following:

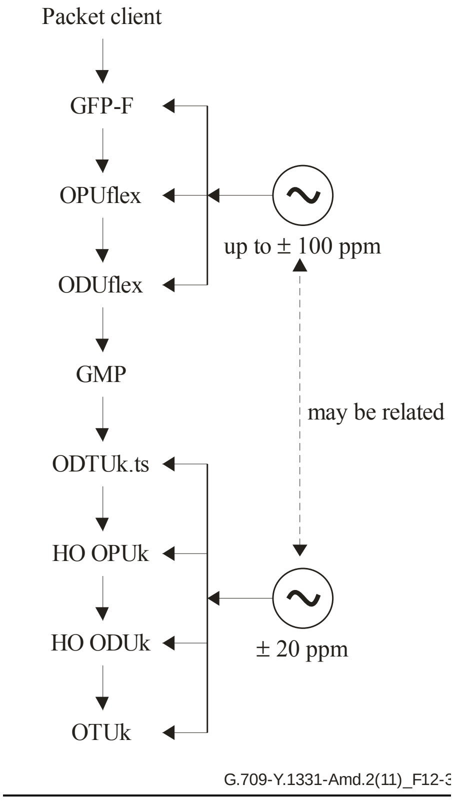

Figure 12-3 – ODUflex clock generation for GFP-F mapped packet client signals

2.8) Clause 15.9.2.1.1

Modify Table 15-8 as follows:

Table 15-8 – Payload type code points

MSB **1 2 3 4**	**LSB** **5 6 7 8**	**Hex code** (Note 1)	**Interpretation**
0 0 0 0	0 0 0 1	01	Experimental mapping (Note 3)
0 0 0 0	0 0 1 0	02	Asynchronous CBR mapping, see clause 17.2
0 0 0 0	0 0 1 1	03	Bit synchronous CBR mapping, see clause 17.2
0 0 0 0	0 1 0 0	04	ATM mapping, see clause 17.3
0 0 0 0	0 1 0 1	05	GFP mapping, see clause 17.4
0 0 0 0	0 1 1 0	06	Virtual Concatenated signal, see clause 18 (Note 5)
0 0 0 0	0 1 1 1	07	PCS codeword transparent Ethernet mapping: • 1000BASE-X into OPU0 mapping, see clauses 17.7.1 and 17.7.1.1 • 40GBASE-R into OPU3, see 17.7.4 and 17.7.4.1 • 100GBASE-R into OPU4, see 17.7.5 and 17.7.5.1
0 0 0 0	1 0 0 0	08	FC-1200 into OPU2e mapping, see clause 17.8.2
0 0 0 0	1 0 0 1	09	GFP mapping into Extended OPU2 payload, see clause 17.4.1 (Note 6)

Table 15-8 – Payload type code points

MSB **1 2 3 4**	**LSB** **5 6 7 8**	**Hex code** (Note 1)	**Interpretation**
0 0 0 0	1 0 1 0	0A	STM-1 mapping into ODU0, see clause 17.7.1
0 0 0 0	1 0 1 1	0B	STM-4 mapping into ODU0, see clause 17.7.1
0 0 0 0	1 1 0 0	0C	FC-100 mapping into ODU0, see clause 17.7.1
0 0 0 0	1 1 0 1	0D	FC-200 mapping into ODU1, see clause 17.7.2
0 0 0 0	1 1 1 0	0E	FC-400 mapping into ODUflex, see clause 17.9
0 0 0 0	1 1 1 1	0F	FC-800 mapping into ODUflex, see clause 17.9
0 0 0 1	0 0 0 0	10	Bit stream with octet timing mapping, see clause 17.6.1
0 0 0 1	0 0 0 1	11	Bit stream without octet timing mapping, see clause 17.6.2
0 0 0 1	0 0 1 0	12	IB SDR mapping into ODUflex, see clause 17.9
0 0 0 1	0 0 1 1	13	IB DDR mapping into ODUflex, see clause 17.9
0 0 0 1	0 1 0 0	14	IB QDR mapping into ODUflex, see clause 17.9
0 0 1 0	0 0 0 0	20	ODU multiplex structure supporting ODTUjk only, see clause 19 (AMP only)
0 0 1 0	0 0 0 1	21	ODU multiplex structure supporting ODTUk.ts or ODTUk.ts and ODTUjk, see clause 19 (GMP capable) (Note 7)
0 1 0 1	0 1 0 1	55	Not available (Note 2)
0 1 1 0	0 1 1 0	66	Not available (Note 2)
1 0 0 0	x x x x	80-8F	Reserved codes for proprietary use (Note 4)
1 1 1 1	1 1 0 1	FD	NULL test signal mapping, see clause 17.5.1
1 1 1 1	1 1 1 0	FE	PRBS test signal mapping, see clause 17.5.2
1 1 1 1	1 1 1 1	FF	Not available (Note 2)

NOTE 1 – There are ~~216~~ 213 spare codes left for future international standardization. Refer to Annex A of [ITU-T G.806] for the procedure to obtain one of these codes for a new payload type.

NOTE 2 – These values are excluded from the set of available code points. These bit patterns are present in ODUk maintenance signals.

NOTE 3 – Value "01" is only to be used for experimental activities in cases where a mapping code is not defined in this table. Refer to Annex A of [ITU-T G.806] for more information on the use of this code.

NOTE 4 – These 16 code values will not be subject to further standardization. Refer to Annex A of [ITU-T G.806] for more information on the use of these codes.

NOTE 5 – For the payload type of the virtual concatenated signal a dedicated payload type overhead (vcPT) is used, see clause 18.

