INTERNATIONAL TELECOMMUNICATION UNION

CCITT

G.708

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

GENERAL ASPECTS OF DIGITAL TRANSMISSION SYSTEMS;

TERMINAL EQUIPMENTS

NETWORK NODE INTERFACE FOR THE SYNCHRONOUS DIGITAL HIERARCHY

Recommendation G.708

Geneva, 1991

FOREWORD

The CCITT (the International Telegraph and Telephone Consultative Committee) is a permanent organ of the International Telecommunication Union (ITU). CCITT 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 Plenary Assembly of CCITT which meets every four years, establishes the topics for study and approves Recommendations prepared by its Study Groups. The approval of Recommendations by the members of CCITT between Plenary Assemblies is covered by the procedure laid down in CCITT Resolution No. 2 (Melbourne, 1988).

Recommendation G.708 was prepared by Study Group XVIII and was approved under the Resolution No. 2 procedure on the 5th of April 1991.

CCITT NOTES

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

2) A list of abbreviations used in this Recommendation can be found in Annex A.

Recommendation G.708

NETWORK-NODE INTERFACE FOR THE SYNCHRONOUS DIGITAL HIERARCHY

(Melbourne, 1988, revised 1990)

The CCITT,

considering

(a) that network node interface (NNI) specifications are necessary to enable interconnection of synchronous digital hierarchy (SDH) network elements for transport of payloads, including digital signals of the plesiochronous digital hierarchy (PDH) defined in Recommendation G.702;

(b) that Recommendation G.707 describes the advantages offered by a synchronous digital hierarchy and multiplexing method and specifies a set of synchronous digital hierarchy bit rates;

(c) that Recommendation G.709 specifies the multiplexing structure;

(d) that Recommendations G.707, G.708 and G.709 form a coherent set of specifications for the synchronous digital hierarchy and network node interface;

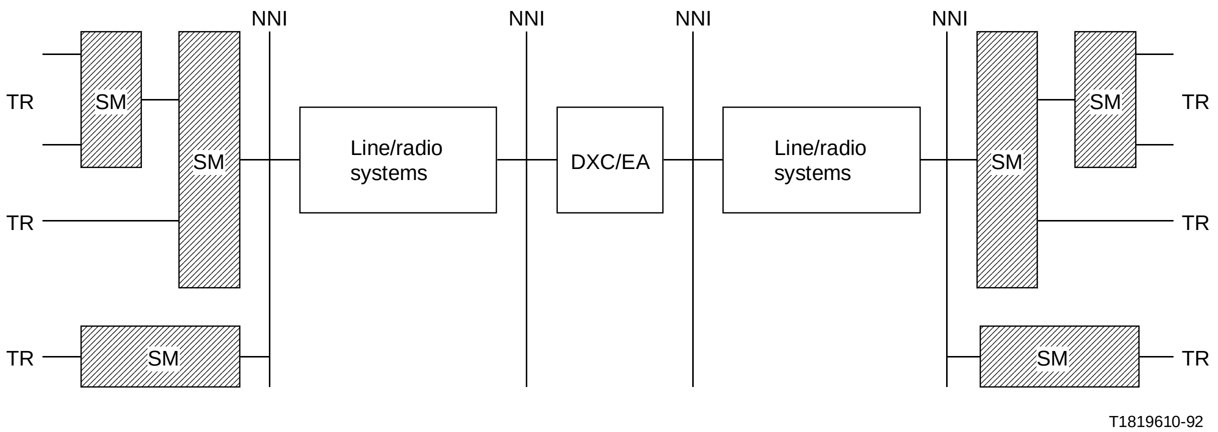
(e) that Recommendation G.802 specifies the interworking between networks based on different plesiochronous digital hierarchies and speech encoding laws,

recommends

that the frame structure for multiplexed digital signals at the NNI of a synchronous digital network including ISDN should be as described in this Recommendation.

1 Location of network-node interface (NNI)

Figure 1-1/G.708 gives a possible network configuration to illustrate the location of NNI specified in this Recommendation.



DXC Digital cross-connect equipment
EA External access equipment
SM Synchronous multiplexer
TR Tributaries

FIGURE 1-1/G.708

Location of the NNI

2 Basic multiplexing principle and multiplexing elements

2.1 *General*

Figure 2-1/G.708 shows the relationship between various multiplexing elements that are defined below, and illustrates possible multiplexing structures.

Figures 2-2/G.708, 2-3/G.708, 2-4/G.708 and 2-5/G.708 are examples of how various signals are multiplexed using these multiplexing elements.

Details of the multiplexing method and mappings are given in Recommendation G.709.

2.2 *Definitions*

2.2.1 **synchronous digital hierarchy (SDH)**

The SDH is a hierarchical set of digital transport structures, standardized for the transport of suitably adapted payloads over physical transmission networks.0

2.2.2 **synchronous transport module (STM)**

An STM is the information structure used to support Section Layer Connections in the SDH. It consists of information payload and section overhead (SOH) information fields organized in a block frame structure which repeats every 125 microseconds. The information is suitably conditioned for serial transmission on the selected media at a rate which is synchronized to the network. A basic STM is defined at 155 520 kbit/s. This is termed STM-1. Higher capacity STMs are formed at rates equivalent to N times multiples of this basic rate. STM capacities for N = 4 and N = 16 are defined; higher values are under consideration.

The STM-1 comprises a single administrative unit group (AUG) together with the SOH.

The STM-N contains N AUGs together with SOH. Values of N corresponding to the SDH levels are given in Recommendation G.707.

2.2.3 **virtual container (VC)**

A VC is the information structure used to support Path Layer Connections in the SDH. It consists of information payload and path overhead (POH) information fields organized in a block frame structure which repeats every 125 or 500 microseconds. Alignment information to identify VC frame start is provided by the server network layer.

Two types of VCs have been identified:

– *Lower order VC: (VC-n (n = 1, 2)*

  This element comprises a single C-*n* (*n* = 1, 2) plus the lower order VC POH appropriate to that level.

