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GENERAL ASPECTS OF DIGITAL TRANSMISSION SYSTEMS; TERMINAL EQUIPMENTS

CHARACTERISTICS OF SYNCHRONOUS DIGITAL HIERARCHY (SDH) EQUIPMENT FUNCTIONAL BLOCKS

ITU-T Recommendation G.783

(Previously "CCITT Recommendation")

FOREWORD

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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.783 was revised by ITU-T Study Group 15 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 20th of January 1994.

NOTE

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

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Recommendation G.783

CHARACTERISTICS OF SYNCHRONOUS DIGITAL HIERARCHY (SDH) EQUIPMENT FUNCTIONAL BLOCKS

(revised 1994)

1 General

This Recommendation defines the interfaces and functions to be supported by the SDH equipment defined in Recommendation G.782. The description is generic and no particular physical partitioning of functions is implied. The input/output information flows associated with the functional blocks serve for defining the functions of the blocks and are considered to be conceptual, not physical.

1.1 Abbreviations

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

AIS	Alarm Indication Signal
ALS	Automatic Laser Shutdown
APS	Automatic Protection Switching
AU	Administrative Unit
AUG	Administrative Unit Group
BER	Bit Error Ratio
BIP	Bit Interleaved Parity
CM	Connection Matrix
CMISE	Common Management Information Service Element
DCC	Data Communications Channel
EOW	Engineering Order-Wire
ES	Errored Second
FAL	Frame Alignment Loss
FEBE	Far End Block Error
FERF	Far End Receive Failure
HCS	Higher order Connection Supervision
HOA	Higher Order Assembler
HOI	Higher Order Interface
HP	Higher order Path
HPA	Higher order Path Adaptation
HPC	Higher order Path Connection
HPOM	Higher order Path Overhead Monitor
HPT	Higher order Path Termination
HUG	Higher order path Unequipped Generator
LCS	Lower order Connection Supervision
LOF	Loss Of Frame
LOI	Lower Order Interface
LOM	Loss Of Multiframe
LOP	Loss Of Pointer

LOS	Loss Of Signal
LP	Lower order Path
LPA	Lower order Path Adaptation
LPC	Lower order Path Connection
LPOM	Lower order Path Overhead Monitor
LPT	Lower order Path Termination
LTI	Loss of all Incoming Timing references
LUG	Lower order path Unequipped Generator
MCF	Message Communications Function
MRTIE	Maximum Relative Time Interval Error
MS	Multiplex Section
MSA	Multiplex Section Adaptation
MSOH	Multiplex Section OverHead
MSP	Multiplex Section Protection
MST	Multiplex Section Termination
MTIE	Maximum Time Interval Error
NDF	New Data Flag
NE	Network Element
NEF	Network Element Function
NNI	Network Node Interface
NU	National Use
OFS	Out-of-Frame Second
OHA	OverHead Access
OOF	Out Of Frame
PDH	Plesiochronous Digital Hierarchy
PPI	PDH Physical Interface
PJE	Pointer Justification Event
POH	Path OverHead
PSE	Protection Switch Event
RS	Regenerator Section
RSOH	Regenerator Section OverHead
RST	Regenerator Section Termination
SD	Signal Degrade
SDH	Synchronous Digital Hierarchy
SDXC	Synchronous Digital hierarchy Cross-Connect
SEMF	Synchronous Equipment Management Function
SES	Severely Errored Second
SETG	Synchronous Equipment Timing Generator
SETPI	Synchronous Equipment Timing Physical Interface
SETS	Synchronous Equipment Timing Source
SF	Signal Fail
SLM	Signal Label Mismatch
SPI	SDH Physical Interface

STM	Synchronous Transport Module
TIM	Trace Identifier Mismatch
TMN	Telecommunications Management Network
TU	Tributary Unit
UNEQ	UnEquipped
VC	Virtual Container

1.2 Definitions

NOTE – The following definitions are relevant in the context of SDH-related Recommendations.

1.2.1 Automatic laser shutdown (ALS)

See Recommendation G.958.

1.2.2 automatic protection switching (APS): Autonomous switching of a signal between and including two MST functions, from a failed working channel to a protection channel and subsequent restoration using control signals carried by the K-bytes in the MSOH.

1.2.3 Administrative unit (AU)

See Recommendation G.708.

1.2.4 Administrative unit group (AUG)

See Recommendation G.708.

1.2.5 Bit interleaved party (BIP)

See Recommendation G.708.

1.2.6 connection matrix (CM): **A** connection matrix is a matrix of appropriate dimensions which describes the connection pattern for assigning VC-*n*s on one side of an LPC or HPC function to VC-*n* capacities on the other side and vice versa.

1.2.7 Common management information service element (CMISE)

See ITU-T Rec. X.710 and ISO/IEC 9595.

1.2.8 Data communications channel (DCC)

See Recommendation G.784.

1.2.9 desynchronizer: The desynchronizer function smoothes out the timing gaps resulting from decoded pointer adjustments and VC payload de-mapping in the time domain.

1.2.10 Frame alignment loss (FAL)

See Recommendation G.706.

1.2.11 Far end block error (FEBE)

See Recommendation G.709.

1.2.12 Far end receive failure (FERF)

See Recommendation G.709.

1.2.13 loss of frame (LOF): An LOF state of an STM-N signal is considered to have occurred when an OOF state persists for a defined period of time.

1.2.14 loss of pointer (LOP): The LOP state is one resulting from a defined number of consecutive occurrences of certain conditions which are deemed to have caused the value of the pointer to be unknown.

1.2.15 loss of signal (LOS): The LOS state is considered to have occurred when the amplitude of the relevant signal has dropped below prescribed limits for a prescribed period.

1.2.16 multiplex section (MS): A multiplex section is the part of a line system between and including two multiplex section terminations.

1.2.17 multiplex section alarm indication signal (MS-AIS): MS-AIS is an STM-N signal that contains a valid RSOH and an all-ones pattern for the remainder of the signal.

1.2.18 Multiplex section far end receive failure (MS-FERF)

See Recommendation G.709.

1.2.19 multiplex section overhead (MSOH): The MSOH comprises rows 5 to 9 of the SOH of the STM-N signal.

1.2.20 Network element function (NEF)

See Recommendation G.784.

1.2.21 Network node interface (NNI)

See Recommendation G.708.

1.2.22 out-of-frame second (OFS): An OFS is a second in which one or more out of frame events have occurred.

