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DIGITAL NETWORKS

TRANSPORT OF SDH ELEMENTS ON PDH NETWORKS – FRAME AND MULTIPLEXING STRUCTURES

ITU-T Recommendation G.832

(Previously "CCITT Recommendation")

FOREWORD

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The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1 (Helsinki, March 1-12, 1993).

ITU-T Recommendation G.832 was revised by ITU-T Study Group 13 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 2nd of November 1995.

NOTE

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

CONTENTS

SUMMARY

This Recommendation defines frame structures and multiplexing arrangements for the transport of SDH elements over existing PDH transport networks operating at G.702 hierarchical rates of 34 368 kbit/s, 44 736 kbit/s, 97 728 kbit/s and 139 264 kbit/s. It is envisaged that these frame structures could, unless otherwise indicated, be used for the transport of other signals (e.g. ATM cells).

TRANSPORT OF SDH ELEMENTS ON PDH NETWORKS – FRAME AND MULTIPLEXING STRUCTURES

(revised in 1995)

1 Introduction

1.1 Scope

The purpose of this Recommendation is to provide frame structures and multiplexing arrangements for the transport of SDH elements over existing PDH transport networks operating at various G.702 hierarchical rates. It is also envisaged that these frame structures could, unless otherwise indicated, be used for the transport of other signals (e.g. ATM cells).

1.2 References

The following 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; all 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.

- ITU-T Recommendation G.708 (1993), *Network node interface for the synchronous digital hierarchy*.
- ITU-T Recommendation G.709 (1993), *Synchronous multiplexing structure*.
- ITU-T Recommendation G.804 (1993), *ATM cell mapping into Plesiochronous Digital Hierarchy (PDH).*
- CCITT Recommendation T.50 (1992), *International Reference Alphabet (IRA) (Formerly International Alphabet No. 5 or IA5) – Information technology – 7-bit coded character set for information interchange.*

1.3 Abbreviations

For the purposes of this Recommendation, the following abbreviations are used:

BIP-8	Bit Interleaved Parity-8
C-n	Container of level n
IEC	Incoming Error Count
LSB	Least Significant Bit
MSB	Most Significant Bit
PDH	Plesiochronous Digital Hierarchy
POH	Path Overhead
PTR	PoinTeR
RDI	Remote Defect Indication
REI	Remote Error Indication
SDH	Synchronous Digital Hierarchy
SOH	Section Overhead

TTI Trail Trace Identifier

TU-n Tributary Unit of level n

TUG-n Tributary Unit Group of level n

VC-n Virtual Container of level n

NOTES

1 The order of transmission of information in all diagrams in this Recommendation is first from left to right and then top to bottom. Within each byte the most significant bit is transmitted first. The most significant bit (bit 1) is illustrated at the left of all diagrams.

2 In this Recommendation the term "SDH elements" indicates the various VCs with their associated pointers.

2 Frame structures

The frame structures defined in this Recommendation are intended to be used in a generic way. When implementing these frame structures, care should be taken to ensure that the performance of the frame alignment mechanism is not compromised by the payload content.

2.1 Frame structure at 34 368 kbit/s

2.1.1 General

The basic frame structure at 34 368 kbit/s comprises 7 octets of overhead and 530 octets of payload capacity per 125 µs as shown in Figure 2-1.

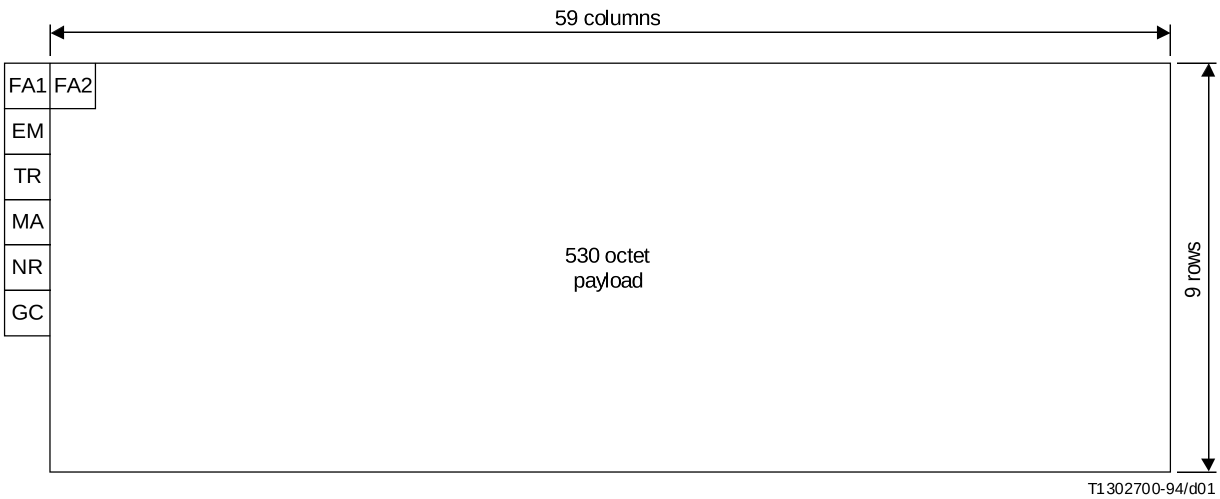


FIGURE 2-1/G.832

Frame structure at 34 368 kbit/s

2.1.2 Overhead allocation

The values and allocation of the overhead bytes are shown in Figure 2-2 and are described below.