NOTE 6 – Supplement 43 (02/2008) to the ITU-T G-series of Recommendations indicated that this mapping recommended using Payload Type 87.

NOTE 7 – Equipment supporting ODTUk.ts for OPU2 or OPU3 must be backward compatible with equipment which supports only the ODTUjk. ODTUk.ts capable equipment transmitting PT=21 which receives PT=20 from the far end shall revert to PT=20 and operate in ODTUjk only mode. Refer to [ITU-T G.798] for the specification.

2.9) Clause 17.7.4.1

Modify the text in the final four paragraphs of clause 17.7.4.1 as follows:

In the mapper, the received Ethernet PCS lane BIP may be compared with the expected Ethernet PCS lane BIP as a non-intrusive monitor~~ or section monitor~~.

The demapper will ~~either~~ insert a compensated Ethernet PCS lane BIP ~~(for path monitoring) or a newly computed PCS lane BIP (for section monitoring)~~ as described in Annex E. In addition, as described in Annex E, the combined error mask resulting from the PCS BIP-8 error mask and the OTN BIP-8 error mask may be used as a non-intrusive monitor.

For 40GBASE-R client mapping, 1-bit timing information (C_1) is not needed.

The demapper will recover from the output of the GMP processor 1027B block lock, and then trans-decode each 1027B block to sixteen 66B blocks as described in Annex E. Trans-decoded lane alignment markers are constructed with ~~either~~ a compensated BIP-8~~ or newly calculated BIP-8 depending on whether the interface is provisioned for path or section monitoring~~. The 66B blocks are then re-distributed round-robin to PCS lanes. If the number of PCS lanes is greater than the number of physical lanes of the egress interface, the appropriate numbers of PCS lanes are bit-multiplexed onto the physical lanes of the egress interface.

2.10) Clause 17.7.5.1

Modify the text in the final four paragraphs of clause 17.7.5.1 as follows:

In the mapper, the received Ethernet PCS lane BIP may be compared with the expected Ethernet PCS lane BIP as a non-intrusive monitor~~ or section monitor~~.

The demapper will ~~either~~ pass through the PCS lane BIP from the ingress ~~(for path monitoring), or insert a newly computed PCS lane BIP (for section monitoring)~~ as described in Annex E. In addition, the received Ethernet PCS lane BIP may be compared with the expected Ethernet PCS lane BIP as a non-intrusive monitor.

For 100GBASE-R client mapping, 1-bit timing information (C_1) is not needed.

The demapper will recover from the output of the GMP processor 64B/66B block lock per the state diagram in Figure 49-12 of [IEEE 802.3] or Figure 82-10 of [IEEE 802.3ba]. ~~If the interface is provisioned to use BIP-8 for section monitoring, BIP-8 is recalculated in each lane alignment marker.~~ The 66B blocks are re-distributed round-robin to PCS lanes. If the number of PCS lanes is greater than the number of physical lanes of the egress interface, the appropriate numbers of PCS lanes are bit-multiplexed onto the physical lanes of the egress interface.

2.11) Clause 17.9

Modify Tables 17-14 and 17-15 in clause 17.9 as follows:

Table 17-14 – supra-2.488G CBR clients

Client signal	Nominal bit rate (kbit/s)	Bit rate tolerance (ppm)
FC-400	4 250 000	±100
FC-800	8 500 000	±100
IB SDR	2 500 000	±100
IB DDR	5 000 000	±100
IB QDR	10 000 000	±100

Table 17-15 – Replacement signal for supra-2.488 Gbit/s clients

Client signal	Replacement Signal	Bit rate tolerance (ppm)
FC-400	For further study	±100
FC-800	For further study	±100
IB SDR	For further study	±100
IB DDR	For further study	±100
IB QDR	For further study	±100

2.12) Clause 19.6.1

Modify Table 19-8 in clause 19.6.1 as follows:

Table 19-8 – C_m and C_n (n=8) for ODUj into ODTU2.M

ODUj signal	M	m=8×M	Floor $C_{m,min}$ (Note)	Minimum c_m	Nominal c_m	Maximum c_m	Ceiling $C_{m,max}$ (Note)
ODU0	1	8	15167	15167.393	15168.000	15168.607	15169
ODUflex(GFP), n=1..8	n	8 × n	ODUflex(GFP) rate dependent				
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(IB SDR)	3	24	10200	10200.928	10202.152	10203.376	10204
– ODUflex(IB DDR)	5	40	12241	12241.113	12242.582	12244.051	12245
– ODUflex(FC-400)	4	32	13006	13006.183	13007.744	13009.305	13010
– ODUflex(FC-800)	7	56	14864	14864.209	14865.993	14867.777	14868
			Floor $C_{8,min}$ (Note)	Minimum c_8	Nominal c_8	Maximum c_8	Ceiling $C_{8,max}$ (Note)
ODU0	1	8	15167	15167.393	15168.000	15168.607	15169
ODUflex(GFP), n=1..8	n	8 × n	ODUflex(GFP) rate dependent				
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(IB SDR)	3	24	30602	30602.783	30606.456	30610.128	30611
– ODUflex(IB DDR)	5	40	61205	61205.566	61212.911	61220.257	61221
– ODUflex(FC-400)	4	32	52024	52024.731	52030.974	52037.218	52038
– ODUflex(FC-800)	7	56	104049	104049.462	104061.949	104074.437	104075

NOTE – Floor $C_{m,min}$, Floor $C_{n,min}$ (n=8), Ceiling $C_{m,max}$ and Ceiling $C_{n,max}$ (n=8) values represent the boundaries of ODUj/ODTU2.M ppm offset combinations (i.e., min. ODUj/max. ODTU and max. ODUj/min. ODTU). In steady state, given instances of ODUj/ODTU offset combinations should not result in generated C_n and C_m values throughout this range but rather should be within as small a range as possible. Under transient ppm offset conditions (e.g., AIS to normal signal), it is possible that C_n and C_m values outside the range $C_{n,min}$ to $C_{n,max}$ and $C_{m,min}$ to $C_{m,max}$ may be generated and a GMP demapper should be tolerant of such occurrences. Refer to Annex D for a general description of the GMP principles.