1.2.23 overhead access (OHA): The OHA function provides access to transmission overhead functions.

1.2.24 out of frame (OOF): The OOF state of an STM-N signal is one in which the position of the frame alignment bytes in the incoming bit stream is unknown.

1.2.25 pointer justification event (PJE): A PJE is an inversion of the I- or D-bits of the pointer, together with an increment or decrement of the pointer value to signify a frequency justification opportunity.

1.2.26 Path overhead (POH)

See Recommendation G.708.

1.2.27 regenerator section (RS): A regenerator section is the part of a line system between and including two regenerator section terminations.

1.2.28 regenerator section overhead (RSOH): The RSOH comprises rows 1 to 3 of the SOH of the STM-N signal.

1.2.29 signal degrade (SD): An SD condition is one in which a signal has been degraded beyond prescribed limits.

1.2.30 Synchronous transport module (STM)

See Recommendation G.708.

1.2.31 Telecommunications management network (TMN)

See Recommendation M.3010.

1.2.32 Tributary unit (TU-*m*)

See Recommendation G.708.

1.2.33 Virtual container (VC-*n*)

See Recommendation G.708.

2 Basic functions

Figure 2-1 is a generalized logical block diagram showing basic and compound functions which may be combined to describe SDH equipment. It illustrates the steps that are required to assemble various payloads and multiplex them into an STM-N output. It does not represent a useful or practical network function. The functional description of each of these functions is based on this figure.

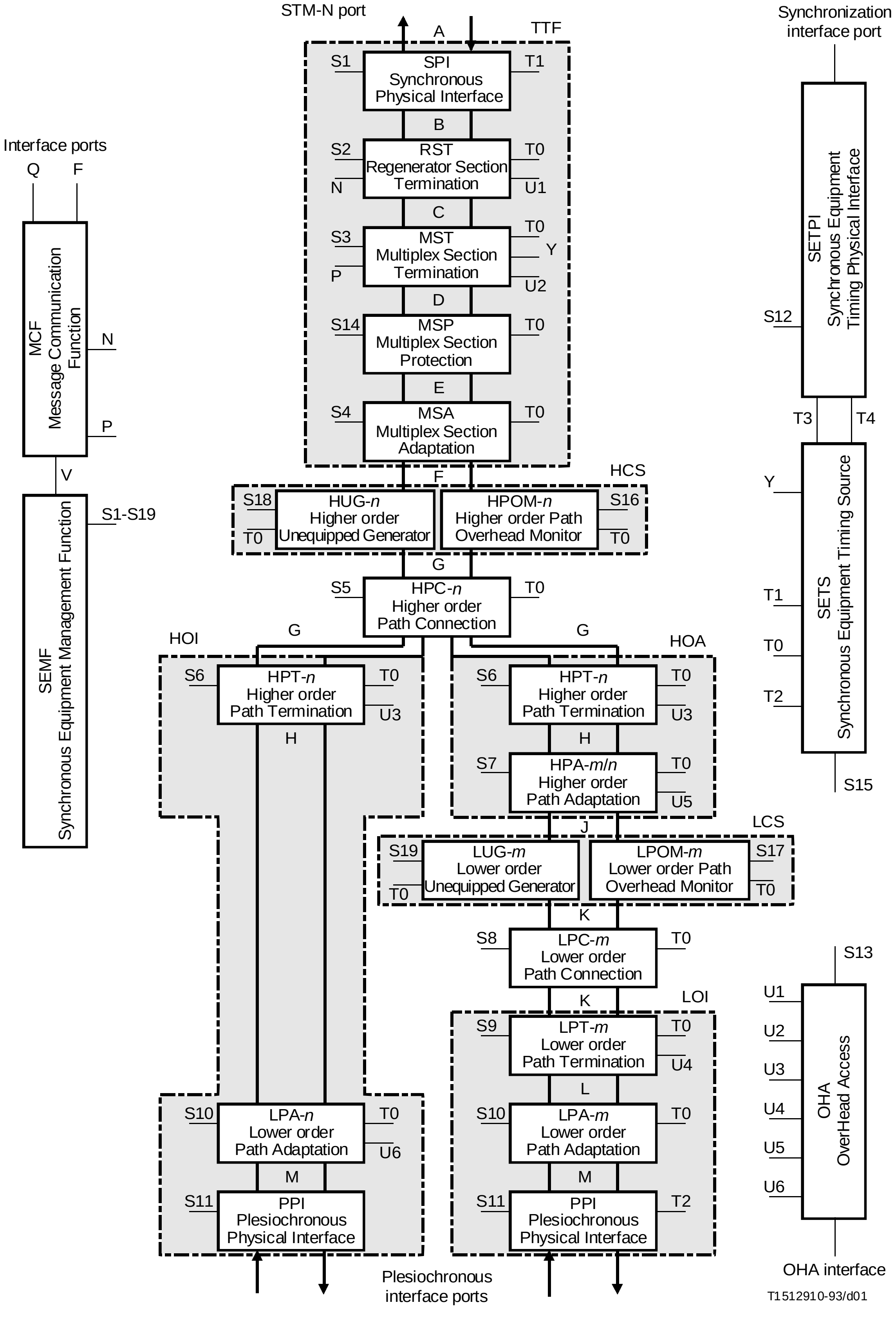


FIGURE 2-1/G.783

General functional block diagram

2.1 SDH physical interface function (SPI)

The SPI function provides the interface between the physical transmission medium at reference point A and the RST function at reference point B. The interface signal at A shall be one of those specified in Recommendation G.707. The physical characteristics of the interface signals are specified in Recommendation G.957 for optical media and Recommendation G.703 for electrical media. The information flows associated with the SPI function are described with reference to Figure 2-2.