– *Higher order VC: VC-n (n = 3, 4)*

  This element comprises either a single C-*n* (*n* = 3, 4) or an assembly of tributary unit groups (TUG-2s or TUG-3s), together with VC POH appropriate to that level.

2.2.4 **administrative unit (AU)**

An AU is the information structure which provides adaptation between the higher order Path Layer and the multiplex Section Layer. It consists of an information payload (the higher order, VC) and an AU pointer which indicates the offset of the payload frame start relative to the multiplex section frame start.

Two AUs are defined. The AU-4 consists of a VC-4 plus an AU pointer which indicates the phase alignment of the VC-4 with respect to the STM-N frame. The AU-3 consists of a VC-3 plus an AU pointer which indicates the phase alignment of the VC-3 with respect to the STM-N frame. In each case, the AU pointer location is fixed with respect to the STM-N frame.

One or more AUs occupying fixed, defined positions in an STM payload is termed an AU group (AUG).

An AUG consists of a homogeneous, byte interleaved, assembly of AU-3s or an AU-4.

2.2.5 **tributary unit (TU)**

A TU is an information structure which provides adaptation between the lower order Path Layer and the higher order Path Layer. It consists of an information payload (the lower order VC) and a TU pointer which indicates the offset of the payload frame start relative to the higher order VC frame start.

The TU-*n* (*n* = 1, 2, 3) consists of a VC-*n* together with a TU pointer.

One or more TUs, occupying fixed, defined positions in a higher order VC payload is termed a tributary unit group (TUG). TUGs are defined in such a way that mixed capacity payloads made up of different size TUs can be constructed to increase flexibility of the transport network.

A TUG-2 consists of a homogeneous assembly of identical TU-1s or a TU-2.

A TUG-3 consists of a homogeneous assembly of TUG-2s or a TU-3.

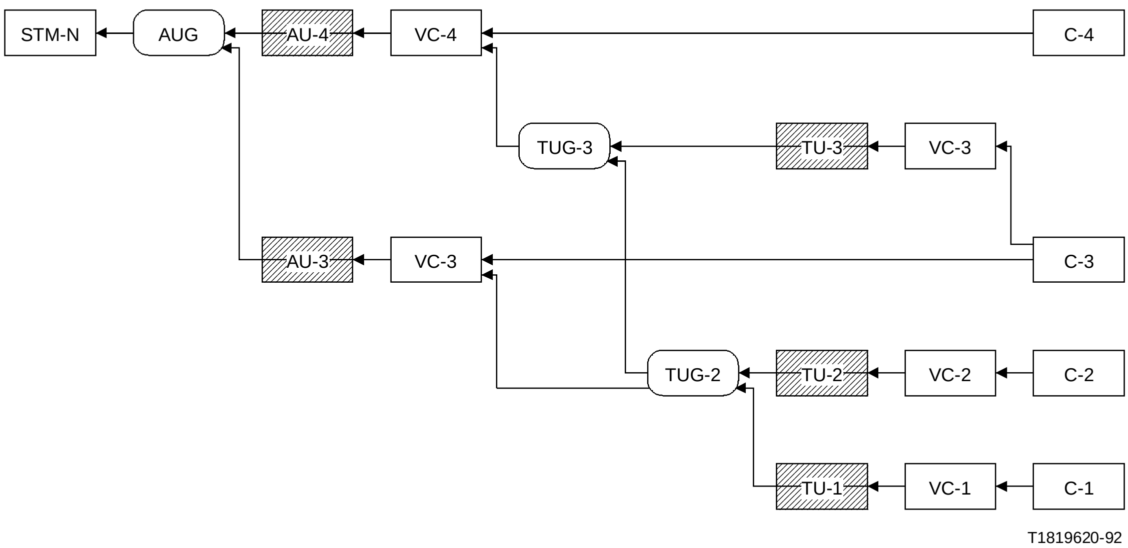
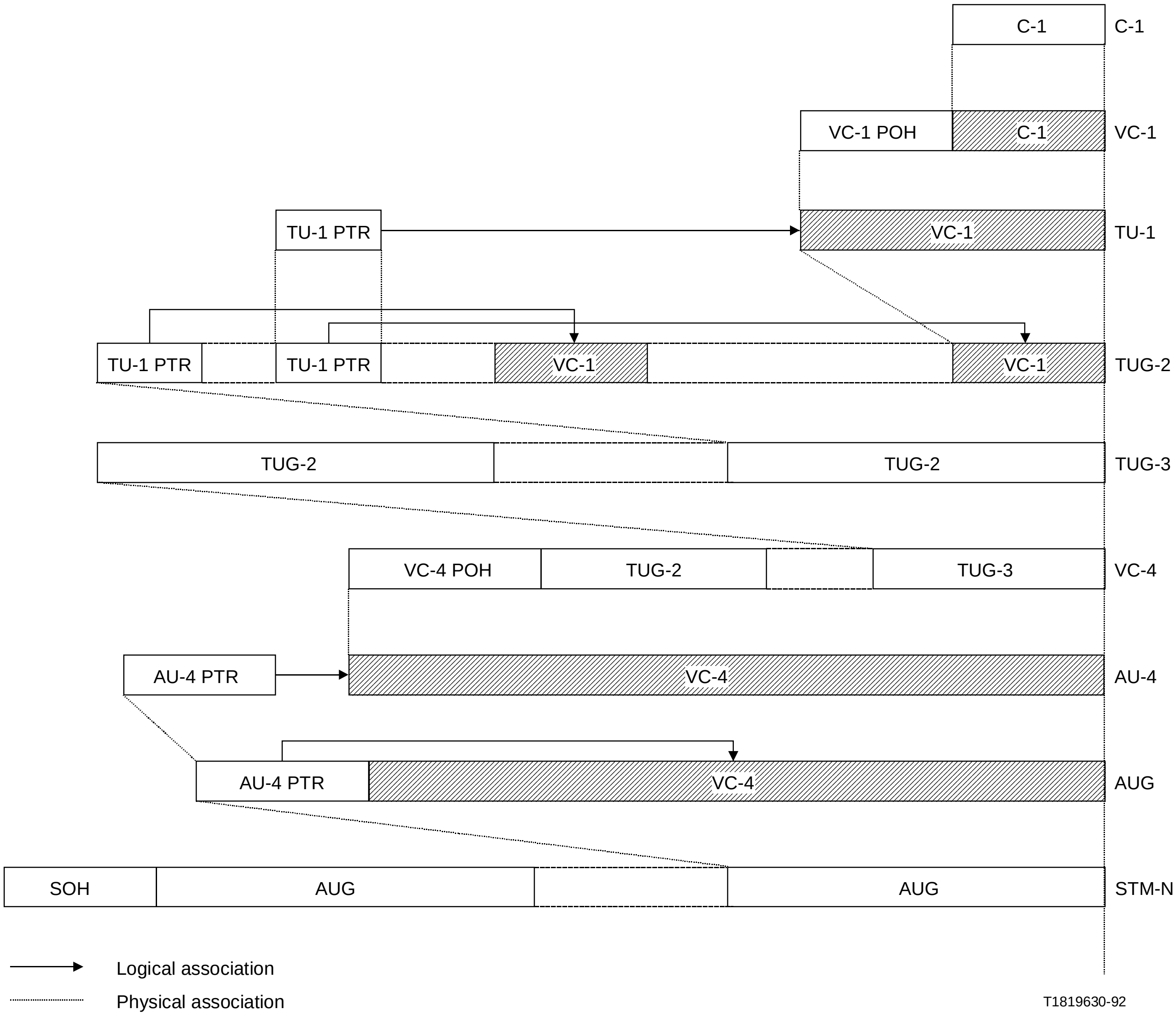