2.13) Clause 19.6.2

Modify Table 19-9 in clause 19.6.2 as follows:

Table 19-9 – C_m and C_n (n=8) for ODUj into ODTU3.M

ODUj signal	M	m=8×M	Floor $C_{m,min}$ (Note)	Minimum c_m	Nominal c_m	Maximum c_m	Ceiling $C_{m,max}$ (Note)
ODU0	1	8	15103	15103.396	15104.000	15104.604	15105
ODU2e	9	72	14026	14026.026	14027.709	14029.392	14030
ODUflex(GFP), n=1..32	n	8 × n	ODUflex(GFP) rate dependent				
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(IB SDR)	3	24	10157	10157.886	10159.105	10160.324	10161
– ODUflex(IB DDR)	5	40	12189	12189.463	12190.926	12192.389	12193
– ODUflex(IB QDR)	9	72	13543	13543.848	13545.473	13547.099	13548
– ODUflex(FC-400)	4	32	12951	12951.304	12952.859	12954.413	12955
– ODUflex(FC-800)	7	56	14801	14801.491	14803.267	14805.043	14806

			Floor $C_{8,min}$ (Note)	Minimum c_8	Nominal c_8	Maximum c_8	Ceiling $C_{8,max}$ (Note)
ODU0	1	8	15103	15103.396	15104.000	15104.604	15105
ODU2e	9	72	126234	126234.232	126249.381	126264.532	126265
ODUflex(GFP), n=1..32	n	8 × n	ODUflex(GFP) rate dependent				
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(IB SDR)	3	24	30473	30473.657	30477.314	30480.972	30481
– ODUflex(IB DDR)	5	40	60947	60947.314	60954.629	60961.943	60962
– ODUflex(IB QDR)	9	72	121894	121894.629	121909.258	121923.887	121924
– ODUflex(FC-400)	4	32	51805	51805.217	51811.434	51817.652	51818
– ODUflex(FC-800)	7	56	103610	103610.434	103622.869	103635.304	103636

NOTE – Floor $C_{m,min}$, Floor $C_{n,min}$ (n=8), Ceiling $C_{m,max}$ and Ceiling $C_{n,max}$ (n=8) values represent the boundaries of ODUj/ODTU3.M ppm offset combinations (i.e., min. ODUj/max. ODTU and max. ODUj/min. ODTU). In steady state, given instances of ODUj/ODTU offset combinations should not result in generated C_n and C_m values throughout this range but rather should be within as small a range as possible. Under transient ppm offset conditions (e.g., AIS to normal signal), it is possible that C_n and C_m values outside the range $C_{n,min}$ to $C_{n,max}$ and $C_{m,min}$ to $C_{m,max}$ may be generated and a GMP demapper should be tolerant of such occurrences. Refer to Annex D for a general description of the GMP principles.

2.14) Clause 19.6.3

Modify Table 19-10 in clause 19.6.3 as follows:

Table 19-10 – C_m and C_n (n=8) for ODUj into ODTU4.M

ODUj signal	**M**	**m=8×M**	**Floor $C_{m,min}$** (Note)	**Minimum c_m**	**Nominal c_m**	**Maximum c_m**	**Ceiling $C_{m,max}$** (Note)
ODU0	1	8	14527	14527.419	14528.000	14528.581	14529
ODU1	2	16	14588	14588.458	14589.042	14589.626	14590
ODU2	8	64	14650	14650.013	14650.599	14651.185	14652
ODU2e	8	64	15177	15177.527	15179.348	15181.170	15182
ODU3	31	248	15186	15186.673	15187.280	15187.888	15188
ODUflex(GFP), n=1..80	n	8 × n	ODUflex(GFP) rate dependent				
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(IB SDR)	2	16	14655	14655.763	14657.522	14659.281	14660
– ODUflex(IB DDR)	4	32	14655	14655.763	14657.522	14659.281	14660
– ODUflex(IB QDR)	8	64	14655	14655.763	14657.522	14659.281	14660
– ODUflex(FC-400)	4	32	12457	12457.399	12458.894	12460.389	12461
– ODUflex(FC-800)	7	56	14237	14237.027	14238.736	14240.444	14241
			Floor $C_{8,min}$ (Note)	**Minimum c_8**	**Nominal c_8**	**Maximum c_8**	**Ceiling $C_{8,max}$** (Note)
ODU0	1	8	14527	14527.419	14528.000	14528.581	14529
ODU1	2	16	29176	29176.917	29178.084	29179.251	29180
ODU2	8	64	117200	117200.105	117204.793	117209.482	117210
ODU2e	8	64	121420	121420.214	121434.786	121449.359	121450
ODU3	31	248	470786	470786.863	470805.695	470824.528	470825
ODUflex(GFP), n=1..80	n	8 × n	ODUflex(GFP) rate dependent				
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(IB SDR)	2	16	29311	29311.526	29315.044	29318.562	29319
– ODUflex(IB DDR)	4	32	58623	58623.052	58630.088	58637.124	58638
– ODUflex(IB QDR)	8	64	117246	117246.105	117260.176	117274.247	117275
– ODUflex(FC-400)	4	32	49829	49829.595	49835.575	49841.555	49842
– ODUflex(FC-800)	7	56	99659	99659.189	99671.149	99683.110	99684