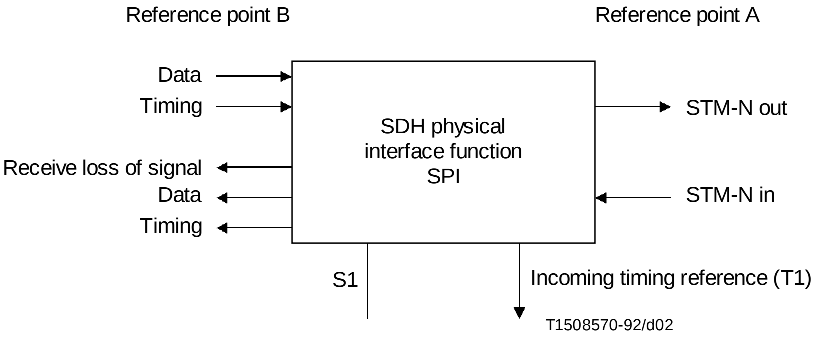


FIGURE 2-2/G.783

SDH physical interface function

2.1.1 Signal flow from B to A

Data at B is fully formatted STM-N data as specified in Recommendations G.707, G.708 and G.709. Data is presented together with associated timing at B by the RST function. The SPI function conditions the data for transmission over a particular medium and presents it at A.

Parameters relating to the physical status of the interface such as transmit fail or transmit degraded (e.g. optical output level, laser bias current, other media-specific indicators) shall be reported at S1. For optical systems, these parameters are specified in Recommendation G.958. For radio systems, these parameters are specified in ITU-R Recommendation S.1108. For other media, these parameters are for further study.

2.1.2 Signal flow from A to B

The STM-N signal at A is a similarly formatted and conditioned signal (as described in 2.1.1) which is degraded within specific limits by transmission over the physical medium. The SPI function regenerates this signal to form data and associated timing at B. The recovered timing is also made available at reference point T1 to the synchronous equipment timing source for the purpose of synchronizing the synchronous equipment reference clock if selected.

If the STM-N signal at A fails, then the receive LOS condition is generated and passed to reference point S1 and to the RST function at B. The criteria for LOS are defined in Recommendation G.958 for optical interfaces. LOS for electrical interfaces is for further study.

2.2 Regenerator section termination function (RST)

The RST function acts as a source and sink for the regenerator section overhead (RSOH). A regenerator section is a maintenance entity between and including two RST functions. The information flows associated with the RST function are described with reference to Figure 2-3.

NOTES

1 In regenerators, the A1, A2 and C1 bytes may be relayed (i.e. passed transparently through the regenerator) instead of being terminated and generated as described below. Refer to Recommendation G.958.

2 This Recommendation is intended for the general case of an inter-station interface. A reduced functionality requirement for an intra-station interface is for further study.

3 RS trace is for further study. When it is defined, it will be processed by the RST function.

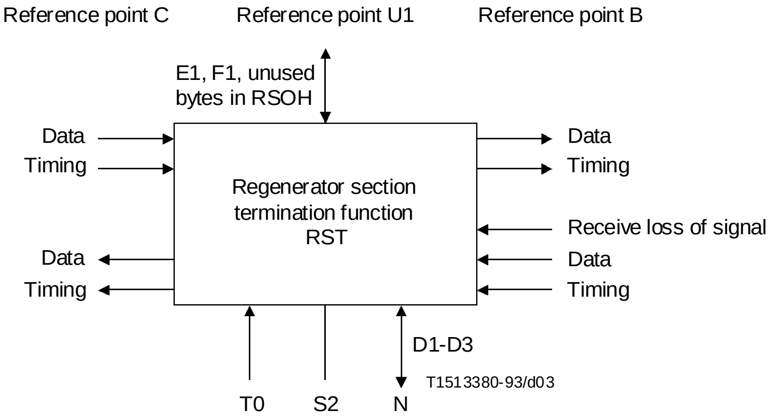


FIGURE 2-3/G.783

Regenerator section termination function

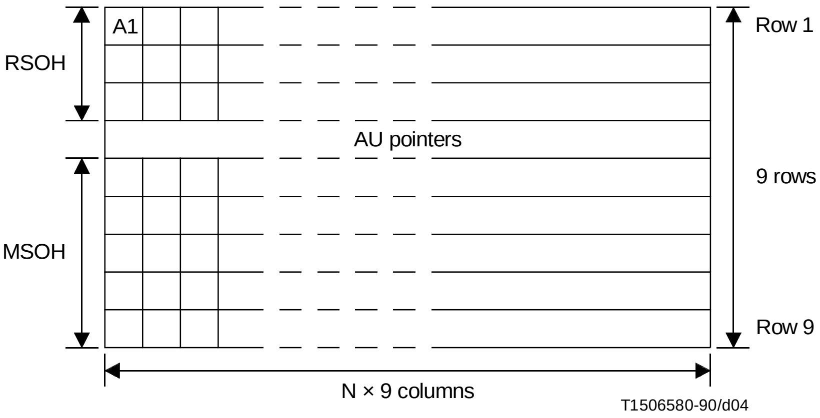
2.2.1 Signal flow from C to B

Data at C is an STM-N signal as specified in Recommendations G.707, G.708 and G.709, timed from the T0 reference point and having a valid multiplex section overhead (MSOH). However, the RSOH bytes (i.e. bytes A1, A2, B1, C1, E1, F1, D1 to D3 and some bytes reserved for national use (NU) or for future international standardization) are indeterminate in this signal. Figure 2-4 shows the assignment of bytes to RSOH and MSOH in the SOH of an STM-N frame. RSOH bytes are set in accordance with Recommendation G.708 as part of the RST function to give a fully formatted STM-N data and associated timing at B. After all RSOH bytes have been set, the RST function shall scramble the STM-N signal before it is presented to B. Scrambling is performed according to Recommendation G.709, which excludes the first row of the STM-N RSOH (9 × N bytes, including the A1, A2, C1 and some bytes reserved for national use or future international standardization) from scrambling.

Frame alignment bytes A1 and A2 (3 × N of each) are generated and inserted in the first row of the RSOH.

The STM identifier bytes are placed in their respective C1 byte positions in the first row of the RSOH. Each is assigned a unique number to identify the binary value of the multi-column, interleave depth coordinate, C (see Recommendation G.708). The C1 byte shall be set to a binary number corresponding to its order of appearance in the byte-interleaved STM-N frame. The first to appear in the frame shall be designated number 1 (00000001). The second shall be designated number 2 (00000010), and so on. If the signal at B is an STM-1 (i.e. N = 1) then the use of the C1 byte is optional.

NOTE – The allocation of the C1 byte may be changed.



NOTE – For detailed byte assignment, refer to Recommendation G.708.

FIGURE 2-4/G.783

Assignment of overhead bytes to RSOH and MSOH in an STM-N frame

The error monitoring byte B1 is allocated in the STM-N for a regenerator section bit error monitoring function. This function shall be a bit interleaved parity 8 (BIP-8) code using even parity as defined in Recommendation G.708. The BIP-8 is computed over all bits of the previous STM-N frame at B after scrambling. The result is placed in byte B1 position of the RSOH before scrambling.