FIGURE 2-1/G.708

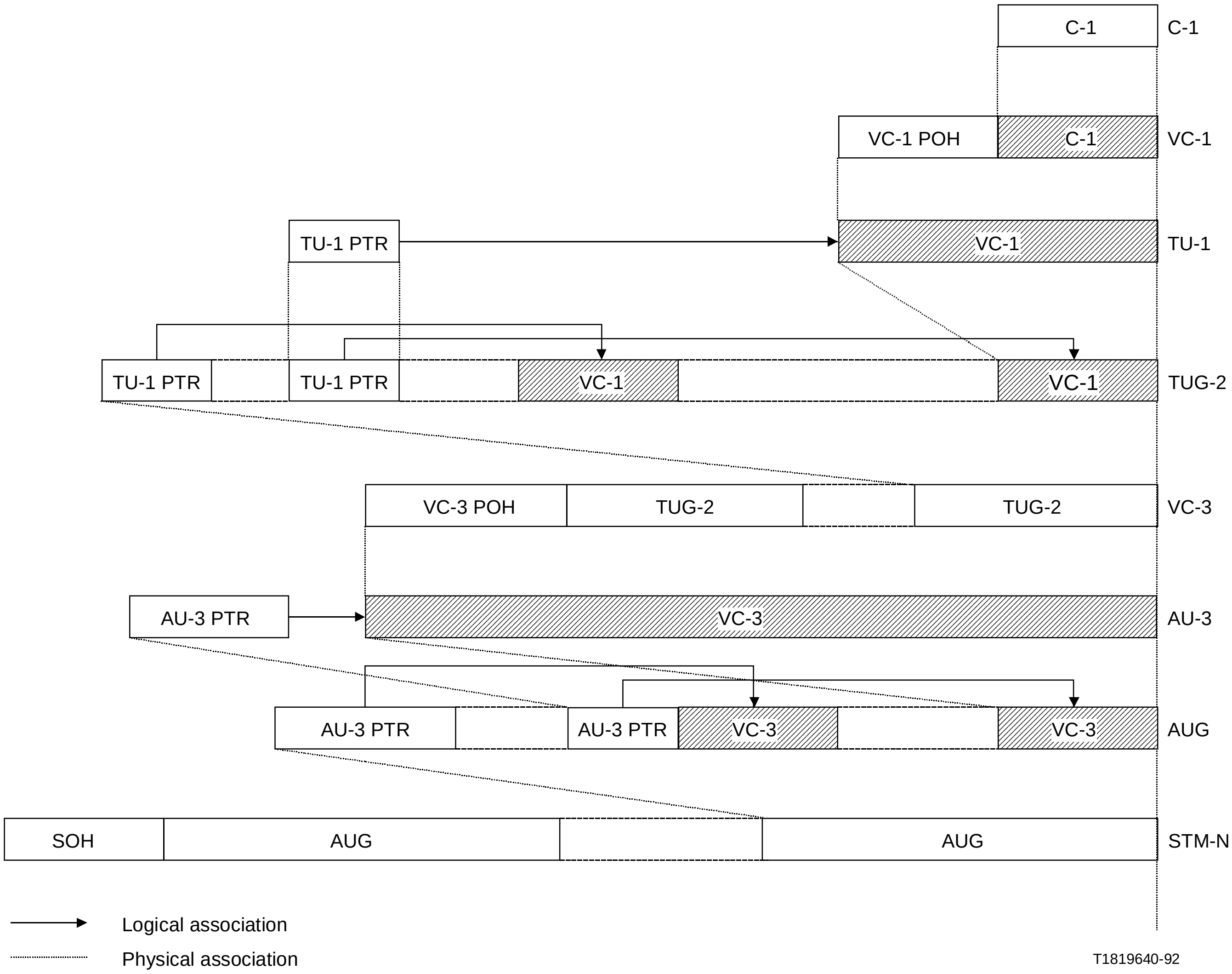
Generalized multiplexing structure



Note – Unshaded areas are phase aligned. Phase alignment between the unshaded and shaded areas is defined by the pointer (PTR) and is indicated by the arrow.