NOTE – Floor $C_{m,min}$, Floor $C_{n,min}$ (n=8), Ceiling $C_{m,max}$ and Ceiling $C_{n,max}$ (n=8) values represent the boundaries of ODUj/ODTU4.M ppm offset combinations (i.e., min. ODUj/max. ODTU and max. ODUj/min. ODTU). In steady state, given instances of ODUj/ODTU offset combinations should not result in generated C_n and C_m values throughout this range but rather should be within as small a range as possible. Under transient ppm offset conditions (e.g., AIS to normal signal), it is possible that C_n and C_m values outside the range $C_{n,min}$ to $C_{n,max}$ and $C_{m,min}$ to $C_{m,max}$ may be generated and a GMP demapper should be tolerant of such occurrences. Refer to Annex D for a general description of the GMP principles.

2.15) Clause B.3.1

Modify the text in the third paragraph of clause B.3.1 as follows:

An invalid 66B block will be converted to an error control block before transcoding and the OTN BIP-8 calculation as described in clause E.4.1. An invalid 66B block is one which does not have a sync header of "01" or "10", or one which has a sync header of "10" and a control block type field which does not appear in Figure B.2. An error control block has sync bits of "10", a block type code of 0x1E, and 8 seven-bit/E/error control characters. This will prevent the Ethernet receiver from interpreting a sequence of bits containing this error as a valid packet.

2.16) Clause E.3

Modify the third dash item of the paragraph that starts with "Each 66B codeword is one of the following: " in clause E.3 as follows:

– a PCS lane alignment marker, also encoded with a sync header of "10". Of the 8 octets following the sync header, 6 octets have fixed values allowing the lane alignment markers to be recognized (see Tables E.1 and E.2). The fourth octet following the sync header is a BIP-8 calculated over the data from one alignment marker to the next. The eighth octet is the complement of this BIP-8 value to maintain DC balance. ~~Note that these BIP-8 values are not manipulated by the mapping or demapping procedure, but simply skipped in the process of recognizing lane alignment markers and copied intact as they are used for monitoring the error ratio of the Ethernet link between Ethernet PCS sublayers.~~ Note that the intended operation is to pass these BIP-8 values transparently, as they are used for monitoring the error ratio of the Ethernet link between Ethernet PCS sublayers. For the case of 100GBASE-R, the BIP-8 values are not manipulated by the mapping or demapping procedure. For the case of 40GBASE-R, a BIP-8 compensation is done as described in Annex E.4.1.

2.17) Clause E.3.2

Modify the text in the second paragraph of clause E.3.2 as follows:

~~In case of end-to-end path monitoring t~~The lane alignment markers transported over the OPU4 are distributed unchanged to the PCS lanes. ~~In the case of section monitoring the lane alignment markers are located as defined in state diagram in Figure 82-11 of [IEEE 802.3ba] and the BIP-8 is newly calculated for each PCS lane as defined in clause 82.2.8 of [IEEE 802.3ba]. This value overwrites BIP_3 and the complement overwrites BIP_7.~~

2.18) Clause E.4.1

Modify the text in the eighth paragraph of clause E.4.1 as follows:

The OTN BIP-8 is calculated similar to the PCS BIP-8 as described in clause 82.2.8 of [IEEE 802.3ba] with the exception that the calculation will be done over unscrambled PCS lane data, the original received lane alignment marker, after error control block insertion and before transcoding. Figure E.2 shows the byte location of the OTN BIP-8 in the transcoded lane marker.

Modify the text in the tenth and 11th paragraphs of clause E.4.1 as follows:

The egress BIP_3 for each PCS lane is calculated over the trans-decoded and scrambled data blocks including the trans-decoded alignment marker (refer to clause E.4) following the process depicted in clause 82.2.8 of [IEEE 802.3ba]. ~~This is the value that is transmitted in case of section monitoring.~~

~~When provisioned for end-to-end path monitoring, t~~The egress BIP$_3$ is then adjusted for the errors that occurred up to the OTN egress by first XORing with the PCS BIP-8 error mask and then XORing with the OTN BIP-8 error mask. This combined error mask will be used to compute the number of BIP errors when used for non-intrusive monitoring.

2.19) Clause E.4.2

Modify the text in the second paragraph of clause E.4.2 as follows:

An invalid 66B block will be converted to an error control block before transcoding~~ or direct adaptation~~. An invalid 66B block is one which does not have a sync header of "01" or "10", or one which has a sync header of "10", is not a valid PCS lane alignment marker and has a control block type field which does not appear in Figure B.2 or has one of the values 0x2d, 0x33, 0x66, or 0x55 which are not used for 40GBASE-R or 100GBASE-R. An error control block has sync bits of "10", a block type code of 0x1e, and 8 seven-bit/E/error control characters. This will prevent the Ethernet receiver from interpreting a sequence of bits containing this error as a valid packet.