The order-wire byte E1 derived from the OHA function at reference point U1 is placed in byte E1 position of the RSOH. This byte shall be terminated at each RST function. Optionally, it provides a 64 kbit/s unrestricted channel and is reserved for voice communication between network elements.

The user channel byte F1 derived from the OHA function at reference point U1 is placed in byte F1 position of the RSOH. It is reserved for the network provider (for example, for network operations). This byte shall be terminated at each RST function; however, access to the F1 byte is optional at regenerators. User channel specifications are for further study. Special usage, such as the identification of a failed section in a simple backup mode while the operations support system is not deployed or not working, is for further study. An example of such usage is given in Appendix I.

The three data communications channel bytes derived from the Message Communications function at reference point N are placed in bytes D1-D3 positions of the RSOH. These bytes are allocated for data communication and shall be used as one 192 kbit/s message-oriented channel for alarms, maintenance, control, monitor, administration, and other communication needs between RST functions. This channel is available for internally generated, externally generated, and manufacturer specific messages. The protocol stack used shall be as specified in Recommendation G.784.

Certain RSOH bytes are presently reserved for national use or for future international standardization, as defined in Recommendation G.708. One or more of these bytes may be derived from the OHA function at reference point U1. The unused bytes in the first row of the STM-N signal, which are not scrambled for transmission, shall be set to 10101010 when not used for a particular purpose. No pattern is specified for the other unused bytes when not used for a particular purpose.

If a logical all-ones data signal is received at reference point C (from an RST function in the case of a regenerator), a multiplex section alarm indication signal (MS-AIS) data signal shall be applied at reference point B.

2.2.2 Signal flow from B to C

Fully formatted and regenerated STM-N data and associated timing is received at B from the SPI function. The RST function recovers frame alignment and identifies the frame start positions in the data at C. The STM-N signal is first descrambled (except for the first row of the RSOH) and then the RSOH bytes are recovered before presenting the framed STM-N data and timing at C.

Frame alignment is found by searching for the A1 and A2 bytes contained in the STM-N signal. The framing pattern searched for may be a subset of the A1 and A2 bytes contained in the STM-N signal. The frame signal is continuously checked with the presumed frame start position for alignment. If in the in-frame state, the maximum out-of-frame (OOF) detection time shall be 625 µs for a random unframed signal. The algorithm used to check the alignment shall be such that, under normal operation, a 10^{-3} (Poisson type) error ratio will not cause a false OOF more than once per six minutes. If in the OOF state, the maximum frame alignment time shall be 250 µs for an error-free signal with no emulated framing patterns. The algorithm used to recover from OOF shall be such that the probability for false frame recovery with a random unframed signal is no more than 10^{-5} per 250 µs time interval.

If the OOF state persists for [TBD] milliseconds, a loss of frame (LOF) state shall be declared. To provide for the case of intermittent OOFs, the integrating timer shall not be reset to zero until an in-frame condition persists continuously for [TBD] milliseconds. Once in a LOF state, this state shall be left when the in-frame state persists continuously for [TBD] milliseconds.

NOTE – Time intervals [TBD] are for further study. Values in the range 0 to 3 ms have been proposed.

OOF events shall be reported at reference point S2 for performance monitoring filtering in the SEMF. An LOF condition shall be reported at reference point S2 for alarm filtering in the SEMF.

The STM identifier C1 bytes are present in the RSOH within the STM-N signal; however, processing of the C1 bytes is not required.

The error monitoring byte B1 is recovered from the RSOH after descrambling and compared with the computed BIP-8 over all bits of the previous STM-N frame at B before descrambling. Any errors are reported at reference point S2 as the number of errors within the B1 byte per frame. The B1 byte shall be monitored and recomputed at every RST function.

The order-wire byte E1 is recovered from the RSOH and passed to the OHA function at reference point U1.

The user channel byte F1 is recovered from the RSOH and passed to the OHA function at reference point U1.

The data communications channel bytes D1-D3 are recovered from the RSOH and passed to the message communications function at reference point N.

One or more of the bytes for national use or future international standardization may be recovered from the STM-N and may be passed to the OHA function at reference point U1. The RST function shall be capable of ignoring these bytes.

If loss of signal (LOS) or loss of frame (LOF) is detected, then a logical all-ones (AIS) signal shall be applied at the data signal output at reference point C towards the MST function within 2 frames (250 µ s). Upon termination of the above failure conditions, the logical all-ones signal shall be removed within 2 frames (250 µs).

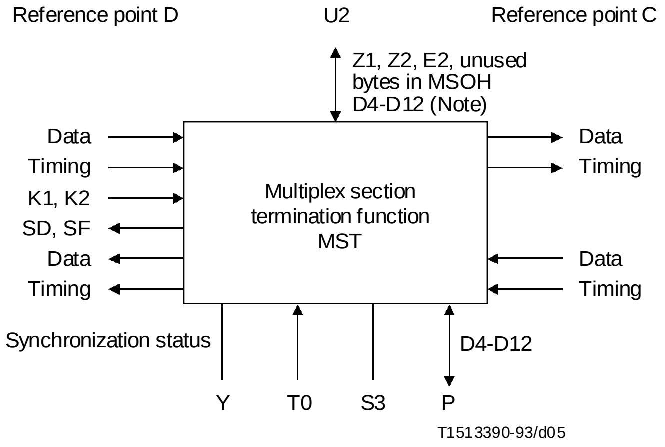
2.3 Multiplex section termination function (MST)

The MST function acts as a source and sink for the multiplex section overhead (MSOH). A multiplex section is a maintenance entity between and including two MST functions. The information flows associated with the MST function are described with reference to Figure 2-5.

NOTES

1 This Recommendation is intended for the general case of an inter-station interface. A reduced functionality requirement for an intra-station interface is for further study.

2 MS FEBE has been provisionally allocated, and is for further study. When it has been more fully defined, it will be processed by the MST function.



NOTE – Alternative to flow over P reference point. See 2.3.1 and 2.3.2.

