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(11/93)

DIGITAL NETWORKS

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

ITU-T Recommendation G.832

(Previously "CCITT Recommendation")

FOREWORD

The ITU-T (Telecommunication Standardization Sector) is a permanent organ of the International Telecommunication Union (ITU). The 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 Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

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 prepared by ITU-T Study Group 13 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 26th of November 1993.

NOTE

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

CONTENTS

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

(Geneva, 1993)

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 Abbreviations

ASCII American Standard Code for Information Interchange

BIP-8 Bit Interleaved Parity-8

C-n Container of level n

FEBE Far End Block Error

FERF Far End Receive Failure

IEC Incoming Error Count

LSB Least Significant Bit

MSB Most Significant Bit

PDH Plesiochronous Digital Hierarchy

POH Path Overhead

PTR PoinTeR

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

2.1 Frame structure at 34 368 kbit/s

2.1.1 General

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

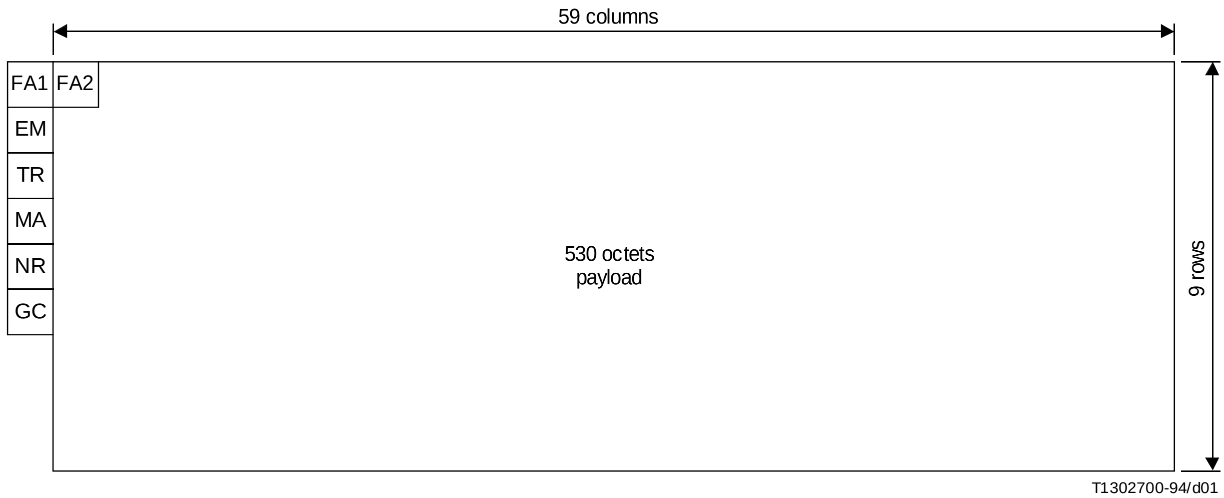


FIGURE 2-1/G.832

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.

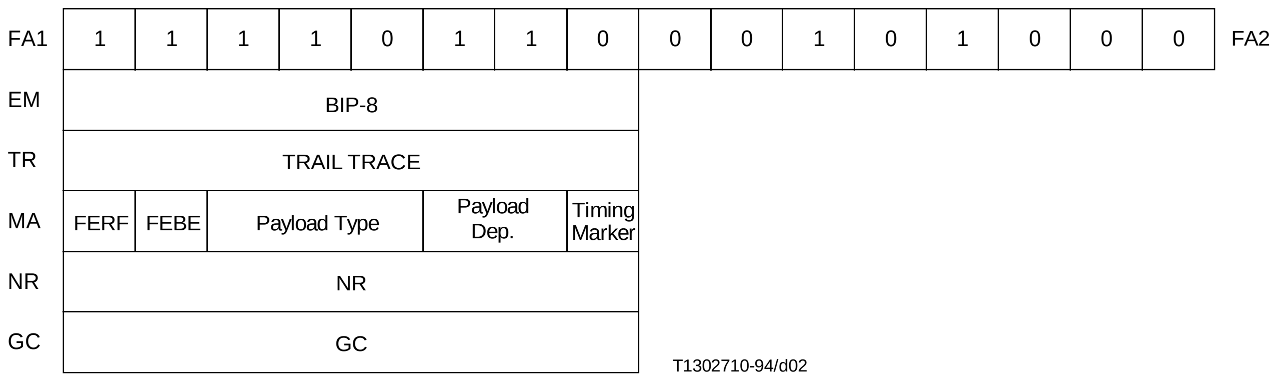


FIGURE 2-2/G.832

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 16-byte numbering format (see Recommendation E.164) as described below.