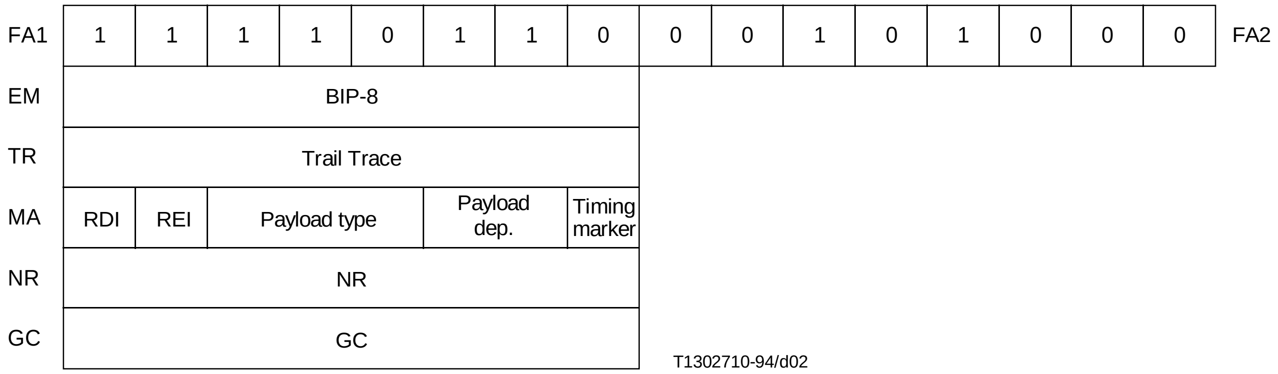


FIGURE 2-2/G.832

Overhead allocation at 34 368 kbit/s

FA1/FA2

Frame Alignment signal, this has the same pattern as A1/A2 defined in Recommendation G.708.

EM

Error Monitoring, BIP-8. One byte is allocated for error monitoring. This function shall be a BIP-8 code using even parity. The BIP-8 is calculated over all bits, including the overhead bits, of the previous 125 µs frame. The computed BIP-8 is placed in the EM byte of the current 125 µs frame.

TR

Trail Trace. This byte is used to repetitively transmit a trail access point identifier so that a trail receiving terminal can verify its continued connection to the intended transmitter. The trail access point identifier shall use the access point identifier format as defined in clause 3/G.831.

A 16-byte frame is defined for the transmission of the access point identifier and this is described in Annex A.

MA Maintenance and Adaptation byte

Bit 1 RDI

Bit 2 REI – This bit is set to "1" and sent back to the remote trail termination if one or more errors were detected by the BIP-8, and is otherwise set to zero.

Bits 3 to 5 Payload type

Code signal:

000 Unequipped

001 Equipped, non-specific

010 ATM

011 SDH TU-12s

Bits 6-7 Payload dependent (e.g. Tributary Unit multiframe indicator)

Bit 8 Timing marker – This bit is set to "0" to indicate that the timing source is traceable to a Primary Reference Clock, and is otherwise set to "1".

NR

Network Operator byte. This byte is allocated for maintenance purposes specific to individual Network Operators. Its transparency from Trail termination to Trail termination is not guaranteed. In the case where this byte is modified at an intermediate point in the trail, the EM byte must be appropriately corrected to ensure performance monitoring integrity. For Tandem Connection Maintenance, the byte is used in the following manner: bits 1 to 4 are used as an incoming error count (with the MSB of the IEC in bit 1) and bits 5 to 8 are used as a communications channel.

GC

General purpose communications channel (e.g. to provide data/voice channel connection for maintenance purposes).

2.2 Frame structure at 44 736 kbit/s

The basic frame structure at 44 736 kbit/s is described in Annex A/G.804.

2.2.1 Intermediate 500 µs frame structure

Since the 44 736 kbit/s frame structure is an asynchronous format with a nominal frame time of 106.402 µs, an intermediate 500 µs frame structure is defined below. This frame consists of 2736 bytes of payload, 4 framing bytes and 19 bytes of fixed stuff as shown in Figure 2-3.

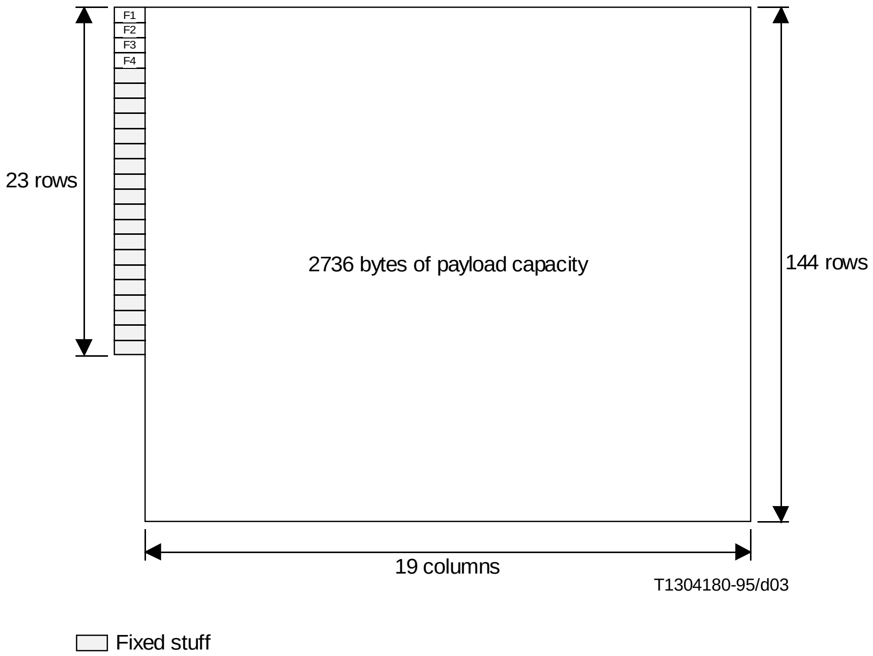


FIGURE 2-3/G.832

Intermediate 500 µs frame structure for transport of SDH elements in the 44 736 kbit/s frame structure

When this intermediate frame is combined along with the 44 736 kbit/s frame level stuffing and the 56 frame overhead bits of the C-bit parity format, the resultant signal will be 44 736 095 bit/s (within the range of the nominal 44 736 kbit/s ± 20 ppm).

2.2.2 Overhead allocation

The framing bytes and fixed stuff bytes are defined below.

- F1 – 11110110
- F2 – 00101000
- F3 – 11110110
- F4 – 00101000
- Fixed stuff – 11001100

2.3 Frame structure at 97 728 kbit/s

2.3.1 General

Using the full 97 728 kbit/s rate, there are 1537 bytes available every 125 µs. As the net capacity of the Container-3 needs 756 bytes every 125 µs, two Container-3s can be allocated leaving 15 bytes every 125 µs for the overhead for the 97 728 kbit/s signal and VC-3 POH functionality and for pointers as shown in Figure 2-4.