FIGURE 2-5/G.783

Multiplex section termination function

2.3.1 Signal flow from D to C

Data at reference point D is an STM-N signal as specified in Recommendations G.707 and G.708, timed from the T0 reference point, having a payload constructed as in Recommendation G.709, but with indeterminate MSOH bytes (i.e. bytes B2, K1, K2, D4 to D12, Z1, Z2, E2, and bytes reserved for national use or future international standardization) and indeterminate RSOH bytes. Figure 2-4 shows the assignment of bytes to MSOH in the SOH of an STM-N frame. The MSOH bytes are set in accordance with Recommendation G.708 as part of the MST function. The resulting STM-N data and associated timing are presented at C.

The error monitoring byte B2 is allocated in the STM-N for a multiplex section bit error monitoring function. This function shall be a bit interleaved parity (BIP-24N) code using even parity as defined in Recommendation G.708. The BIP-24N is computed over all bits (except those in the RSOH bytes) of the previous STM-N frame and placed in the 3 × N respective B2 byte positions of the current STM-N frame.

The automatic protection switching bytes derived from the multiplex section protection (MSP) function at reference point D are placed in the K1 and K2 byte positions. Bits 6 to 8 of the K2 byte are reserved for future use for drop and insert and nested protection switching. Note that codes 111 and 110 will not be assigned to bits 6, 7, and 8 of K2 for protection switching since they are used for MS-AIS detection and MS-FERF indication.

The nine data communications channel bytes issued by the message communications function via the P reference point are placed consecutively in the D4 to D12 byte positions. This should be considered as a single message based channel for alarms, maintenance, control, monitoring, administration, and other communication needs. It is available for internally generated, externally generated, and manufacturer specific messages. The protocol stack used shall be in accordance with the specifications given in Recommendation G.784. Regenerators are not required to access this DCC. The nine DCC bytes may alternatively be issued by the overhead access function via the U2 reference point to provide a transparent data channel by using an appropriate OHA interface.

The $(6 \times N - 1)$ spare bytes issued by the OHA function at reference point U2 are placed in the $(3 \times N - 1)$ Z1 and $(3 \times N)$ Z2 byte positions. These bytes are reserved for future use and currently have no defined value.

The order-wire byte is issued by the OHA function at reference point U2 and is placed in the E2 byte position. It provides an optional 64 kbit/s unrestricted channel and is reserved for voice communications between terminal locations.

Certain MSOH bytes are presently reserved for national use or for future international standardization, as defined in Recommendation G.708. One or more of these bytes may be derived from the OHA function at reference point U2. No patterns are specified for these bytes when they are not used.

If an MS-AIS or excessive error defect at reference point D (see 2.3.2) is detected, then MS-FERF shall be applied within 250 µs at the data signal output at reference point C. MS-FERF is defined as an STM-N signal with the code 110 in bit positions 6, 7 and 8 of byte K2. It should be possible to disable the insertion of MS-FERF at reference point C on the detection of excessive error defect by a configuration command from the SEMF.

Bits 5-8 of the byte Z1 (9,1,1) are set to indicate the synchronization status message. These bits are coded as per Recommendation G.708 based on the synchronization quality level indicated by the Y reference point.

2.3.2 Signal flow from C to D

The framed STM-N data signal whose RSOH bytes have already been recovered in the RST function is received at reference point C from the RST function together with the associated timing. The MST function recovers the MSOH bytes. Then, the STM-N data and associated timing are presented at reference point D.

The $3 \times N$ error monitoring B2 bytes are recovered from the MSOH. A BIP-24N code is computed for the STM-N frame. The computed BIP-24N value for the current frame is compared with the recovered B2 bytes from the following frame and errors are reported at reference point S3 as number of errors within the B2 bytes per frame for performance monitoring filtering in the synchronous equipment management function.

The BIP-24N errors are also processed within the MST function to detect excessive error and signal degrade (SD) defects.

An excessive error defect should be detected if the equivalent BER exceeds a threshold of 10^{-3}. An SD defect should be detected if the equivalent BER exceeds a preset threshold in the range of 10^{-5} to 10^{-9}. Maximum detection time requirements for the BER calculation are listed in Table 2-1. The SD defect should be applied at reference point D. Excessive error and SD defects should be reported at reference point S3 for alarm filtering in the synchronous equipment management function.

NOTE – The figures above and Table 2-1 are based on a Poisson distribution of errors. Studies have shown that error distributions in practice tend to be bursty. Derivation of BER values from BIP measurements depends on the error distribution. An example of the excessive error defect process is described below.

The excessive error defect shall be declared if M consecutive bad intervals (interval is the 1 second period used for performance monitoring) are detected. An interval is declared bad if the percentage of detected errored blocks or BIP violations in that interval ≥ interval threshold (IT).

The excessive error defect shall be cleared if M consecutive good intervals are detected. An interval shall be declared good if the percentage of detected errored blocks or BIP violations in that interval < IT.

The parameter M shall be in the range 2 to 10. The parameter IT shall be in the range $0 < IT \leq 100\%$.

TABLE 2-1/G.783

Maximum detection time requirements

BER	Detection time
$\geq 10^{-3}$	10 ms
10^{-4}	100 ms
10^{-5}	1 s
10^{-6}	10 s
10^{-7}	100 s
10^{-8}	1000 s
10^{-9}	10 000 s

Automatic protection switching bytes K1 and K2 are recovered from the MSOH at C and are passed to the MSP function at reference point D.

The multiplex section data communications channel bytes D4 to D12 are recovered from the MSOH and are passed to the message communications function at reference point P. Alternatively, they may be passed to the overhead access function via reference point U2.

The $(6 \times N - 1)$ spare bytes Z1 and Z2 may be recovered from the STM-N signal and may be passed to the OHA function at reference point U2. These bytes are reserved for future use and currently have no defined value.

The order-wire byte E2 is recovered from the MSOH and is passed to the OHA function at reference point U2.

One or more of the bytes reserved for national use or for future international standardization may be recovered from the STM-N signal and may be passed to the OHA function at reference point U2. The MST function shall be capable of ignoring these bytes.

An MS-AIS defect shall be detected by the MST function when the pattern 111 is observed in bits 6, 7 and 8 of byte K2 in at least three consecutive frames. Removal of the MS-AIS defect shall take place when any pattern other than the code 111 in bits 6, 7 and 8 of byte K2 is received in at least three consecutive frames.

An incoming MS-FERF defect shall be detected by the MST function when the pattern 110 is observed in bits 6, 7 and 8 of byte K2 in at least three consecutive frames. Removal of MS-FERF defect shall take place when any pattern other than 110 in bits 6, 7 and 8 of byte K2 is received in at least three consecutive frames.