A 16-byte frame is defined for the transmission of the E.164 numbering. 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 ASCII characters required for the E.164 numbering format. 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 — ASCII character of the E.164 string

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 then 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 encoding 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/division 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.

MA Maintenance and Adaptation byte

Bit 1 FERF

Bit 2 FEBE – 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

For further study.

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 2-3.

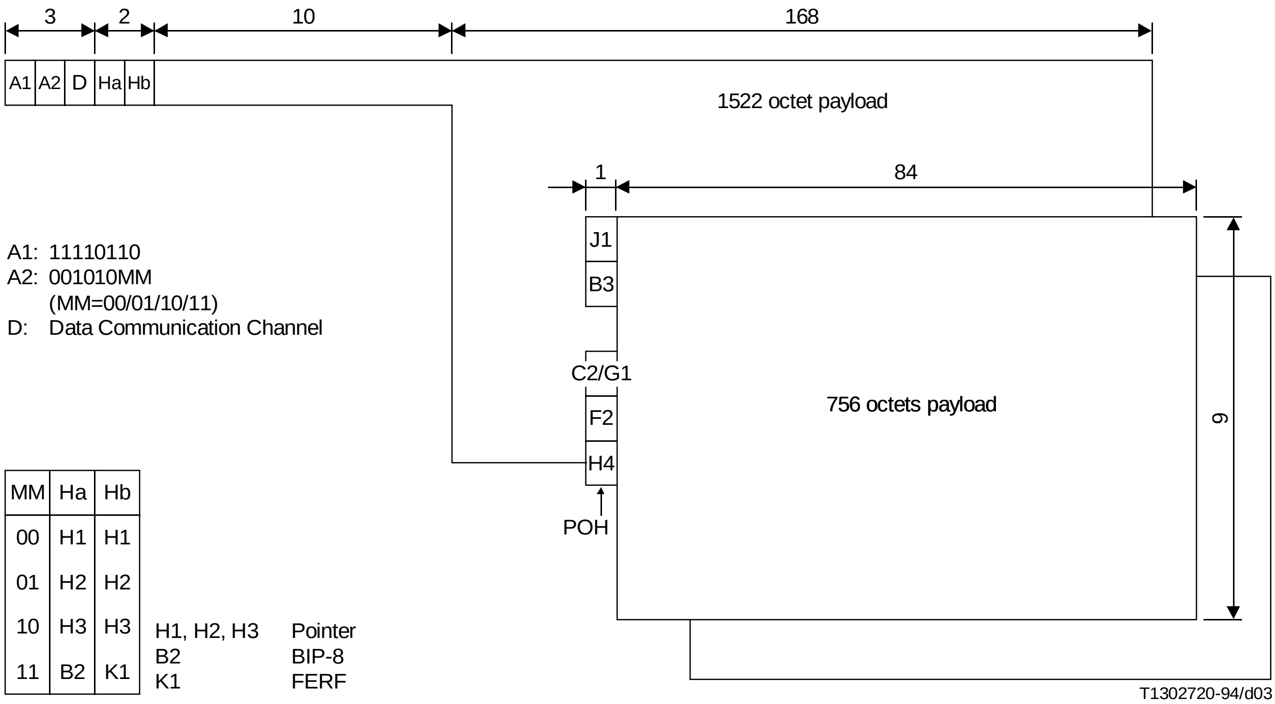


FIGURE 2-3/G.832

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 FERF. 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 FEBE, bit 5 is for VC-3 FERF 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 2-4.