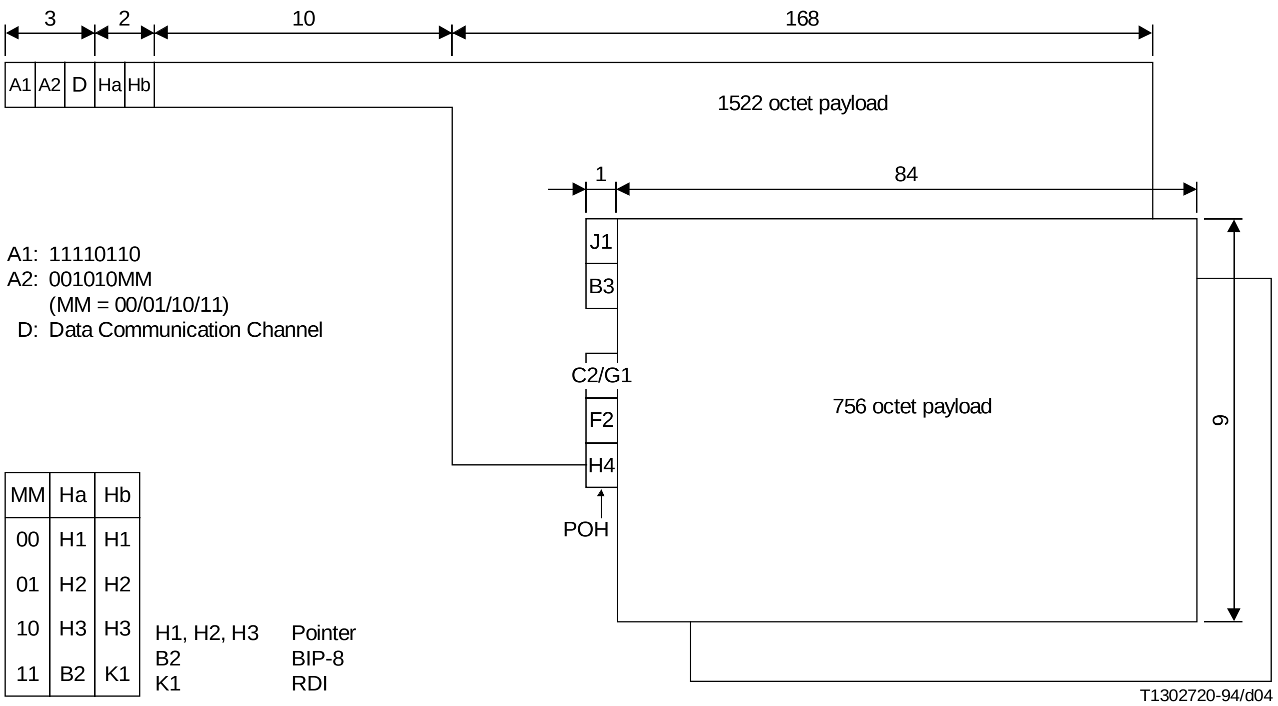


FIGURE 2-4/G.832

Frame structure and overhead allocation for the 97 728 kbit/s

2.3.2 Overhead allocation

The overheads and pointers are described below.

A1, A2 Frame alignment signal:

A1 11110110

A2 001010MM,

where MM (= 00/01/10/11) is multiframe indicator for Ha and Hb bytes.

D A 64 kbit/s data communication channel.

Ha, Hb These multiframe structured bytes have the following functionality:

H1, H2, H3 Reduced AU-3 pointer, which has the same function as defined in Recommendation G.708.

B2 Error monitoring, BIP-8. One byte is allocated for error monitoring of the 97 728 kbit/s signal. This function shall be a BIP-8 code using even parity. The BIP-8 is calculated over all bits of the previous 500 µs multiframe. The computed BIP-8 is placed in the B2 byte of the current 500 µs multiframe.

K1 Bit 8 is used for RDI. Bits 1-7 are reserved for future use.

J1 VC-3 path trace as defined in Recommendation G.709.

B3 VC-3 path BIP-8 as defined in Recommendation G.709.

C2/G1 Bits 1-4 are for VC-3 path REI, bit 5 is for VC-3 RDI and bits 6-8 are for VC-3 signal label.

F2 VC-3 path user channel as defined in Recommendation G.709.

H4 VC-3 position indicator as defined in Recommendation G.709.

2.4 Frame structure at 139 264 kbit/s

2.4.1 General

The basic frame structure at 139 264 kbit/s comprises 16 octets of overhead and 2160 octets of payload capacity per 125 µs as shown in Figure 2-5.