The MS-AIS and MS-FERF defects shall be reported at reference point S3 for alarm filtering in the synchronous equipment management function.

If MS-AIS or excessive error defect is detected, then a logical all-ones (AIS) data signal and a signal fail condition shall be applied at reference point D within 2 frames. Upon termination of the above defect condition, the logical all-ones signal shall be removed within 2 frames. It should be possible to disable this action on detection of excessive error defect by a configuration command from the SEMF.

The synchronization status message is recovered from bits 5-8 of the byte Z1 (9.1.1) and the synchronization quality level is reported to the SETS at reference point Y. A persistency check for the detection of the synchronization status message is for further study.

2.4 Multiplex section protection function (MSP)

The MSP function provides protection for the STM-N signal against channel-associated failures within a multiplex section, i.e. the RST, SPI functions and the physical medium from one MST function where section overhead is inserted to the other MST function where that overhead is terminated.

The MSP functions at both ends operate the same way, by monitoring STM-N signals for failures, evaluating the system status taking into consideration the priorities of failure conditions and of external and remote switch requests, and switching the appropriate channel to the protection section. The two MSP functions communicate with each other via a bit-oriented protocol defined for the MSP bytes (K1 and K2 bytes in the MSOH of the protection section). This protocol is described in A.1, for the various protection switching architectures and modes defined in Recommendation G.782.

The signal flow associated with the MSP function is described with reference to Figure 2-6. The MSP function receives control parameters and external switch requests at the S14 reference point from the synchronous equipment management function and outputs status indicators at S14 to the synchronous equipment management function, as a result of switch commands described in A.2.

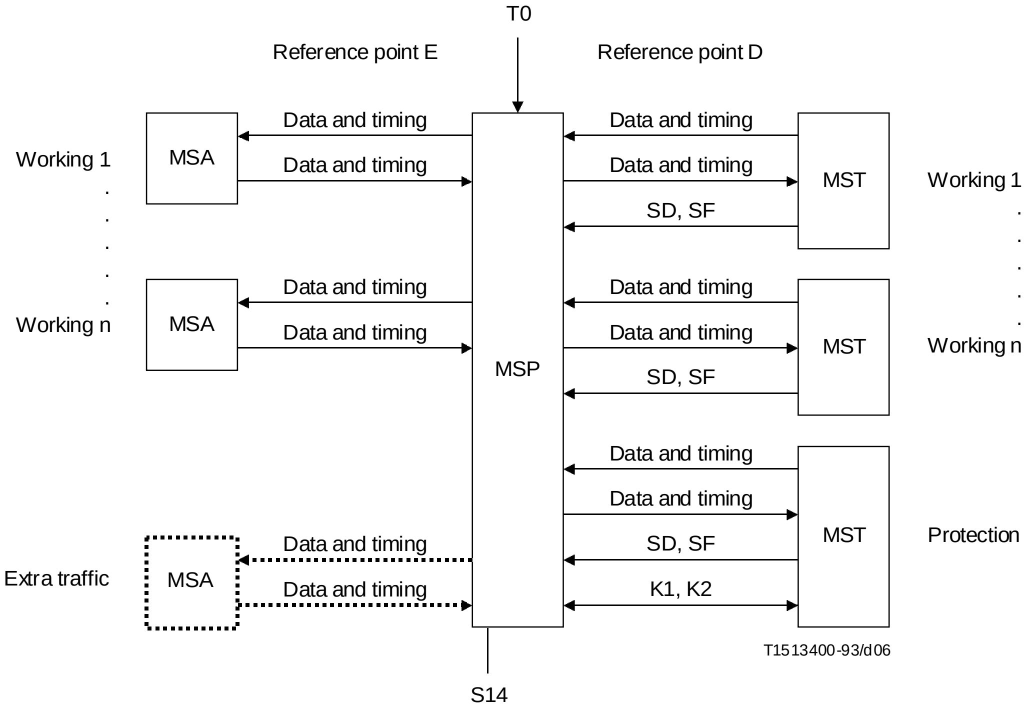


FIGURE 2-6/G.783

Multiplex section protection function

2.4.1 Signal flow from E to D

Data at reference point E is an STM-N signal, timed from the T0 reference point, with indeterminate MSOH and RSOH bytes.

For 1 + 1 architecture, the signal received at E from the MSA function is bridged permanently at D to both working and protection MST functions.

For 1 : n architecture, the signal received at E from each working MSA is passed at D to its corresponding MST. The signal from an extra traffic MSA (if provisioned) is connected to the protection MST. When a bridge is needed to protect a working channel, the signal at E from that working MSA is bridged at D to the protection MST and the extra traffic channel is terminated.

The K1 and K2 bytes generated according to the rules in A.1 are presented at D to the protection MST. These bytes may also be presented to the working MST functions.

2.4.2 Signal flow from D to E

Framed STM-N signals (data) whose RSOH and MSOH bytes have already been recovered are presented at the reference point D along with incoming timing references. The failure conditions SF and SD are also received at the reference point D from all MST functions.

The recovered K1 and K2 bytes from the protection MST function are presented at the reference point D. Working MST functions may also present these bytes to the MSP. The MSP must be able to ignore these bytes from the working MST functions.

Under normal conditions, MSP passes the data and timing from the working MST functions to their corresponding working MSA functions at the reference point E. The data and timing from the protection section is passed to the extra traffic MSA, if provisioned in a 1 : n MSP architecture, or else it is terminated.

If a switch is to be performed, then the data and timing received from the protection MST at reference point D is switched to the appropriate working channel MSA function at E, and the signal received from the working MST at D is terminated.

2.4.3 Switch initiation criteria

Automatic protection switching is based on the failure conditions of the working and protection sections. These conditions, signal fail (SF) and signal degrade (SD), are provided by the MST functions at reference point D. Detection of these conditions is described in 2.3.

The protection switch can also be initiated by switch commands received via the synchronous equipment management function.

2.4.4 Switching time

Protection switching shall be completed within 50 ms of detection of an SF or SD condition that initiates a switch. After the completion of an automatic protection switch, a protection switch event (PSE) shall be reported at reference point S14.