FIGURE 2-2/G.708

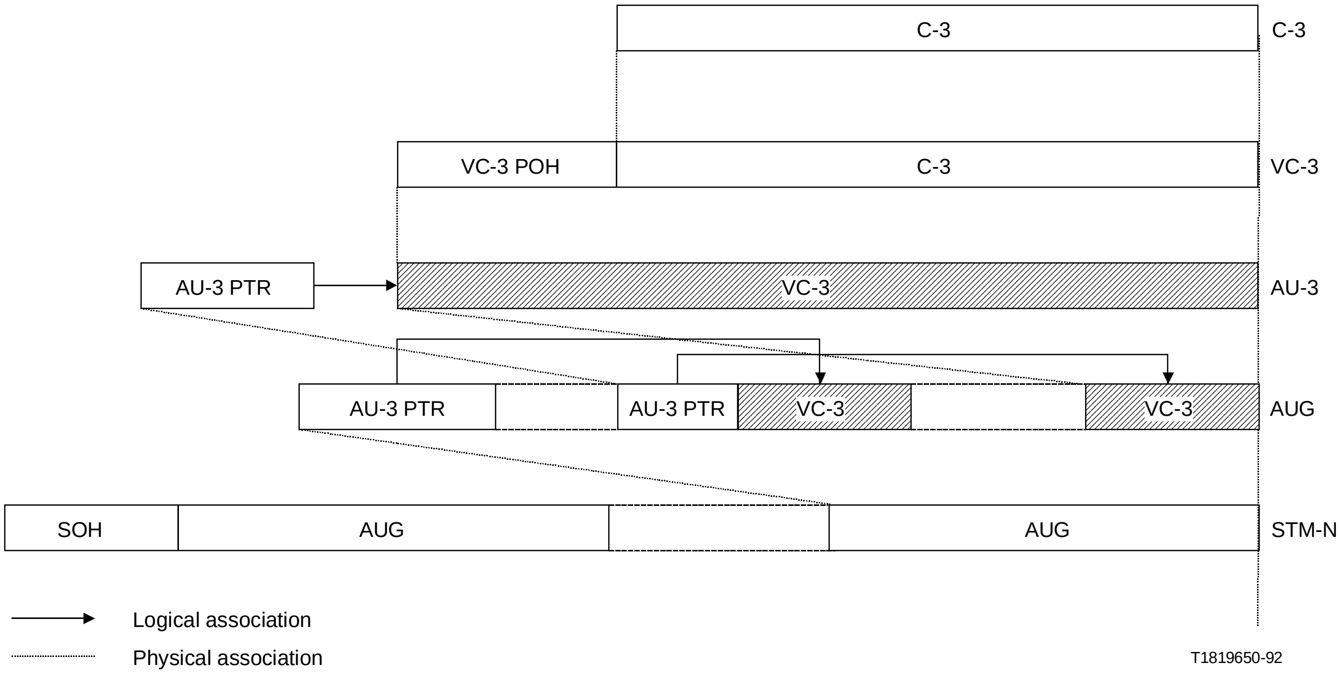
Multiplexing method directly from C-1 using AU-4



Note – Unshaded areas are phase aligned. Phase alignment between the unshaded and shaded areas is defined by the pointer (PTR) and is indicated by the arrow.

FIGURE 2-3/G.708

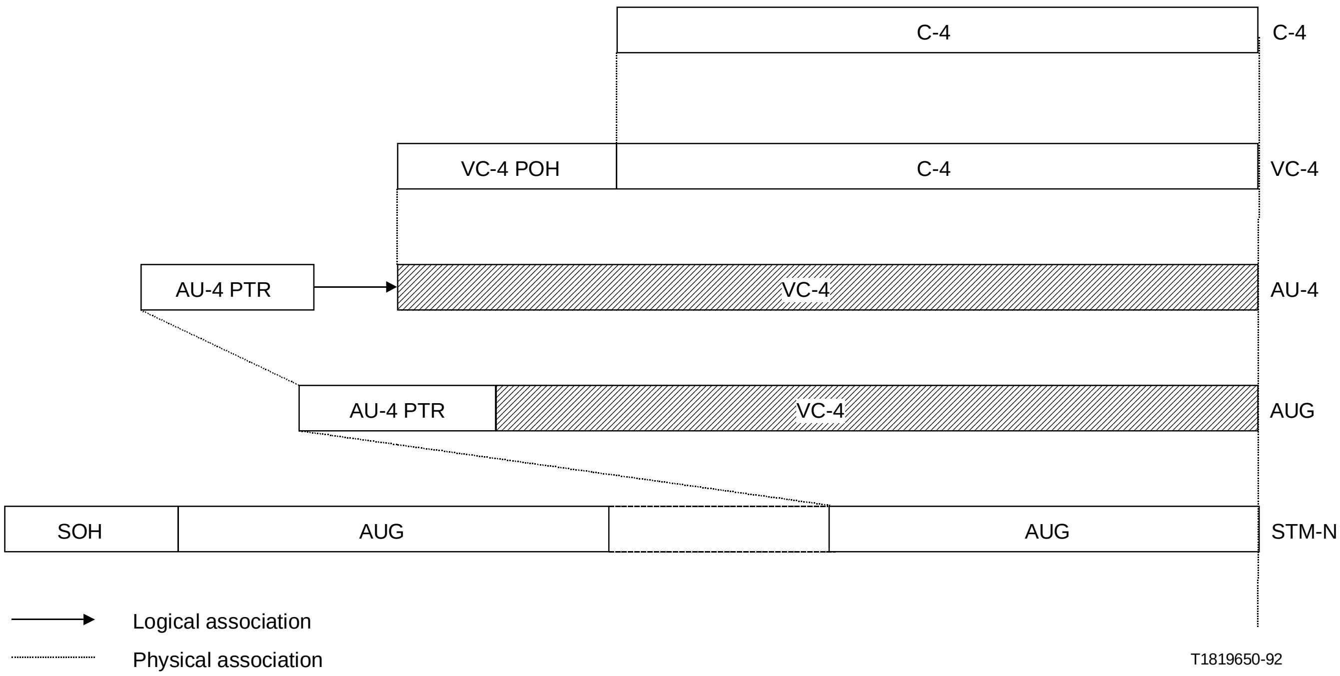
Multiplexing method directly from C-1 using AU-3



Note – Unshaded areas are phase aligned. Phase alignment between the unshaded and shaded areas is defined by the pointer (PTR) and is indicated by the arrow.