2.20) Appendix VIII

Add the following tables at the end of the appendix:

Table VIII-5 – Number of tributary slots required for ODUj into HO OPUk

	# 2.5G tributary slots		**# 1.25G tributary slots**			
LO ODU	**OPU2**	**OPU3**	**OPU1**	**OPU2**	**OPU3**	**OPU4**
ODUflex(CBR)						
– ODUflex(CPRI Opt 4)	–	–	–	3	3	3
– ODUflex(CPRI Opt 5)	–	–	–	4	4	4
– ODUflex(CPRI Opt 6)	–	–	–	5	5	5

Table VIII-6 – C_m and C_n (n=8) for ODUj into ODTU2.M

ODUj signal	**M**	**m=8×M**	**Floor $C_{m,min}$**	**Minimum c_m**	**Nominal c_m**	**Maximum c_m**	**Ceiling $C_{m,max}$**
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(CPRI 4)	3	24	12534	12534.900	12536.404	12537.909	12538
– ODUflex(CPRI 5)	4	32	15041	15041.880	15043.685	15045.490	15046
– ODUflex(CPRI 6)	5	40	15041	15041.880	15043.685	15045.490	15046
			Floor $C_{8,min}$	**Minimum c_8**	**Nominal c_8**	**Maximum c_8**	**Ceiling $C_{8,max}$**
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(CPRI 4)	3	24	37525	37525.698	37530.202	37534.705	37535
– ODUflex(CPRI 5)	4	32	60041	60041.117	60048.323	60055.529	60056
– ODUflex(CPRI 6)	5	40	75051	75051.396	75060.403	75069.411	75070

Table VIII-7 – C_m and C_n (n=8) for ODUj into ODTU3.M

ODUj signal	M	m=8×M	Floor $C_{m,min}$	Minimum c_m	Nominal c_m	Maximum c_m	Ceiling $C_{m,max}$
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(CPRI 4)	3	24	12482	12482.010	12483.508	12485.006	12486
– ODUflex(CPRI 5)	4	32	14978	14978.412	14980.210	14982.007	14983
– ODUflex(CPRI 6)	5	40	14978	14978.412	14980.210	14982.007	14983
			Floor $C_{8,min}$	**Minimum c_8**	**Nominal c_8**	**Maximum c_8**	**Ceiling $C_{8,max}$**
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(CPRI 4)	3	24	37446	37446.030	37450.524	37455.018	37456
– ODUflex(CPRI 5)	4	32	59913	59913.648	59920.838	59928.029	59929
– ODUflex(CPRI 6)	5	40	74892	74892.060	74901.048	74910.036	74911

Table VIII-8 – C_m and C_n (n=8) for ODUj into ODTU4.M

ODUj signal	M	m=8×M	Floor $C_{m,min}$	Minimum c_m	Nominal c_m	Maximum c_m	Ceiling $C_{m,max}$
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(CPRI 4)	3	24	12006	12006.001	12007.442	12008.883	12009
– ODUflex(CPRI 5)	4	32	14407	14407.201	14408.930	14410.659	14411
– ODUflex(CPRI 6)	5	40	14407	14407.201	14408.930	14410.659	14411
			Floor $C_{8,min}$	**Minimum c_8**	**Nominal c_8**	**Maximum c_8**	**Ceiling $C_{8,max}$**
ODUflex(CBR)	ODUflex(CBR) dependent						
– ODUflex(CPRI 4)	3	24	36018	36018.003	36022.326	36026.649	36027
– ODUflex(CPRI 5)	4	32	57628	57628.805	57635.722	57642.638	57643
– ODUflex(CPRI 6)	5	40	72036	72036.007	72044.652	72053.297	72054

2.21) Appendix IX

Modify Table IX.1 in Appendix IX as follows:

Table IX.1 – Overview of CBR client into LO OPU mapping types

	OPU0	OPU1	OPU2	OPU2e	OPU3	OPU4	OPUflex
STM-1	GMP with C_{1D}	–	–	–	–	–	–
STM-4	GMP with C_{1D}	–	–	–	–	–	–
STM-16	–	AMP, BMP	–	–	–	–	–
STM-64	–	–	AMP, BMP	–	–	–	–
STM-256	–	–	–	–	AMP, BMP	–	–
1000BASE-X	TTT+GMP no C_{nD}	–	–	–	–	–	–
10GBASE-R	–	–	–	16FS+BMP	–	–	–
40GBASE-R	–	–	–	–	TTT+GMP with C_{8D}	–	–
100GBASE-R	–	–	–	–	–	GMP with C_{8D}	–
FC-100	GMP no C_{nD}	–	–	–	–	–	–
FC-200	–	GMP with C_{8D}	–	–	–	–	–
FC-400	–	–	–	–	–	–	BMP
FC-800	–	–	–	–	–	–	BMP
FC-1200	–	–	–	TTT+16FS+BMP (Note)	–	–	–
CPRI Option 1	GMP TBD $C_{\cancel{n}1D}$	–	–	–	–	–	–
CPRI Option 2	GMP T~~D~~BD $C_{\cancel{n}1D}$	–	–	–	–	–	–
CPRI Option 3	–	GMP TBD $C_{\cancel{n}1D}$	–	–	–	–	–
CPRI Option 4	–	–	–	–	–	–	BMP
CPRI Option 5	–	–	–	–	–	–	BMP
CPRI Option 6	–	–	–	–	–	–	BMP
CM_GPON	–	AMP	–	–	–	–	–
IB SDR	–	–	–	–	–	–	BMP
IB DDR	–	–	–	–	–	–	BMP
IB QDR	–	–	–	–	–	–	BMP

NOTE – For this specific case the mapping used is byte synchronous.

2.22) Appendix X

Add a new Appendix X with the following text:

Appendix X

Overview of LO ODU into HO OPU mapping types

(This appendix does not form an integral part of this Recommendation.)

As there are many different LO ODU bit rate signals and multiple mapping procedures, Table X.1 provides an overview of the mapping procedure that is specified for each LO ODU.