2.4.5 Switch restoral

In the revertive mode of operation, the working channel shall be restored, i.e. the signal on the protection section shall be switched back to the working section, when the working section has recovered from failure. Restoral allows other failed working channels or an extra traffic channel to use the protection section.

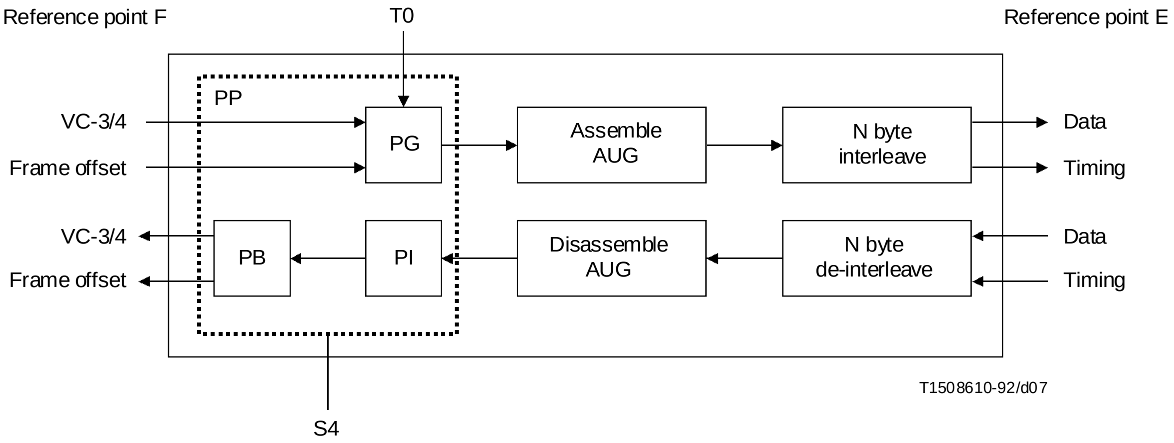
To prevent frequent operation of the protection switch due to an intermittent failure (e.g. BER fluctuating around the SD threshold), a failed section must become fault-free (i.e. BER less than a restoral threshold). After the failed section meets this criterion, a fixed period of time shall elapse before it is used again by a working channel. This period, called wait-to-restore (WTR) period should be of the order of 5-12 minutes and should be capable of being set. An SF or SD condition shall override the WTR.

2.5 Multiplex section adaptation function (MSA)

This function provides adaptation of higher order paths into administrative units (AUs), assembly and disassembly of AU groups, byte interleaved multiplexing and demultiplexing, and pointer generation, interpretation and processing. The signal flow associated with the MSA function is described with reference to Figure 2-7.

2.5.1 Signal flow from F to E

The higher order paths at reference point F are mapped into AUs which are incorporated into AU groups. N such AUGs are byte interleaved to form an STM-N payload at the reference point E. The byte interleaving process shall be as specified in Recommendation G.709. The frame offset information is used by the PG function to generate pointers according to pointer generation rules in Recommendation G.709. STM-N data at E is synchronized to timing from the T0 reference point. When an all-ones signal is applied at reference point F, an all-ones (AU-AIS) signal shall be applied at reference point E within 2 frames (250 µs). Upon termination of the all-ones signal at reference point F, the all-ones (AU-AIS) signal shall be terminated within 2 frames (250 µs).



PB	Pointer buffer
PG	Pointer generator
PI	Pointer interpreter
PP	Pointer processor

FIGURE 2-7/G.783

Multiplex section adaptation function

2.5.2 Signal flow from E to F

STM-N payloads received at reference point E are de-interleaved and the VC-3/4s recovered using the AU pointers. The latter process must allow for the case of continuously variable frame offset which occurs when the received STM-N signal has been derived from a source which is plesiochronous with the local clock reference.

2.5.3 Pointer processing function

The PP function provides accommodation for wander and plesiochronous offset in the received signal with respect to the synchronous equipment timing reference. This function may be null in some applications where the timing reference is derived from the incoming STM-N signal, i.e. loop timing.

The PP function can be modeled as a data buffer which is being written with data, timed from the received VC clock, and read by a VC clock derived from reference point T0. When the write clock rate exceeds the read clock rate the buffer gradually fills and vice-versa. Upper and lower buffer occupancy thresholds determine when pointer adjustment should take place. The buffer is required to reduce the frequency of pointer adjustments in a network. When the data in the buffer rises above the upper threshold for a particular VC, the associated frame offset is decremented by one byte for a VC-3 or three bytes for a VC-4, and the corresponding number of bytes are read from the buffer. When the data in the buffer falls below the lower threshold for a particular VC, the associated frame offset is incremented by one byte for a VC-3 or three bytes for a VC-4 and the corresponding number of read opportunities are canceled. The pointer hysteresis threshold spacing allocation is specified in 6.1.4.1.

The mechanism of pointer processing is illustrated as a flow chart in Figure 2-8.

The algorithm for pointer detection is defined in Annex B. Two failure conditions can be detected by the pointer interpreter:

- loss of pointer (LOP);
- AU-AIS.

If either of these failure conditions are detected, then a logical all-ones (AIS) signal shall be applied at reference point F within 2 frames (250 µs). Upon termination of these defects, the all-ones signal shall be removed within 2 frames (250 µs). These defects shall be reported at reference point S4 for alarm filtering at the synchronous equipment management function. Outgoing pointer justification events (PJE), i.e. pointer value increment or decrement respectively, after the AU has been resynchronized to the local clock, are also reported at reference point S4 for performance monitoring filtering. PJE's need only be reported for one selected AU-3/4 out of an incoming STM-N signal. Pointer increments (positive events) and decrements (negative events) are reported separately.

It should be noted that a persistent mismatch between provisioned and received AU type will result in a LOP defect and also that AU-3 and AU-4 structures can be differentiated by checking the Y bytes in the pointer area.

2.6 Higher order connection supervision (HCS)

The Higher order Connection Supervision function comprises as a compound function the basic functions Higher order Path Overhead Monitor (HPOM) and Higher order Unequipped Generator (HUG) as illustrated in Figure 2-9.

This function acts as a source and sink for parts of the higher order path overhead (VC-*n* POH, $n = 3, 4$). A higher order connection is a maintenance entity defined between two higher order connection supervision functions or between a Higher order Path Termination (HPT) and a higher order connection supervision function.

NOTE – The HCS-*n* ($n = 3, 4$) function enables supervision of unassigned and assigned HO-connections. Since it has the identical information flows at the reference points F and G, it may be optional.