FIGURE 2-4/G.708

Multiplexing method directly from C-3 using AU-3



Note – Unshaded areas are phase aligned. Phase alignment between the unshaded and shaded areas is defined by the pointer (PTR) and is indicated by the arrow.

FIGURE 2-5/G.708

Multiplexing method directly from C-4 using AU-4

2.2.6 **container: C-*n* (*n* = 1-4)**

A container is the information structure which forms the network synchronous information payload for a VC. For each of the defined VCs there is a corresponding container. Adaptation functions have been defined for many common network rates into a limited number of standard containers. These include those rates already defined in Recommendation G.702. Further adaptation functions will be defined in the future for new broadband rates.

2.2.7 **network-node interface (NNI)**

The interface at a network node which is used to interconnect with another network node.

Note – The above definition is a working definition only; the precise definition is for further study.

2.2.8 **pointer**

An indicator whose value defines the frame offset of a virtual container with respect to the frame reference of the transport entity on which it is supported.

2.2.9 **concatenation**

A procedure whereby a multiplicity of virtual containers is associated one with another with the result that their combined capacity can be used as a single container across which bit sequence integrity is maintained.

2.2.10 **mapping synchronous digital hierarchy**

A procedure by which tributaries are adapted into virtual containers at the boundary of a SDH network.

2.2.11 **multiplexing synchronous digital hierarchy**

A procedure by which multiple lower order Path Layer Signals are adapted into a higher order path or the multiple high order Path Layer Signals are adapted into a multiplex section.

2.2.12 **aligning synchronous digital hierarchy**

A procedure by which the frame offset information is incorporated into the tributary unit (or the administrative unit) when adapting to the frame reference of the supporting layer.

3 Frame structure

3.1 *Basic frame structure*

STM-N frame structure is shown in Figure 3-1/G.708. The three main areas of the STM-N frame are indicated:

– SOH;

– AU pointers;

– information payload.

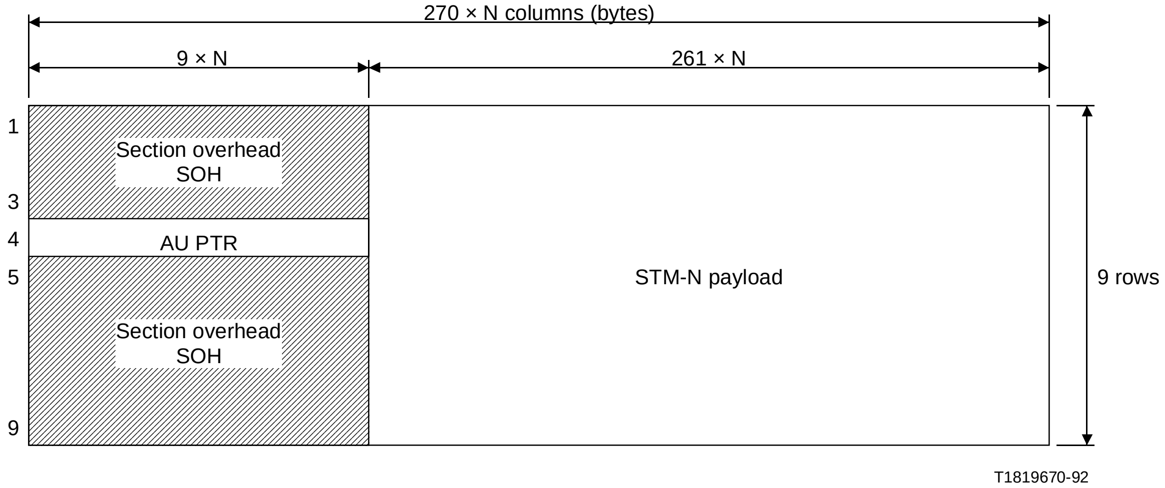


FIGURE 3-1/G.708

STM-N frame structure

3.2 *Section overhead*

Rows 1-3 and 5-9 of columns 1 to 9 × N of the STM-N in Figure 3-1/G.708 are dedicated to the SOH.

The allocation of SOH capacity and an explanation of the overhead functions are given in § 5.

3.3 *Administrative unit pointers*

Row 4, of columns 1 to 9 × N in Figure 3-1/G.708, is available for AU pointers. The application of pointers and their detailed specifications are given in Recommendation G.709.

3.4 *Administrative units in the STM-N*

The STM-N payload can support N AUGs where each AUG may consist of:

– one AU-4, or

– three AU-3s.

The VC-*n* associated with each AU-*n* does not have a fixed phase with respect to the STM-N frame. The location of the first byte of the VC-*n* is indicated by the AU-*n* pointer. The AU-*n* pointer is in a fixed location in the STM-N frame. Examples are illustrated in Figures 2-2/G.708, 2-3/G.708, 2-4/G.708, 2-5/G.708, 3-1/G.708, 3-2/G.708 and 3-3/G.708.

The AU-4 may be used to carry, via the VC-4, a number of TU-*n*s (*n* = 1, 2, 3) forming a two stage multiplex. An example of this agreement is illustrated in Figures 2-2/G.708 and 3-3a/G.708. The VC-*n* associated with each TU-*n* does not have a fixed phase relationship with respect to the start of the VC-4. The TU-*n* pointer is in a fixed location in the VC-4 and the location of the first byte of the VC-*n* is indicated by the TU-*n* pointer.

The AU-3 may be used to carry, via the VC-3, a number of TU-*n*s (*n* = 1, 2) forming a two stage multiplex. An example of this arrangement is illustrated in Figures 2-3/G.708 and 3-3b/G.708. The VC-*n* associated with each TU-*n* does not have a fixed phase relationship with respect to the start of the VC-3. The TU-*n* pointer is in a fixed location in the VC-3 and the location of the first byte of the VC-*n* is indicated by the TU-*n* pointer.