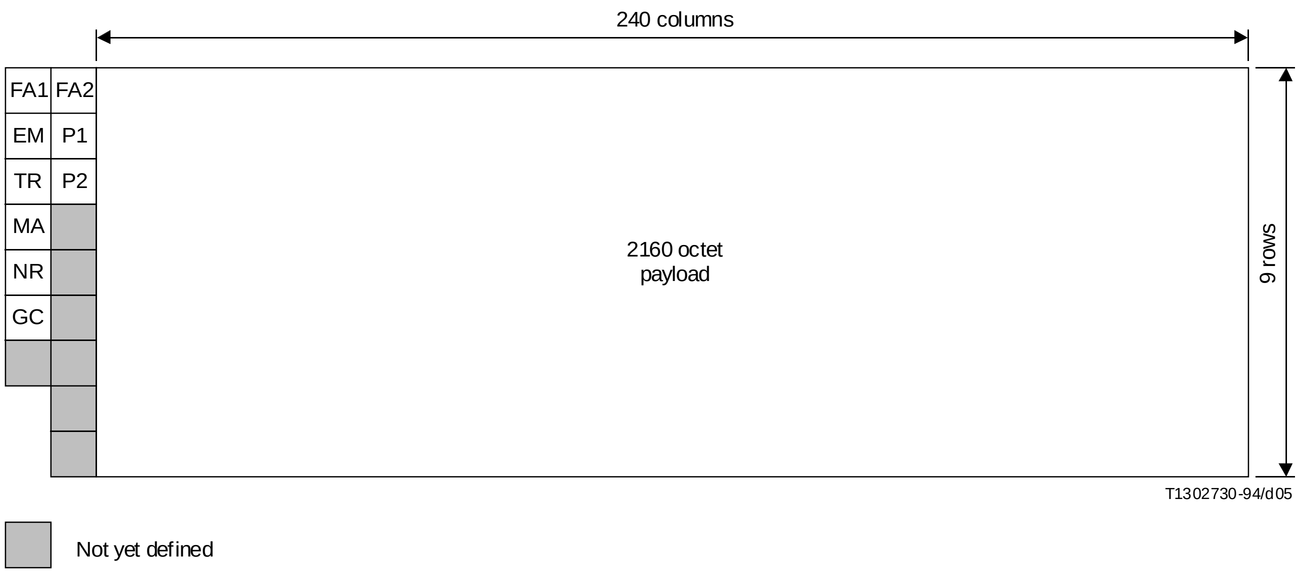


FIGURE 2-5/G.832

Frame structure at 139 264 kbit/s

2.4.2 Overhead allocation

The values and allocation of the overhead bytes are shown in Figure 2-6 and are described below.

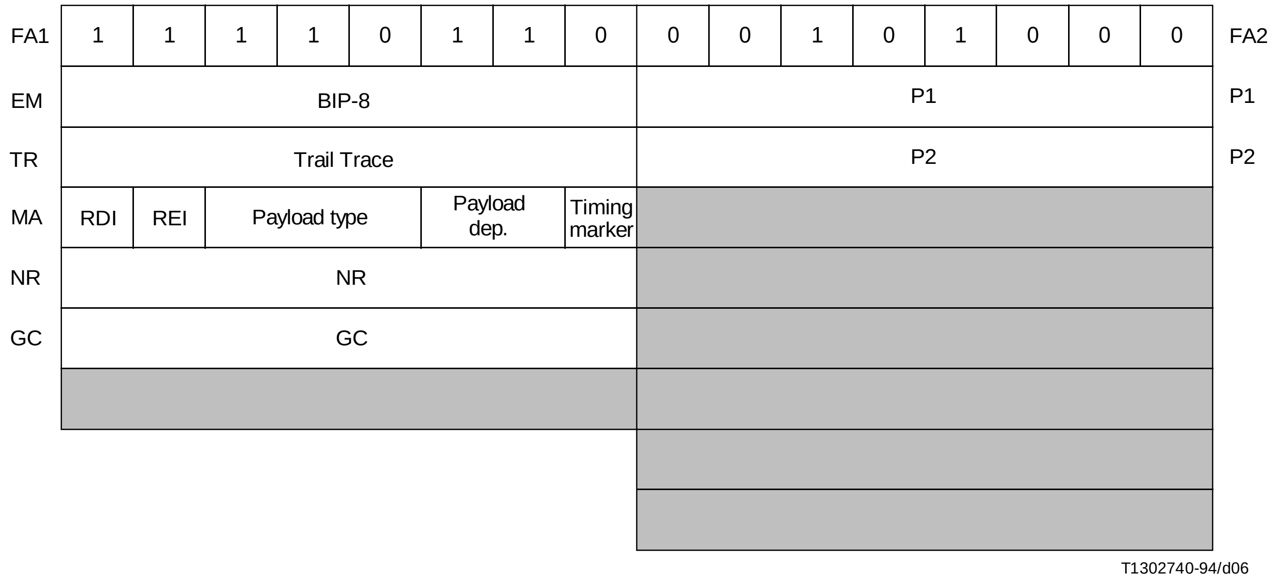


FIGURE 2-6/G.832

Overhead allocation at 139 264 kbit/s

FA1/FA2

Frame Alignment signal, this has the same pattern as A1/A2 defined in Recommendation G.708.

EM

Error Monitoring, BIP-8. One byte is allocated for error monitoring. This function shall be a BIP-8 code using even parity. The BIP-8 is calculated over all bits of the previous 125 μs frame. The computed BIP-8 is placed in the EM byte of the current 125 μs frame.

TR

Trail Trace. This byte is used to repetitively transmit a trail access point identifier so that a trail receiving terminal can verify its continued connection to the intended transmitter. The trail access point identifier shall use the access point identifier format as defined in clause 3/G.831.

A 16-byte frame is defined for the transmission of the access point identifier and this is described in Annex A.

MA Maintenance and Adaptation byte

Bit 1 RDI

Bit 2 REI – This bit is set to “1” and sent back to the remote trail termination if one or more errors were detected by the BIP-8, and is otherwise set to zero.

Bits 3 to 5 Payload type

Code signal:

000	Unequipped	
001	Equipped, non-specific	
010	ATM	
011	SDH elements mapping I	20 × TUG-2
100	SDH elements mapping II	2 × TUG-3 and 5 × TUG-2

Bits 6-7 Payload dependent (e.g. Tributary Unit multiframe indicator)

Bit 8 Timing marker – This bit is set to “0” to indicate that the timing source is traceable to a Primary Reference Clock, and is otherwise set to “1”.

NR

Network Operator byte. This byte is allocated for maintenance purposes specific to individual Network Operators. Its transparency from Trail termination to Trail termination is not guaranteed. In the case where this byte is modified at an intermediate point in the trail, the EM byte must be appropriately corrected to ensure performance monitoring integrity. For Tandem Connection Maintenance, the byte is used in the following manner: bits 1 to 4 are used as an incoming error count (with the MSB of the IEC in bit 1) and bits 5 to 8 are used as a communications channel.

GC

General purpose communications channel (e.g. to provide data/voice channel connection for maintenance purposes).

P1/P2

Automatic Protection Switching.

3 Multiplexing structures

3.1 Support of SDH elements in the 34 368 kbit/s frame structure

14 × TU-12s are arranged in the 530 octets payload area as shown in Figure 3-1.

Columns one (except the first octet), thirty and thirty-one are occupied by fixed stuff, the 14 × TU-12s are 1-column interleaved into this structure and have a fixed phase relationship with respect to the frame structure. The Tributary Unit pointers occupy the octets in the first row from columns 2 to 15.