Table X.1 – Overview of LO ODU client into HO OPU mapping types

	2.5G tributary slots		**1.25G tributary slots**			
	OPU2	**OPU3**	**OPU1**	**OPU2**	**OPU3**	**OPU4**
ODU0	–	–	ODTU01 AMP (PT=20)	ODTU2.1 GMP (PT=21)	ODTU3.1 GMP (PT=21)	ODTU4.1 GMP (PT=21)
ODU1	ODTU12 AMP (PT=20)	ODTU13 AMP (PT=20)	–	ODTU12 AMP (PT=21)	ODTU13 AMP (PT=21)	ODTU4.2 GMP (PT=21)
ODU2	–	ODTU23 AMP (PT=20)	–	–	ODTU23 AMP (PT=21)	ODTU4.8 GMP (PT=21)
ODU2e	–	–	–	–	ODTU3.9 GMP (PT=21)	ODTU4.8 GMP (PT=21)
ODU3	–	–	–	–	–	ODTU4.31 GMP (PT=21)
ODUflex	–	–	–	ODTU2.ts GMP (PT=21)	ODTU3.ts GMP (PT=21)	ODTU4.ts GMP (PT=21)
ODUflex(IB SDR)	–	–	–	ODTU2.3 GMP (PT=21)	ODTU3.3 GMP (PT=21)	ODTU4.2 GMP (PT=21)
ODUflex(IB DDR)	–	–	–	ODTU2.5 GMP (PT=21)	ODTU3.5 GMP (PT=21)	ODTU4.4 GMP (PT=21)
ODUflex(IB QDR)	–	–	–	–	ODTU3.9 GMP (PT=21)	ODTU4.8 GMP (PT=21)
ODUflex(FC-400)	–	–	–	ODTU2.4 GMP (PT=21)	ODTU3.4 GMP (PT=21)	ODTU4.4 GMP (PT=21)

Table X.1 – Overview of LO ODU client into HO OPU mapping types

	2.5G tributary slots		**1.25G tributary slots**			
	OPU2	**OPU3**	**OPU1**	**OPU2**	**OPU3**	**OPU4**
ODUflex(FC-800)	–	–	–	ODTU2.7 GMP (PT=21)	ODTU3.7 GMP (PT=21)	ODTU4.7 GMP (PT=21)
ODUflex(CPRI Option 4)	–	–	–	ODTU2.3 GMP (PT=21)	ODTU3.3 GMP (PT=21)	ODTU4.3 GMP (PT=21)
ODUflex(CPRI Option 5)	–	–	–	ODTU2.4 GMP (PT=21)	ODTU3.4 GMP (PT=21)	ODTU4.4 GMP (PT=21)
ODUflex(CPRI Option 6)	–	–	–	ODTU2.5 GMP (PT=21)	ODTU3.5 GMP (PT=21)	ODTU4.5 GMP (PT=21)
ODUflex(GFP), n=1, … ,8 (ts=n)	–	–	–	ODTU2.ts (GMP) (PT=21)	ODTU3.ts (GMP) (PT=21)	ODTU4.ts (GMP) (PT=21)
ODUflex(GFP), n=9, … ,32 (ts=n)	–	–	–	–	ODTU3.ts (GMP) (PT=21)	ODTU4.ts (GMP) (PT=21)
ODUflex(GFP), n=33, … ,80 (ts=n)	–	–	–	–	–	ODTU4.ts (GMP) (PT=21)

2.23) Appendix XI

Add a new Appendix XI with the following text:

Appendix XI

Derivation of recommended ODUflex(GFP) bit-rates and examples of ODUflex(GFP) clock generation

(This appendix does not form an integral part of this Recommendation.)

XI.1 Introduction

The recommended bit-rates for ODUflex(GFP) are provided in Table 7-8. While in principle an ODUflex(GFP) may be of any bit-rate, there are a variety of reasons for recommending particular rates:

- to encourage a common set of bit-rates which can be expected to be supported by multiple manufacturers;
- to provide the largest amount of bandwidth possible within a given amount of resource (number of tributary slots) independent of the HO ODUk over which the ODUflex(GFP) may be routed;
- to maintain the number of tributary slots required if the ODUflex(GFP) must be rerouted, e.g., during a restoration;
- to satisfy a protocol requirement for ODUflex hitless resizing that a resizable ODUflex must occupy the same number of tributary slots on every HO ODUk path over which it is carried, and that a resize operation must always add or remove at least one tributary slot.

XI.2 Tributary slot sizes

ODUflex(GFP) is mapped via GMP into a certain number of 1.25G tributary slots of a HO OPU2, OPU3, or OPU4. Each of these have different tributary slot sizes:

$$OPU2\_TS = \frac{238}{237} \times 4 \times STM16 \times \frac{476\,columns}{3808\,columns} = 1249409.620\text{ kbit/s} \pm 20\text{ppm}$$

$$OPU3\_TS = \frac{238}{236} \times 16 \times STM16 \times \frac{119\,columns}{3808\,columns} = 1254703.729\text{ kbit/s} \pm 20\text{ppm}$$

$$OPU4\_TS = \frac{238}{227} \times 40 \times STM16 \times \frac{47.5\,columns}{3808\,columns} = 1301709.251\text{ kbit/s} \pm 20\text{ppm}$$

An ODUflex(GFP) that occupies 8 or fewer tributary slots may be routed over HO OPU2, OPU3, or OPU4. The smallest tributary slot that may be encountered along the route of the ODUflex(GFP) is that of HO OPU2. Even if the initially selected route does not choose a link of HO OPU2, the ODUflex(GFP) should be sized to a multiple of the OPU2 tributary slot size to preserve the possibility to restore the ODUflex(GFP) over a route that includes HO OPU2 without changing the size of the ODUflex or the number of tributary slots it occupies.