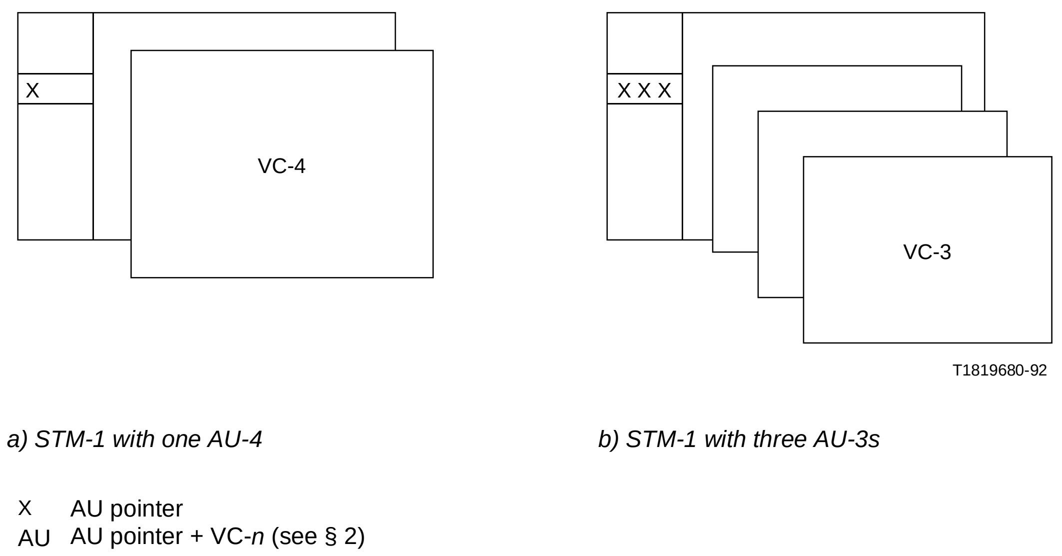
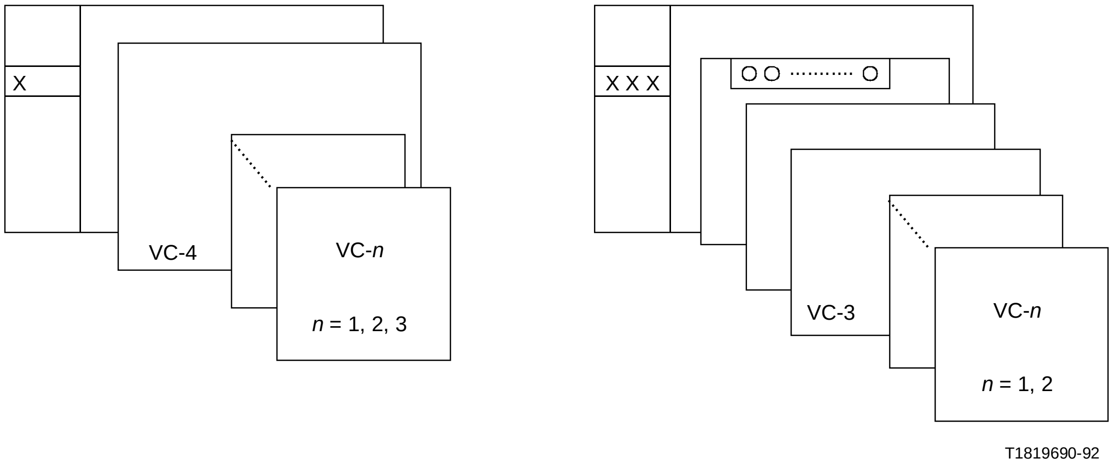


FIGURE 3-2/G.708

Administrative units in STM-1 frame



a) STM-1 with one AU-4 containing TUs *b) STM-1 with three AU-3s containing TUs*

X AU pointer
O TU pointer
AU AU pointer + VC-*n* (see § 2)
TU TU pointer + VC-*n* (see § 2)

FIGURE 3-3/G.708

Two stage multiplex

4 Interconnection of STM-Ns

The SDH is designed to be universal, allowing transport of a large variety of signals including all those specified in Recommendation G.702. However, different structures can be used for the transport of VCs. The following interconnection rules will be used:

a) The rule for interconnecting two AUGs based upon two different types of AU, namely AU-4 and AU-3, will be to use the AU-4 structure. Therefore, the AUG based upon AU-3 will be demultiplexed to the TUG-2 or VC-3 level according to the type of the payload, and remultiplexed within an AUG via the TUG-3/VC-4/AU-4 route.

b) The rule for interconnecting VC-11s transported via different types of TU, namely TU-11 and TU-12, will be to use the TU-11 structure. VC-11, TU-11 and TU-12 are described in Recommendation G.709.

This SDH interconnection rule does not modify the interworking rules defined in Recommendation G.802 for networks based upon different plesiochronous digital hierarchies and speech encoding laws.

Note – The need for specifying rules for interconnection between networks using different types of concatenation (see Recommendation G.709, § 3.3.7) is for further study.

5 Overhead functions

5.1 *Types of overhead*

Several types of overhead have been identified for application in the SDH.

5.1.1 *Section overhead (SOH)*

SOH information is added to the information payload to create an STM-N. It includes block framing information and information for maintenance, performance monitoring and other operational functions. The SOH information is further classified into regenerator section overhead (RSOH) which is terminated at regenerator functions and multiplex section overhead (MSOH) which passes transparently through regenerators and is terminated where the AUGs are assembled and disassembled.

The rows 1 to 3 of the SOH are designated as RSOH while rows 5 to 9 are designated to be MSOH. This is illustrated in Figure 5-2/G.708 for the case of STM-1.

5.1.2 *Virtual container path overhead VC (POH)*

VC POH provides for integrity of communication between the point of assembly of a VC and its point of disassembly. Two categories of VC POH have been identified:

– *Lower order VC POH (VC-1/VC-2 POH)*

  Lower order VC POH is added to the container (C-1/C-2) when the VC-1/VC-2 is created. Among the functions included in this overhead are VC path performance monitoring, signals for maintenance purposes and alarm status indications.