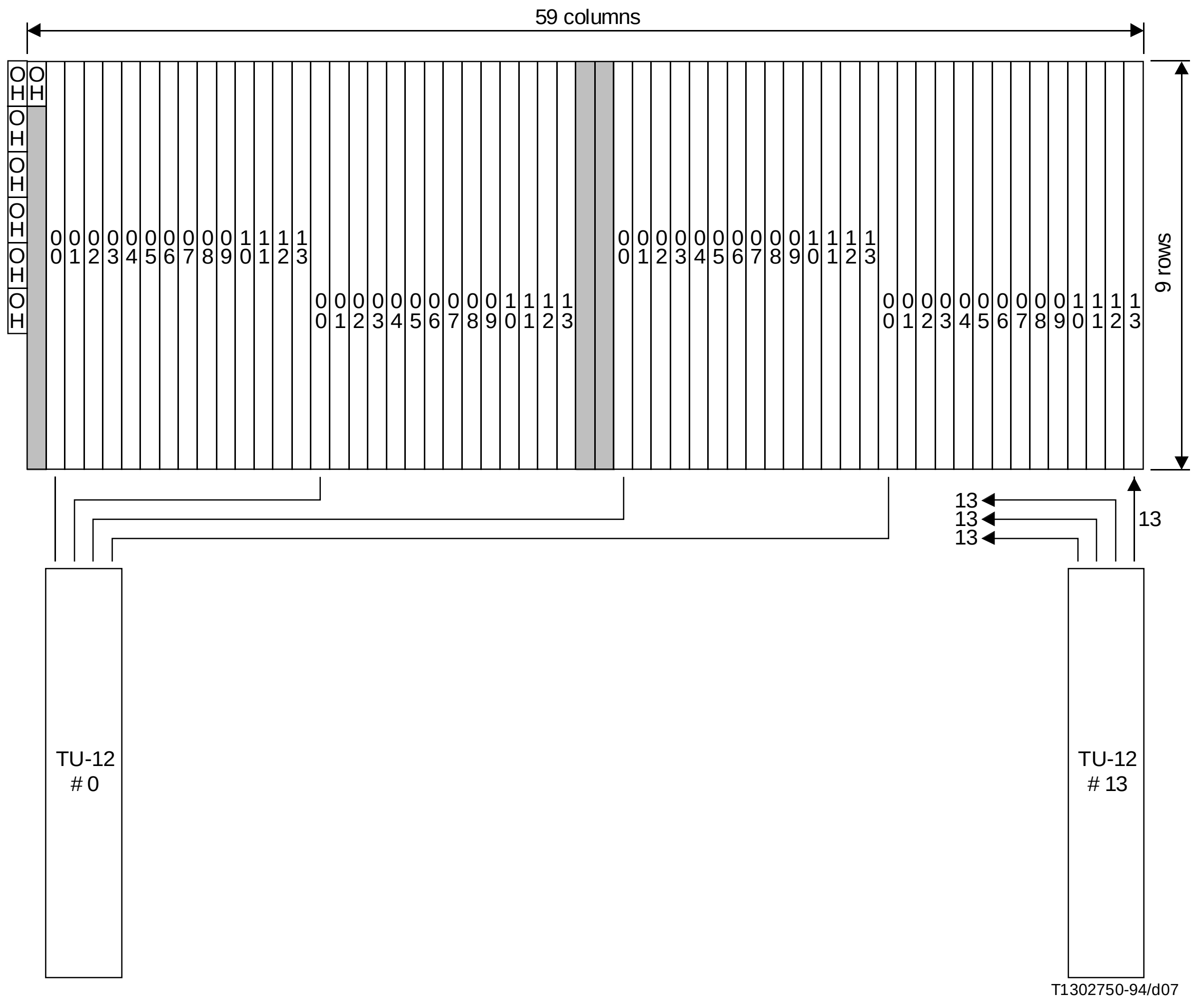


FIGURE 3-1/G.832

Support of 14 TU-12 s in the 34 368 kbit/s frame structure

The TU-12 elements are defined in Recommendations G.708 and G.709.

Figure 3-2 shows the multiplexing structure.

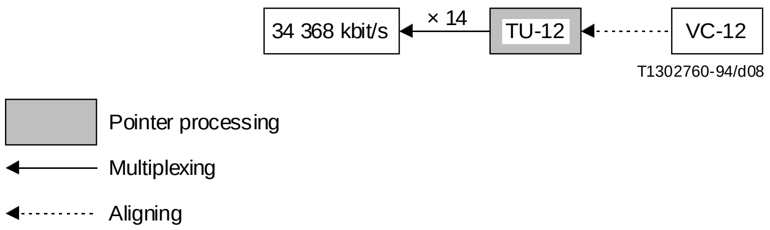


FIGURE 3-2/G.832

Multiplexing route for the 34 368 kbit/s frame structure

3.1.1 Coding of payload dependent bits for Tributary Unit multiframe indication

Table 3-1 shows the coding of the payload dependent bits (bits 6 and 7 of the MA octet) in case of TU-12s mapping.

TABLE 3-1/G.832

Bit 6	Bit 7	TU-PTR content in the following frame
0	0	V1
0	1	V2
1	0	V3
1	1	V4

500 µs Tributary Unit multiframe

The relation between the TU-PTR content and the coding of the payload dependent bits is shown in Figure 3-13/G.709.

3.2 Support of SDH elements in the 44 736 kbit/s frame structure

A TU-12 consists of 144 bytes per 500 µs. 19 × TU-12s are arranged in the 2736 octets payload area of the intermediate 500 µs frame as shown in Figure 3-3.

The Tributary Unit pointers occupy the octets in the first row from columns 2 to 20.

Figure 3-4 shows the multiplexing structure.

3.3 Support of SDH elements in the 97 728 kbit/s frame structure

The 1522 octets payload capacity can be used to support two reduced VC-3s (VC-3Rs). The VC-3R can contain seven TUG-2s or one C-3 defined in Recommendation G.709.

Figure 3-5 shows the multiplexing structure with the relevant lower level options.