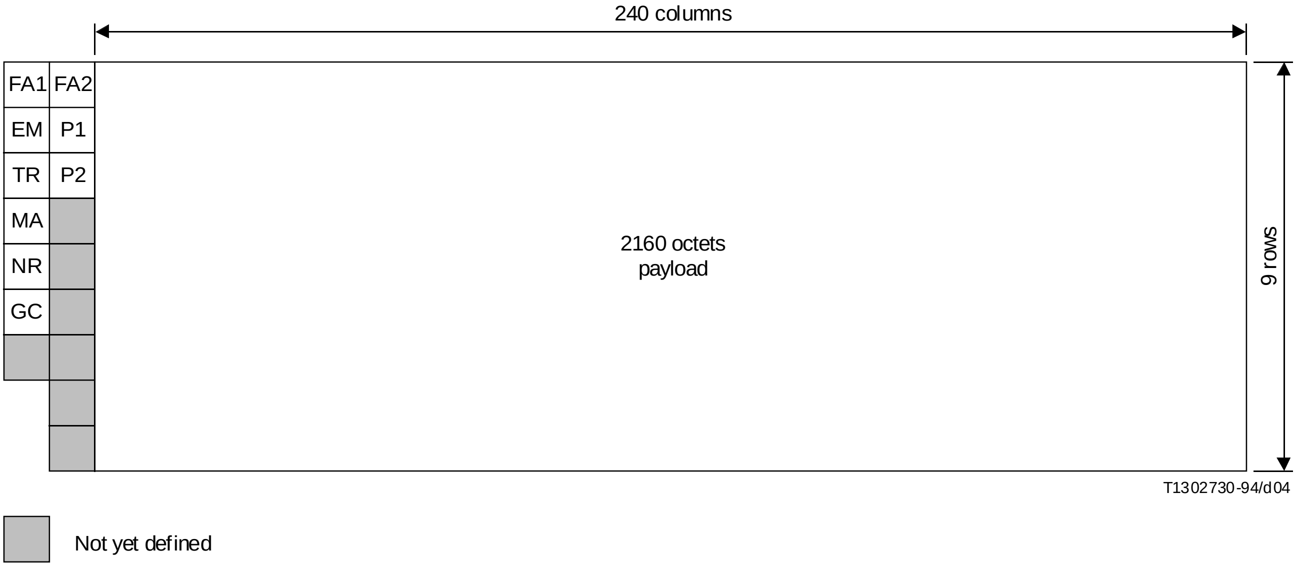


FIGURE 2-4/G.832

Frame structure at 139 264 kbit/s

2.4.2 Overhead allocation

The values and allocation of the overhead bytes are shown in Figure 2-5 and are described below.

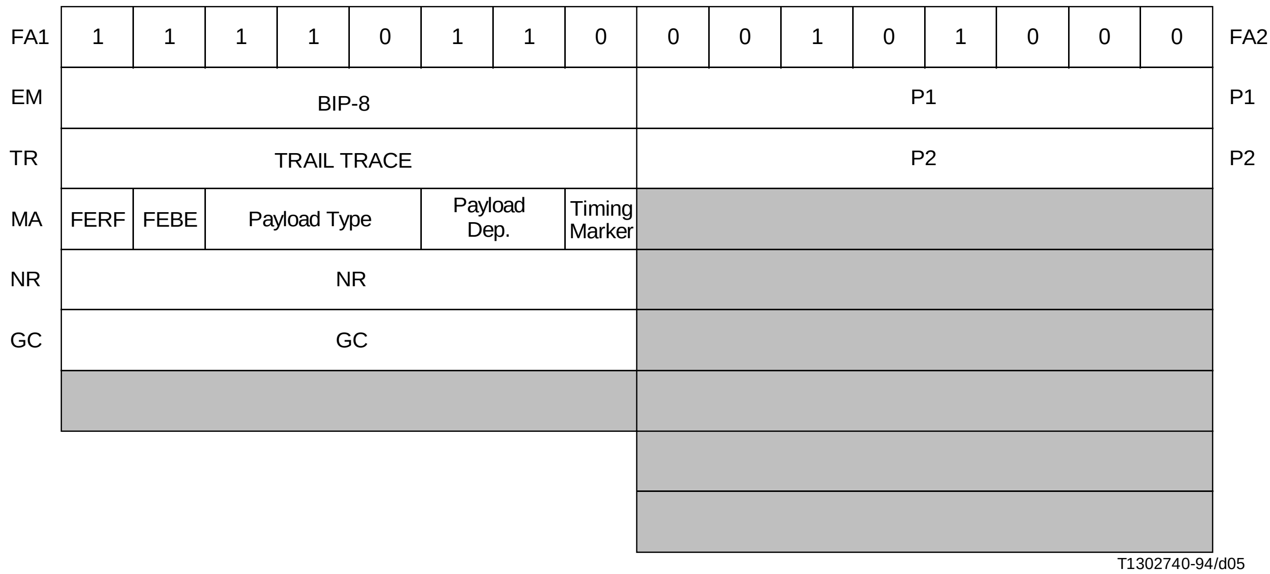


FIGURE 2-5/G.832

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 16-byte E.164 numbering format described below.