– *Higher order VC POH (VC-3/VC-4 POH)*

  VC-3 POH is added to either an assembly of TUG-2s or a C-3 to form a VC-3. VC-4 POH is added to either an assembly of TUG-3s or a C-4 to form a VC-4. Amongst the functions included within this overhead are VC path performance monitoring, alarm status indications, signals for maintenance purposes and multiplex structure indications (VC-3/VC-4 composition). POH descriptions are contained in Recommendation G.709.

5.2 *SOH descriptions*

5.2.1 *SOH bytes location*

The location of SOH bytes within an STM-N frame is identified by a three coordinate vector S (a, b, c) where a (1 to 3, 5 to 9) represents the row number, b (1 to 9) represents a multi-column number and c (1 to N) represents the depth of the interleaved within the multi-column. This is illustrated in Figure 5-1/G.708.

For example, the K1 byte in an STM-1 is located at S (5, 4, 1).

The assignment of the various SOH bytes in the STM-1/4/16 frames is illustrated in Figures 5-2/G.708, 5-3/G.708, 5-4/G.708.

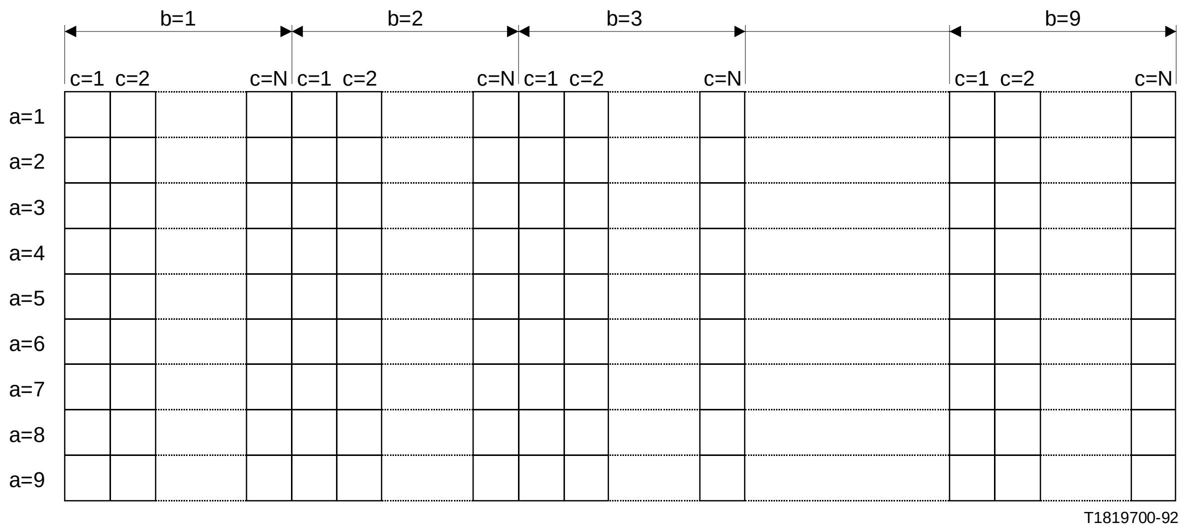
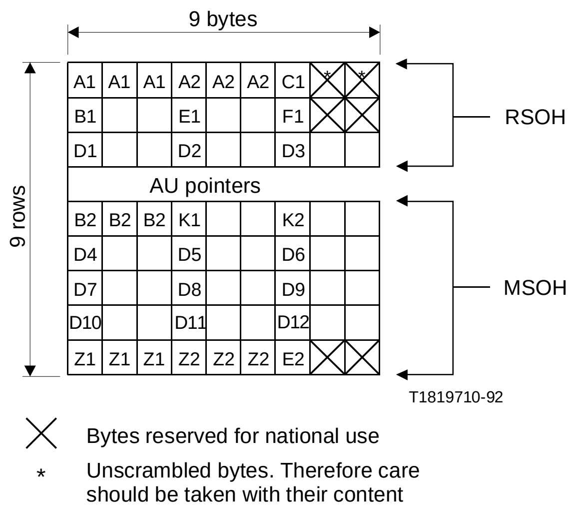


FIGURE 5-1/G.708

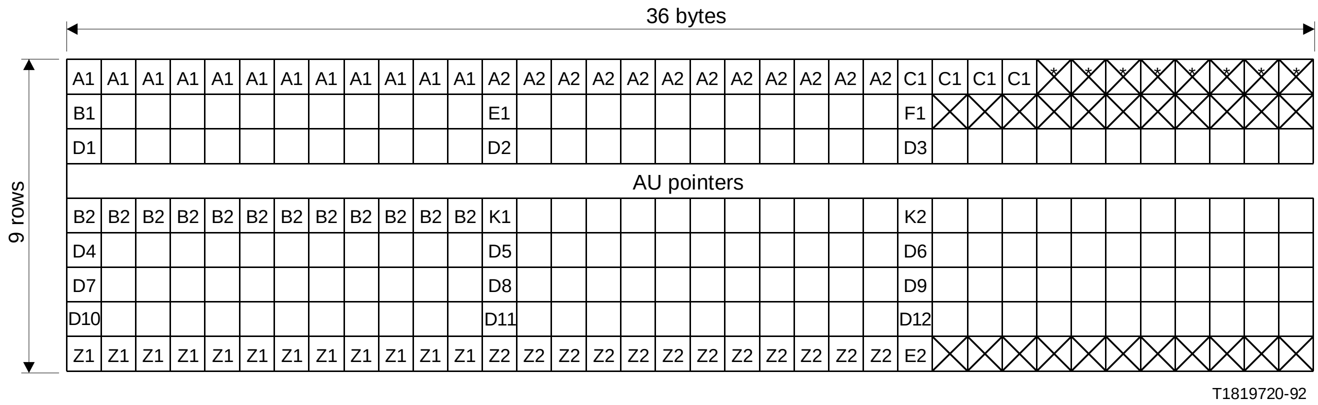
Numbering of SOH byte locations



Note – All unmarked bytes are reserved for future international standardization (for media dependent, additional national use and other purposes).