An ODUflex(GFP) that occupies at least 9, but no more than 32, tributary slots may be routed over HO OPU3 or OPU4. It does not fit over HO OPU2. Therefore such an ODUflex may be sized to a multiple of the OPU3 tributary slot size. Even if the initially selected route does not choose a link of HO OPU3, the ODUflex(GFP) should be sized to a multiple of the OPU3 tributary slot size to preserve the possibility to restore the ODUflex(GFP) over a route that includes HO OPU3 without changing the size of the ODUflex or the number of tributary slots it occupies.

An ODUflex(GFP) that occupies at least 33, but no more than 80 tributary slots may only be carried via HO OPU4, and may therefore take advantage of the full size of the OPU4 tributary slot size.

A small margin must be left between the ODUflex(GFP) size and the integral multiple of the tributary slot size to accommodate possible clock variation along a sequence of HO OPUk links without overflowing the range of C_m in the GMP mapper.

Physical layers for data interfaces such as Ethernet and Fibre Channel have historically used a clock tolerance of ±100 ppm. This range is sufficiently wide that specifying this as the clock tolerance for ODUflex(GFP) can accommodate a variety of mechanisms for generating an ODUflex(GFP) clock and remain within the clock tolerance range.

ODUk.ts as shown in Table 7-8 is an increment of bandwidth, which, when multiplied by a number of tributary slots, gives the recommended size of an ODUflex(GFP) optimized to occupy a given number of tributary slots of a higher order OPUk. These values are chosen to allow sufficient margin that allows the HO OPUk and the ODUflex(GFP) to independently vary over their full clock tolerance range without exceeding the capacity of the allocated tributary slots.

The nominal values for ODUk.ts are chosen to be 186 ppm below the bandwidth of a single 1.25G tributary slot of a higher order OPUk. This allows the ODUflex(GFP) clock to be as much as 100 ppm above its nominal rate and the higher order OPUk to be as much as 20 ppm below its nominal clock rate, allowing approximately 66 ppm of margin to accommodate jitter and to ensure that the largest average C_m value even in the worst-case situation of the HO OPUk at –20 ppm from its nominal value and the ODUflex(GFP) at +100 ppm from its nominal value will be one less than the maximum value (i.e., the maximum average C_m is no more than 15231 out of 15232 for ODUflex carried over OPU2 or OPU3, and no more than 15199 out of 15200 for ODUflex carried over OPU4).

XI.3 Example methods for ODUflex(GFP) clock generation

XI.3.1 Generating ODUflex(GFP) clock from higher order OPUk clock

The clock for an ODUflex(GFP) may be generated from the initial higher order OPUk over which the ODUflex is carried by setting the value of C_m to a fixed value on the initial segment. Normal GMP processing on subsequent segments avoids the need to couple the higher order OPUk clocks along the path.

Table XI.1 – Generation of ODUflex(GFP) clock from higher order OPUk clock using fixed C_m

Higher order OPUk	Nominal bit rate	Nominal 1.25G TS bit rate	ODU2.ts		ODU3.ts		ODU4.ts	
			C_m out of	Bit-rate per TS	C_m out of	Bit-rate per TS	C_m out of	Bit-rate per TS
OPU2	9'995'276.962	1'249'409.620	15230 15232	1'249'245.570				
			+20 ppm	1'249'270.555				
			–20 ppm	1'249'220.585				
OPU3	40'150'519.322	1'254'703.729	15165 15232	1'249'184.746	15230 15232	1'254'538.983		
			+20 ppm	1'249'209.729		1'254'564.074		
			–20 ppm	1'249'159.762		1'254'513.892		
OPU4	104'355'975.330	1'301'709.251	14587 15200	1'249'212.687	14649 15200	1'254'522.291	15198 15200	1'301'537.974
			+20 ppm	1'249'237.671		1'254'547.381		1'301'564.004
			–20 ppm	1'249'187.703		1'254'497.200		1'301'511.943
		ODUk.ts	nominal	1'249'177.230		1'254'470.354		1'301'467.133
			+100 ppm	1'249'302.148		1'254'595.801		1'301'597.280
			–100 ppm	1'249'052.312		1'254'344.907		1'301'336.986

Table XI.1 illustrates how a clock for an ODUflex(GFP) occupying n × ODUk.ts can be derived from the higher order OPUk clock using a fixed value of C_m in the initial segment of the path.

For example, an ODUflex(GFP) occupying up to 8 tributary slots should be based on ODU2.ts, and therefore have a clock frequency of n × 1'249'177.230 kbit/s ±100 ppm. This allows the ODUflex(GFP) to have a frequency of between n × 1'249'052.312 kbit/s and n × 1'249'302.148 kbit/s.

– If the initial segment over which the ODUflex(GFP) is carried is an OPU2, a clock in this range can be generated by fixing the value of C_m on the initial segment to 15230, which will result in the ODUflex having a clock of n × 1'249'245.570 kbit/s ±20 ppm. While the center frequency of this range differs from the nominal value of ODU2.ts, the clock tolerance is narrower, being locked to the higher order OPU2, so the possible clock range is fully within the ±100 ppm range allowed.

– If the initial segment is a higher order OPU3, the ODUflex(GFP) of a multiple of ODU2.ts can be generated using a fixed value of C_m=15165 on the initial ODU3 segment, which will result in the ODUflex having a clock of n × 1'249'184.746 kbit/s ±20 ppm,

– If the initial segment is a higher order OPU4, the ODUflex(GFP) of a multiple of ODU2.ts can be generated using a fixed value of C_m=14587 on the initial OPU4 segment, which will result in the ODUflex having a clock of n × 1'249'212.687 kbit/s ±20 ppm.