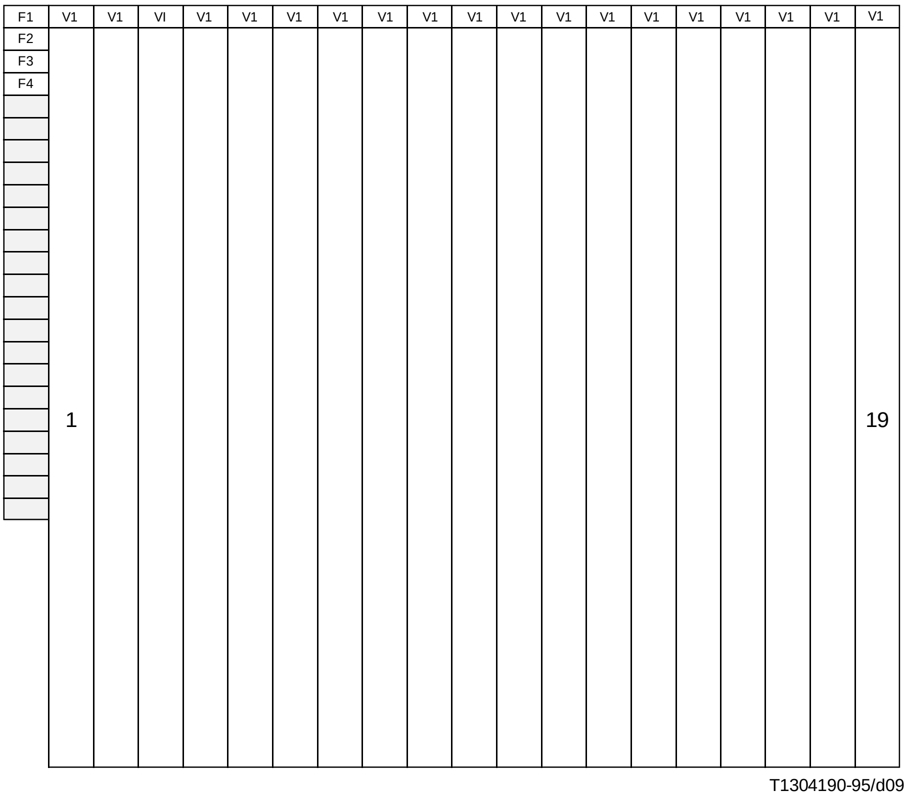


FIGURE 3-3/G.832

Multipexing of 19 TU-12 s into the intermediate 500 µs frame structure for transport within the 44 736 kbit/s frame structure

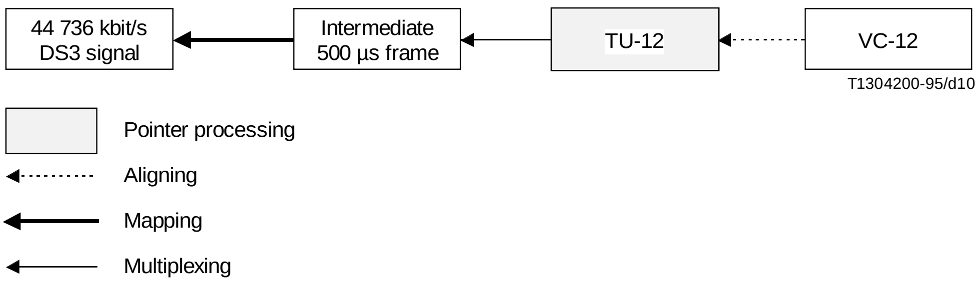
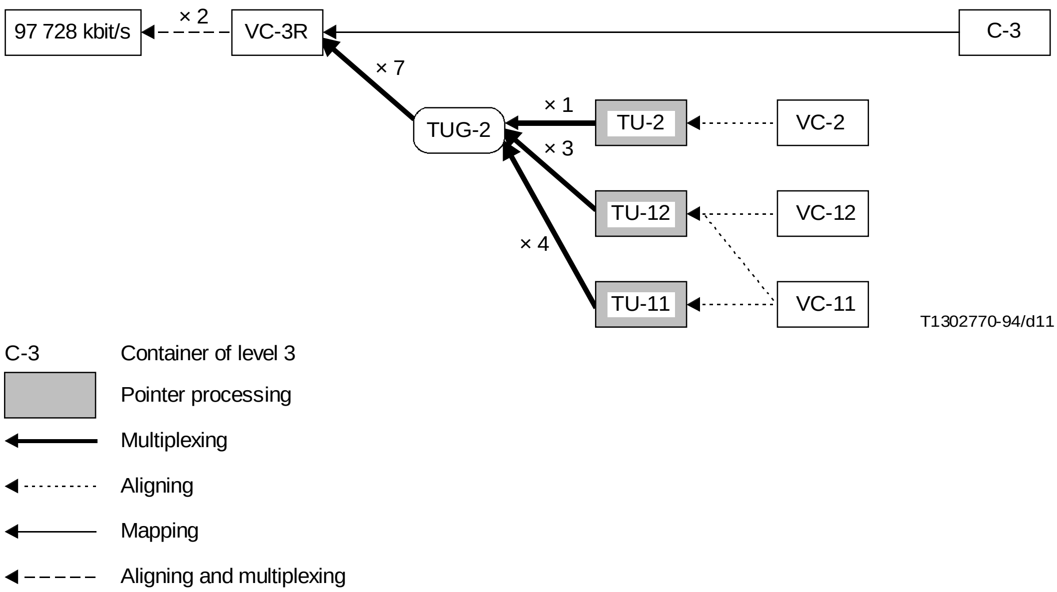


FIGURE 3-4/G.832

Multiplexing route for the transport of SDH elements in the 44 736 kbit/s frame structure



NOTE – The VC-3R is a VC-3 SDH element with reduced functionality as shown in Figure 2-4.

FIGURE 3-5/G.832

Multiplexing routes for the transport of SDH elements in the 97 728 kbit/s frame structure

3.4 Support of SDH elements in the 139 264 kbit/s frame structure

The 2160 octets payload capacity can be used to support the following multiplexing options:

- Option I – 20 × TUG-2;
- Option II – 2 × TUG-3 and 5 × TUG-2.