FIGURE 5-2/G.708

STM-1 SOH



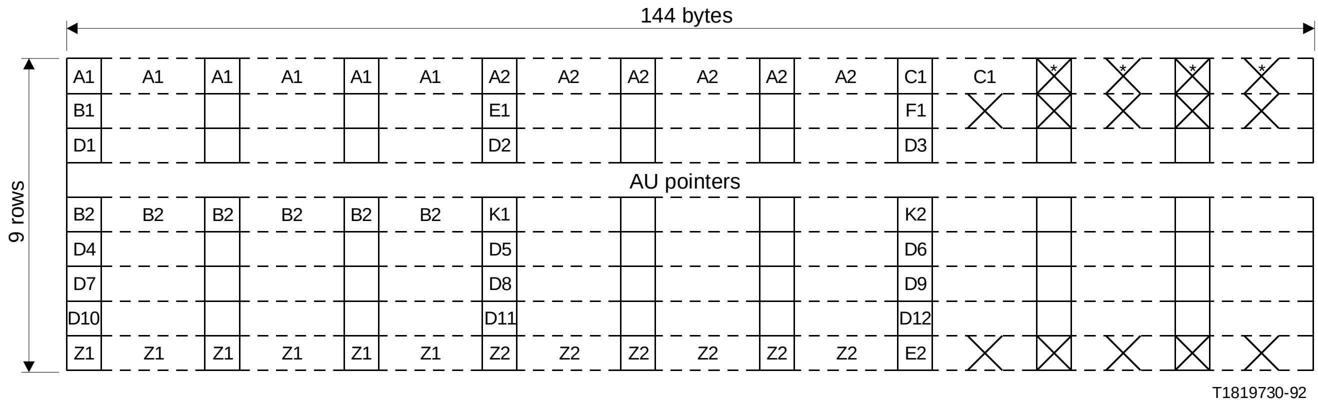
Bytes reserved for national use

* Unscrambled bytes. Therefore care should be taken with their content

Note – All unmarked bytes are reserved for future international standardization (for media dependent, additional national use and other purposes).

FIGURE 5-3/G.708

STM-4 SOH



Bytes reserved for national use

* Unscrambled bytes. Therefore care should be taken with their content

Note – All unmarked bytes are reserved for future international standardization (for media dependent, additional national use and other purposes).

FIGURE 5-4/G.708

STM-16 SOH

5.2.2 *SOH bytes description*

5.2.2.1 *Framing: A1, A2*

Two types of bytes are defined for framing:

A1: 11110110

A2: 00101000

5.2.2.2 *STM identifier: C1*

This is a unique identifier indicating the binary value of the multi-column, interleave depth coordinate, c. It may be used to assist in frame alignment.

5.2.2.3 *Data communication channel (DCC): D1-D12*

A 192 kbit/s channel is defined using bytes D1, D2, D3 as a regenerator section DCC.

A 576 kbit/s channel is defined using bytes D4 to D12 as multiplex section DCC.

5.2.2.4 *Orderwire: E1, E2*

These two bytes may be used to provide orderwire channels for voice communication. E1 is part of the RSOH and may be accessed at regenerators. E2 is part of the MSOH and may be accessed at multiplex section terminations.

5.2.2.5 *User channel: F1*

This byte is reserved for user purposes (for example network operators).

5.2.2.6 *BIP-8: B1*

One byte is allocated for regenerator section error monitoring. This function shall be a bit interleaved parity 8 (BIP-8) code using even parity. The BIP-8 is computed over all bits of the previous STM-N frame after scrambling and is placed in byte B1 before scrambling. (For details of the scrambling process see Recommendation G.709.)

Note – Bit interleaved parity-X (BIP-X) code is defined as a method of error monitoring. With even parity an X-bit code is generated by the transmitting equipment over a specified portion of the signal in such a manner that the first bit of the code provides even parity over the first bit of all X-bit sequences in the covered portion of the signal, the second bit provides even parity over the second bit of all X-bit sequences within the specified portion, etc. Even parity is generated by setting the BIP-X bits so that there is an even number of 1s in each of all monitored partitions of the signal including the BIP-X (a monitor partition of the signal is built by all bits which are in the same bit position within the X-bit sequences in the covered portion of the signal).

5.2.2.7 *BIP-N × 24: B2*

The B2 bytes are allocated for a multiplex section error monitoring function. This function shall be a bit interleaved parity N × 24 code (BIP-N × 24) using even parity. The BIP-N × 24 is computed over all bits of the previous STM-N frame except for the first three rows of SOH and is placed in bytes B2 before scrambling.

5.2.2.8 **automatic protection switching (APS)** *channel: K1, K2*

Two bytes are allocated for APS signalling.

5.2.2.9 *Spare: Z1, Z2*

These bytes are allocated for functions not yet defined.

6 Physical specification of the NNI

Specification for physical electrical characteristics of the NNI are contained in Recommendation G.703.

Specification for physical optical characteristics of the NNI are contained in Recommendation G.957.

ANNEX A

(to Recommendation G.708)

Alphabetical list of abbreviations used in this Recommendation

APS	Automatic protection switching
AU	Administrative unit
AUG	Administrative unit group
BIP-8	Bit interleaved parity 8
BIP-X	Bit interleaved parity-X
C	Container
DCC	Data communication channel
DXC	Digital cross-connect equipment
EA	External access equipment
MSOH	Multiplex section overhead
NNI	Network-node interface
POH	Path overhead
PTR	Pointer
RSOH	Regenerator section overhead
SDH	Synchronous digital hierarchy
SM	Synchronous multiplexer
SOH	Section overhead
STM	Synchronous transport module
TR	Tributary
TU	Tributary unit
TUG	Tributary unit group
VC	Virtual container

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