A 16-byte frame is defined for the transmission of the E.164 numbering. 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 ASCII characters required for the E.164 numbering format. 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 ASCII character of the E.164 string

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 then 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 encoding 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/division 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.

MA Maintenance and Adaptation byte

Bit 1 FERF

Bit 2 FEBE – 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 $20 \times$ TUG-2

100 SDH elements mapping II $2 \times$ TUG-3 and $5 \times$ 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

$14 \times$ 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 $14 \times$ 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 two to fifteen.

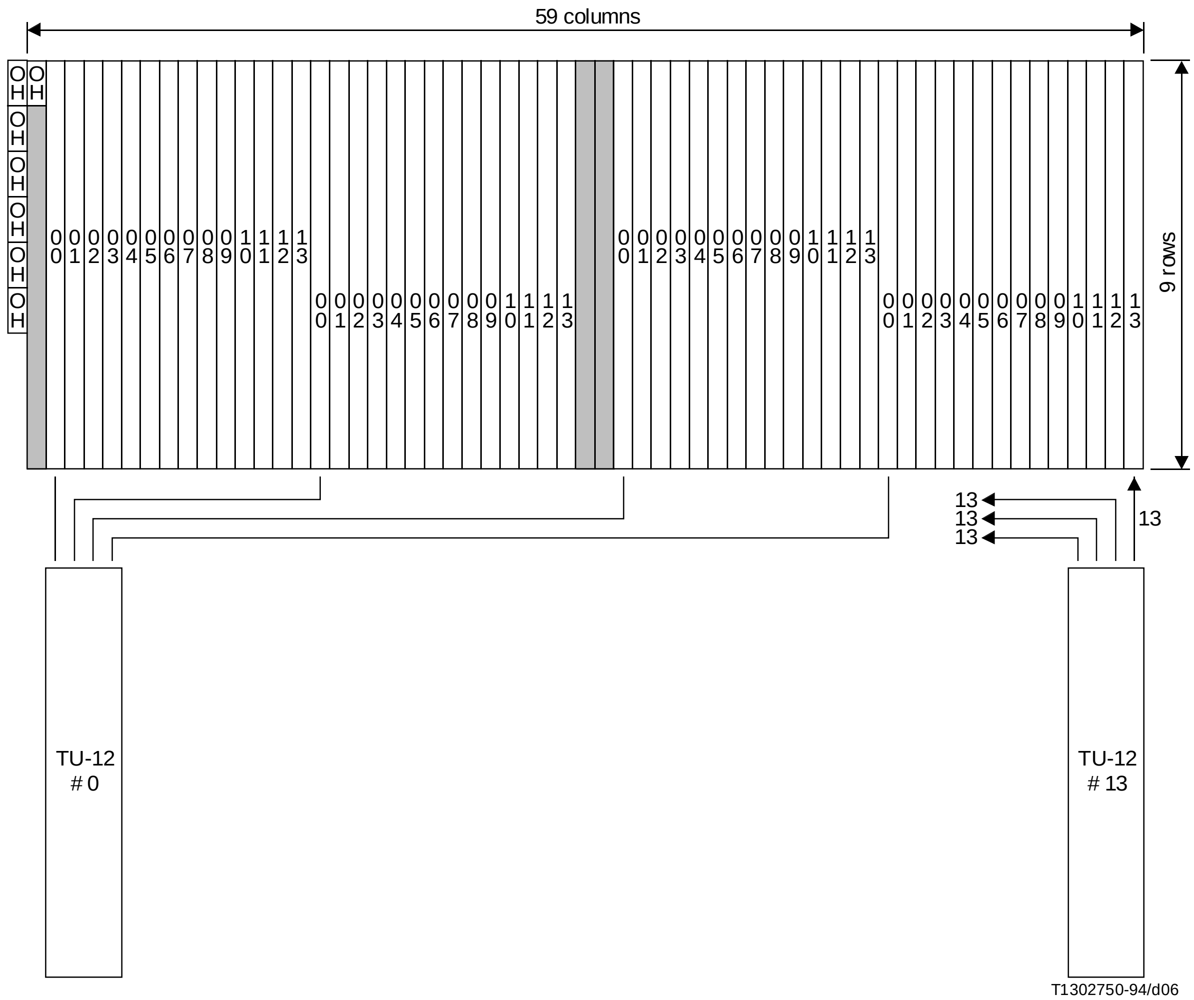