The TUG-2 and the TUG-3 are defined in Recommendations G.708 and G.709.

Figure 3-6 shows the two TUG multiplexing opportunities with the relevant lower level structure.

3.4.1 Multiplexing of 20 × TUG-2

The arrangement of 20 TUG-2s multiplexed into the 9 rows by 240 columns payload is shown in Figure 3-7. The 20 TUG-2s are one-byte interleaved into this structure and have a fixed phase relationship with respect to the frame overhead.

3.4.2 Multiplexing of 2 × TUG-3 and 5 × TUG-2

The arrangement of 2 TUG-3s and 5 TUG-2s multiplexed into the 9 rows by 240 columns payload is shown in Figure 3-8.

As a first step, four fixed stuff columns are added to each TUG-3 structure in the leading positions, resulting in two 90 column structures (“A” and “B”). The 5 TUG-2s are one-byte interleaved to a 60 columns by 9 rows structure (“C”).

These three intermediate structures are then byte interleaved in the following sequence:

$$[ABACBABC]_1 \qquad [ABACBABC]_2 .... [ABACBABC]_{30}$$

If further interworking flexibility is required, this arrangement could also be further demultiplexed into one TUG-3 and 12 (7 + 5) TUG-2s or all TUG-2s in which case a maximum of 19 TUG-2s can be carried. If only TUG-2s are required, this last situation is unlikely as the arrangment described in 3.4.1 provides for 20 TUG-2s.

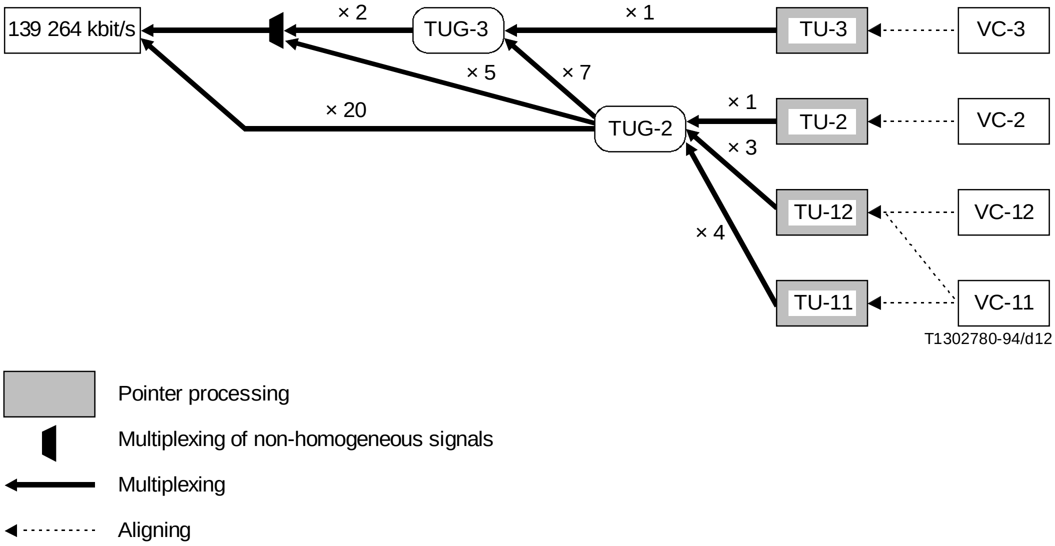


FIGURE 3-6/G.832

Multiplexing routes for the transport of SDH elements into the 139 264 kbit/s frame structure

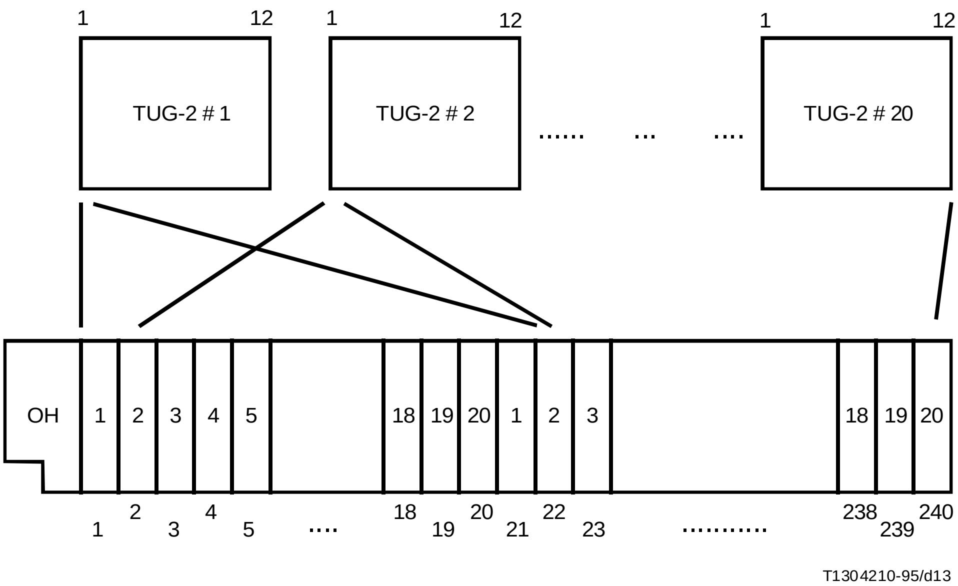


FIGURE 3-7/G.832

Multiplexing of 20 × TUG-2 info the 139 264 kbit/s payload capacity

3.4.3 Coding of payload dependent bits for Tributary Unit multiframe indication

Table 3-2 shows the coding of the payload dependent bits (bits 6 and 7 of the MA octet) in the case of TU-1xs mapping.

TABLE 3-2/G.832

Bit 6	Bit 7	TU-PTR content in the following frame
0	0	V1
0	1	V2
1	0	V3
1	1	V4

500 µs Tributary Unit multiframe

The relation beween the TU-PTR content and the coding of the payload dependent bits is shown in Figure 3-13/G.709.