The center frequencies of all of these ODUflex(GFP) are slightly different, but the resulting ranges for the clocks all fall within the ±100 ppm window (see Figure XI.1). Fixed C_m for generating ODU3.ts and ODU4.ts from the initial higher order OPUk can similarly be found from this table.

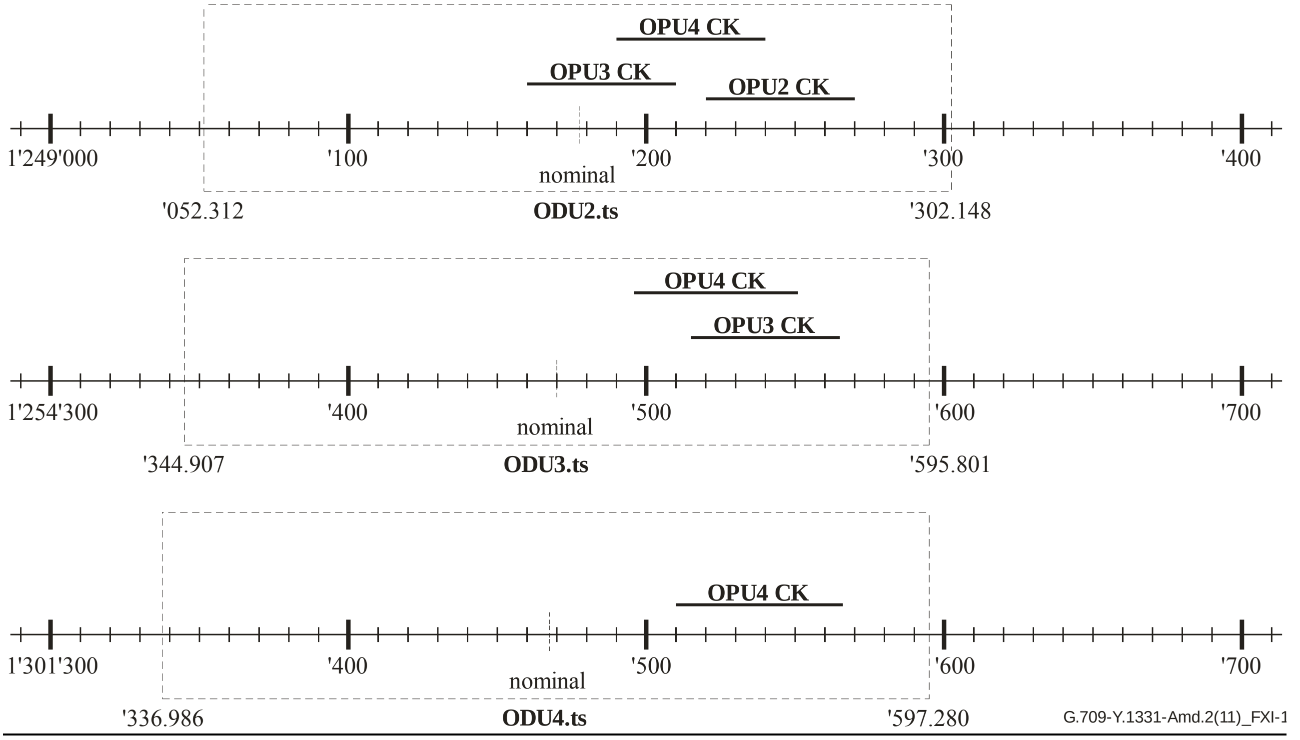

Figure XI.1 – Graphical representation of frequency ranges in Table X.1

To ensure that this method is future proof, likely rates for future OPU5, OPU6, and OPU7 have been checked to ensure that it is possible to select a fixed C_m to generate ODUflex(GFP) clocks based on any ODUk.ts value. As future tiers of the hierarchy are yet to be agreed, it would be premature to list them here, but the following reasoning ensures that this mechanism can be extended to future tiers: Based on the M-byte mechanism for GMP mapping into tributary slots, each increment of fixed C_m represents a 65-66 ppm difference in the resulting ODUflex frequency. There will generally be three (exceptionally four) values of C_m for which, if the higher order OPUk is running at nominal frequency, would generate an ODUflex clock that falls within a ±100 ppm window. At least one of these possible values of C_m is 67 ppm or more from each end of the ±100 ppm range. Since the actual variation of the clock for an ODUflex whose clock is generated in this manner is only ±20 ppm, and the higher order OPUk for downstream segments can also vary by ±20 ppm, at least 40 ppm difference is needed between the center frequency of an ODUflex(GFP) generated from a future OPUk (k>4) and each end of the ±100 ppm range. Since only 40 ppm is required and at least 67 ppm are available, it will be possible to select fixed C_m values to generate ODUflex(GFP) clocks from future higher order OPUk.

XI.3.2 Generating ODUflex(GFP) clock from system clock

The clock for an ODUflex(GFP) may be generated using a multiplier from the internal system clock. Normally the internal system clock will have an accuracy of at least ±20 ppm, perhaps even ±4.6 ppm, for a network element that supports both SDH and OTN interfaces. The exact multiplier to be used is implementation specific, and should be chosen so that the range of the generated clock falls within the specified ±100 ppm window around the nominal value of n × ODUk.ts.

2.24) Bibliography

Add a new reference to the Bibliography:

[b-IB ARCH] InfiniBand Trade Association, *InfiniBand Architecture Specification Volume 2, Release 1.2.1* (2006).

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