FIGURE 3-1/G.832

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

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

Figure 3-2 shows the multiplexing structure.

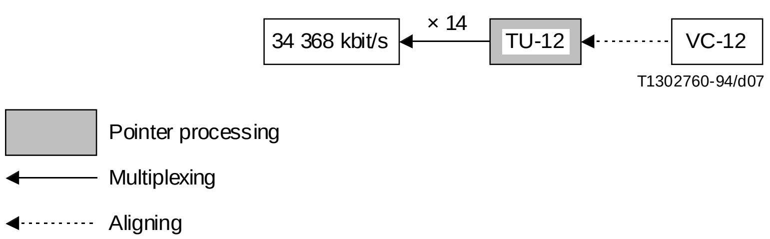


FIGURE 3-2/G.832

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.

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

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

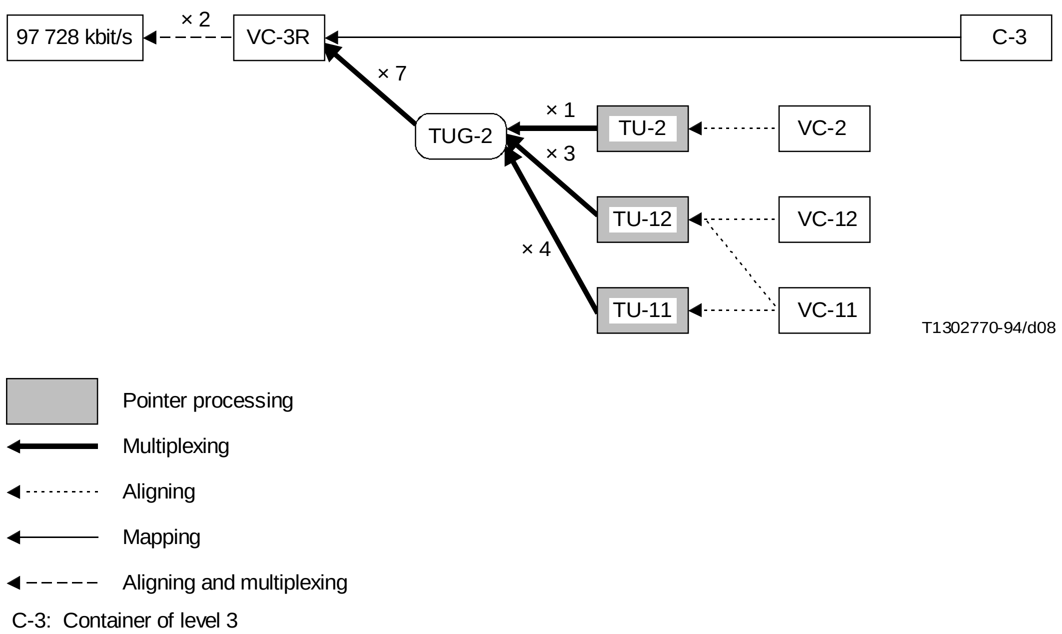
3.2 Support of SDH elements in the 44 736 kbit/s

For further study.

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

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



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

FIGURE 3-3/G.832

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

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

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.

Figures 3-4 shows the two TUG multiplexing opportunities with the relevant lower level structure.