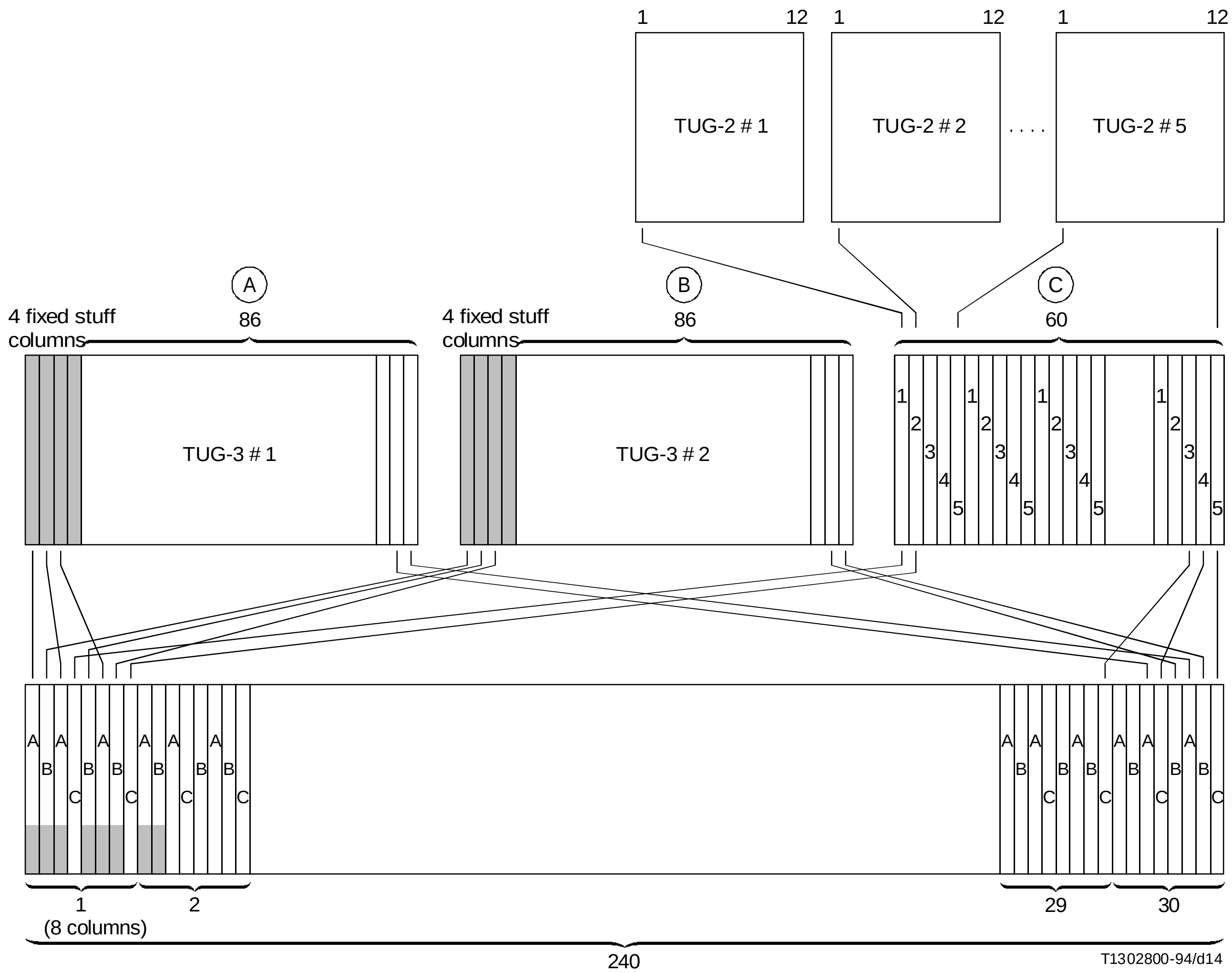


FIGURE 3-8/G.832

Multiplexing of 2 × TUG-3 and 5 × TUG-2 into the 139 264 kbit/s payload capacity

Annex A

Description of the 16-byte frame and CRC-7 calculation

(This annex forms an integral part of this Recommendation)

The first byte of the string is a frame start marker and includes the result of a CRC-7 calculation over the previous frame. The following 15 bytes are used for the transport of 15 T.50 characters (International reference version) required for the access point identifier. The 16-byte frame is given below:

1	C_1	C	C	C	C	C	C_7	Frame start marker
0	X	X	X	X	X	X	X	byte 2
•	•	•	•	•	•	•	•	
•	•	•	•	•	•	•	•	
•	•	•	•	•	•	•	•	
0	X	X	X	X	X	X	X	byte 16

X	X	X	X	X	X	X	T.50 character
C_1	C	C	C	C	C	C_7	Result of the CRC-7 calculation over the previous frame

The description of the CRC-7 calculation is given below:

Multiplication/division process

A particular CRC-7 word is the remainder after multiplication by X^7 and the division (modulo 2) by the generator polynomial $X^7 + X^3 + 1$, of the polynomial representation of the previous Trail Trace Identifier (TTI) multiframe.

When representing the contents of the block as a polynomial, the first bit in the block, i.e. byte 1, bit 1 should be taken as being the most significant bit. Similarly, C_1 is defined to be the most significant bit of the remainder and C_7 to be the least significant bit of the remainder.

Encoding procedure

The CRC-7 word is static because the data is static (the TTI represents the source address). This means that the CRC-7 checksum can be calculated either over the previous multiframe or *a priori*. In the last case this means that the 16-byte string that is loaded in a device for repetitive transmission should have the calculated checksum in the correct position.

The enconding procedure is as follows:

i) The CRC-7 bits in the TTI are replaced by binary 0s.

ii) The TTI is then acted upon by the multiplication/division process referred to above.

iii) The remainder resulting from the multiplication/division process is inserted into the CRC-7 location.

The CRC-7 bits generated do not affect the result of the multiplication process because, as indicated in i) above, the CRC-7 bit positions are initially set to 0 during the multiplication/division process.

Decoding procedure

i) A received TTI is acted upon by the multiplication/division process referred to above after having its CRC-7 bits extracted and replaced by 0s.

ii) The remainder resulting from the division process is then compared on a bit-by-bit basis with the CRC-7 bits received.

iii) If the remainder calculated in the decoder exactly corresponds to the CRC-7 bits received, it is assumed that the received TTI is error free.

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