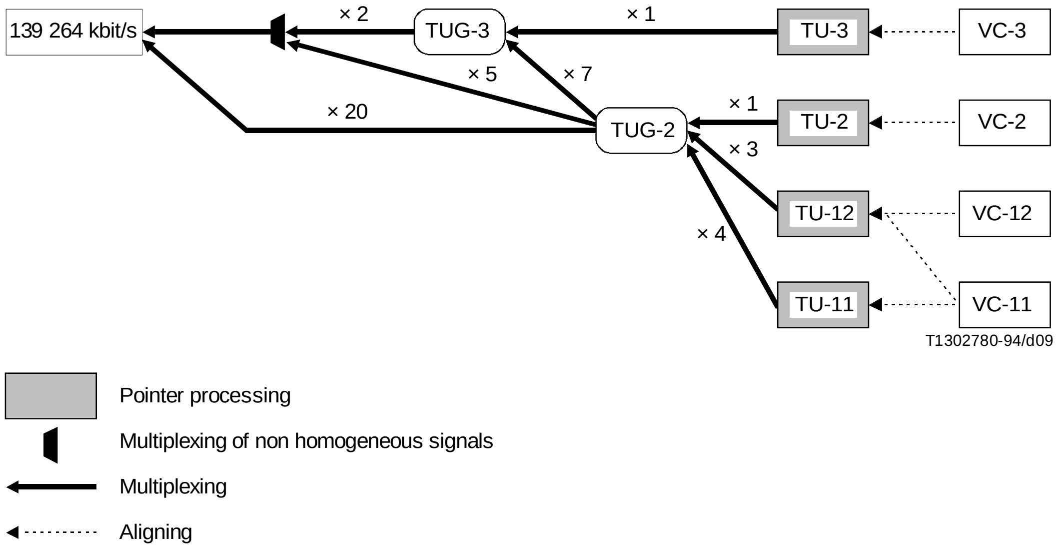


FIGURE 3-4/G.832

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

3.4.1 Multiplexing of 20 × TUG-2

The arrangement of 20 TUG-2s multiplexed into the nine rows by 240 columns payload is shown in Figure 3-5. The 20 TUG-2s are one-byte interleaved into this structure and have a fixed phase relationship with respect to the frame overhead.

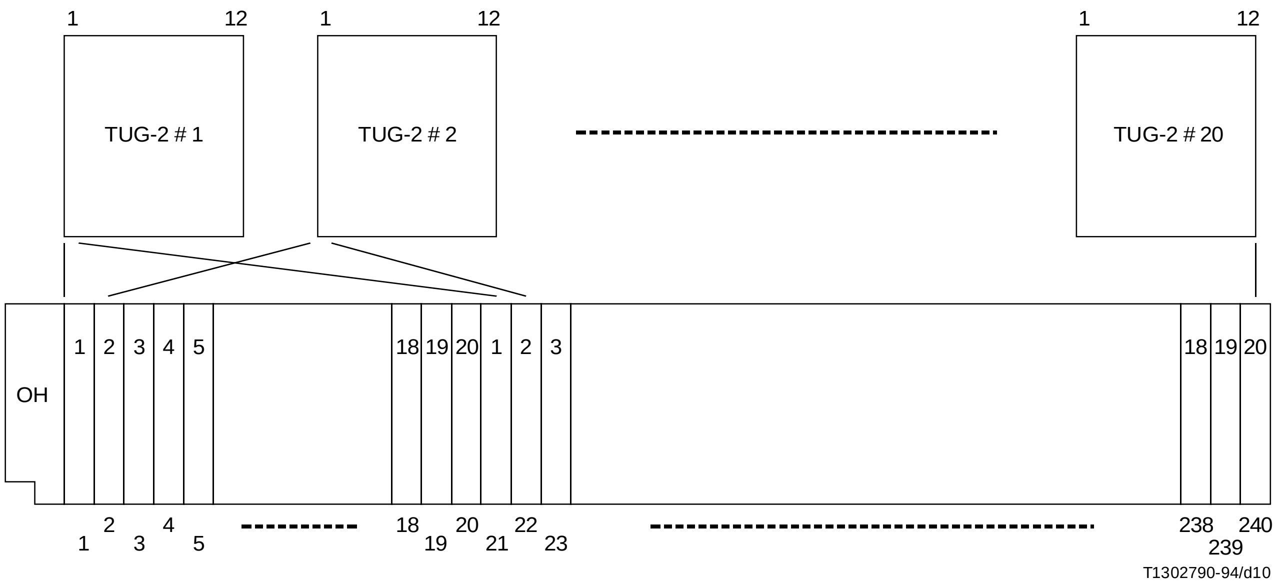


FIGURE 3-5/G.832

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

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 nine rows by 240 columns payload is shown in Figure 3-6.

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 nine rows structure ("C").

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

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

If further interworking flexibility is required, this arrangement could also be further demultiplexed into one TUG-3 and twelve (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 case in 9.1 provides for 20 TUG-2s.

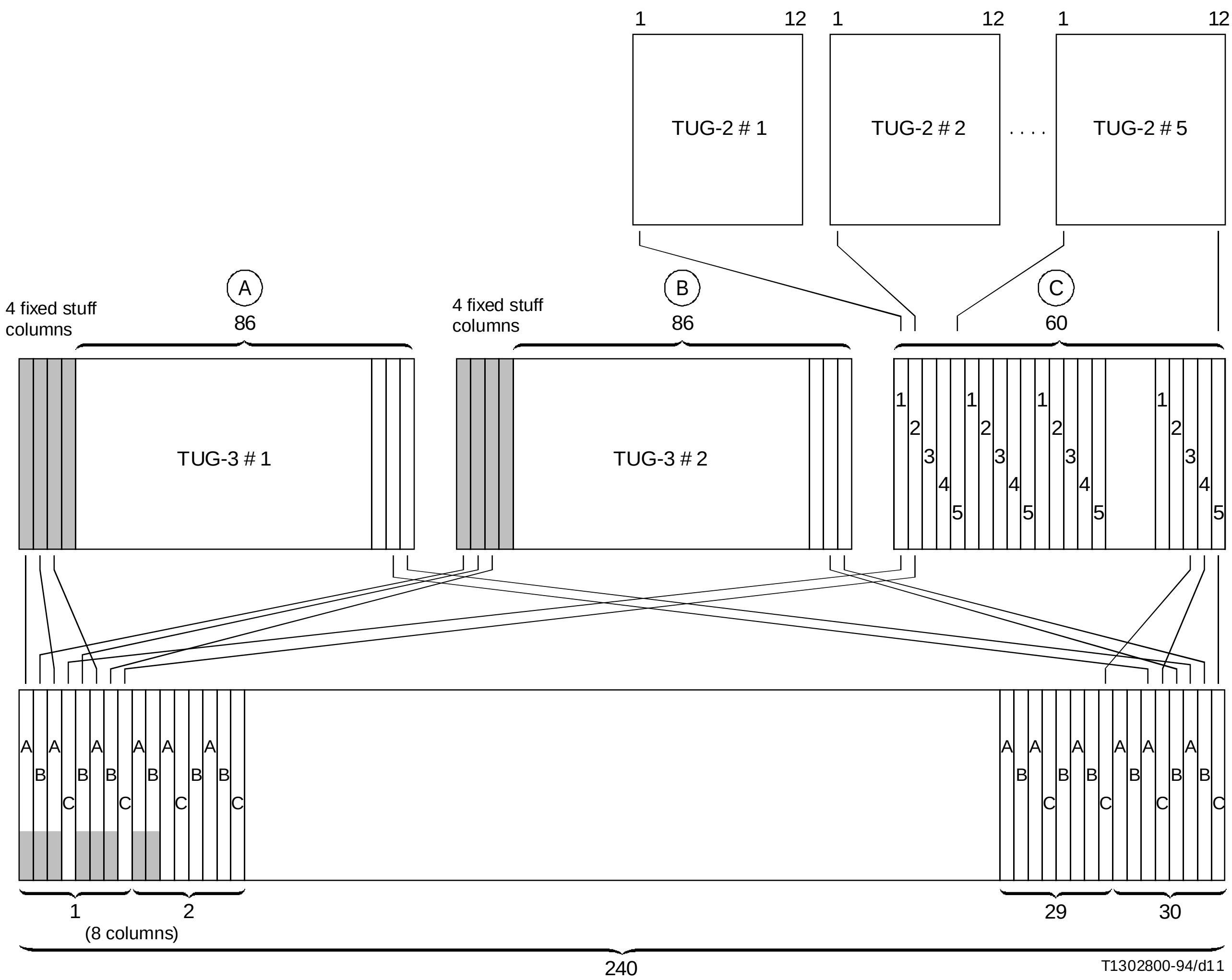


FIGURE 3-6/G.832

Multiplexing of 2 × TUG-3 and 5 × TUG-2 into 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.

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

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

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