The HCS-*n* function shall be able to be set into two operational states, the inactive state and the active state. In the inactive state, the data is transparently passed through from F to G and vice versa. HPOM and HUG may be set to active/inactive independently. In the active state, the main tasks of the HCS are:

- Monitoring of parts of HO-POH to get alarm and performance information about the path segment [sub-function HPOM (Higher order Path Overhead Monitoring)];
- Termination of "unused" connections which are the free resources of the network.
- Generation of HO-POH with Signal label "unequipped" [sub-function HUG (Higher order Unequipped Generator)];
- Monitoring parts of HO-POH to supervise the "unused" connections.

These functions are necessary for supervision of the unused direction in unidirectional path, broadcast and connection based automatic path protection switching applications.

Depending on the network application for a specific equipment, the partition of HCS functions to be supported in the active state at the same time may vary in the range of 0% to 100%.

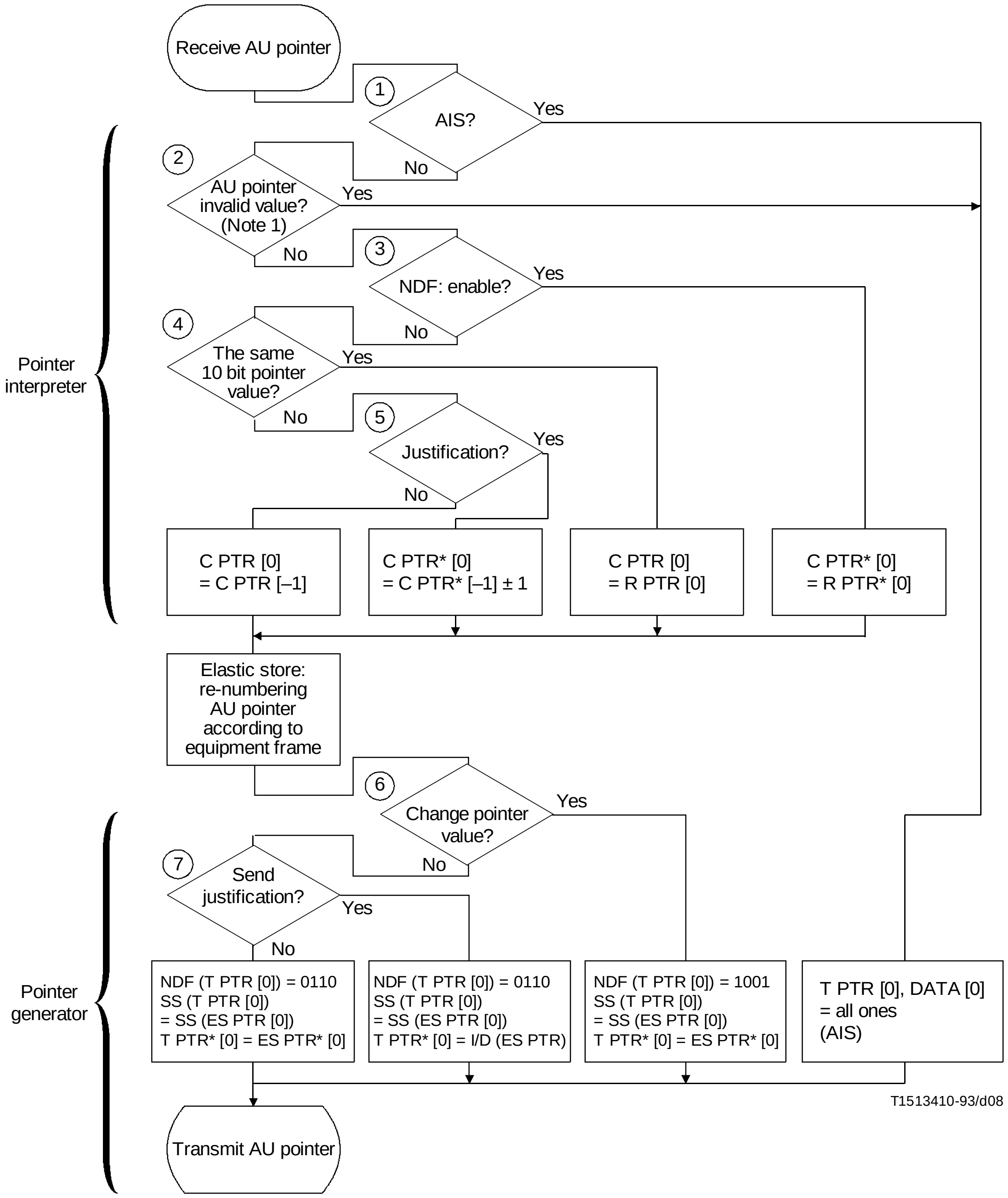
The timing signal is provided from the SETS at the T0 reference point.

NOTE – Clarification of the definition of unequipped signal and the use of the term "unequipped" is for further study. Alignment between this Recommendation and Recommendations G.709 and G.803 is needed.

2.6.1 Signal flow from F to G (HPOM function)

At reference point S16, the following primitives are possible:

- Set active/inactive, which is a request from the SEMF to the HPOM to select either the active or inactive state, as determined by the SEMF request. The HPOM reports its state back to the SEMF (acknowledgement).
- Get active/inactive state, which is a request from the SEMF to the HPOM to report its state to the SEMF.



C PTR [ ]	AU pointer value inside equipment
R PTR [ ]	AU pointer value received
T PTR [ ]	AU pointer value transmitted
ES PTR [ ]	Output AU pointer value of an ELASTIC STORE
I/D ( )	Invert I or D of AU pointer

DATA	Payload data
NDF (T PTR [ ])	NDF in AU pointer
SS (T PTR [ ])	SS bits in AU pointer value transmitted
SS (ES PTR [ ])	SS bits in AU pointer value transmitted
*	10 bit pointer
n	The n-th frame preceding the present one

NOTES

1 Concatenation indication (CI) should be interpreted at this point. From the rules in Recommendation G.709, the first AU-4 of an AU-4-Xc shall be interpreted according to the flow chart; the pointers of the other AU-4s contain CI bits, and the pointer processor shall perform the same operation as performed on the first AU-4.

2 AU pointer: NDF, SS, 10 bits pointer.

FIGURE 2-8/G.783

Pointer processing flow chart

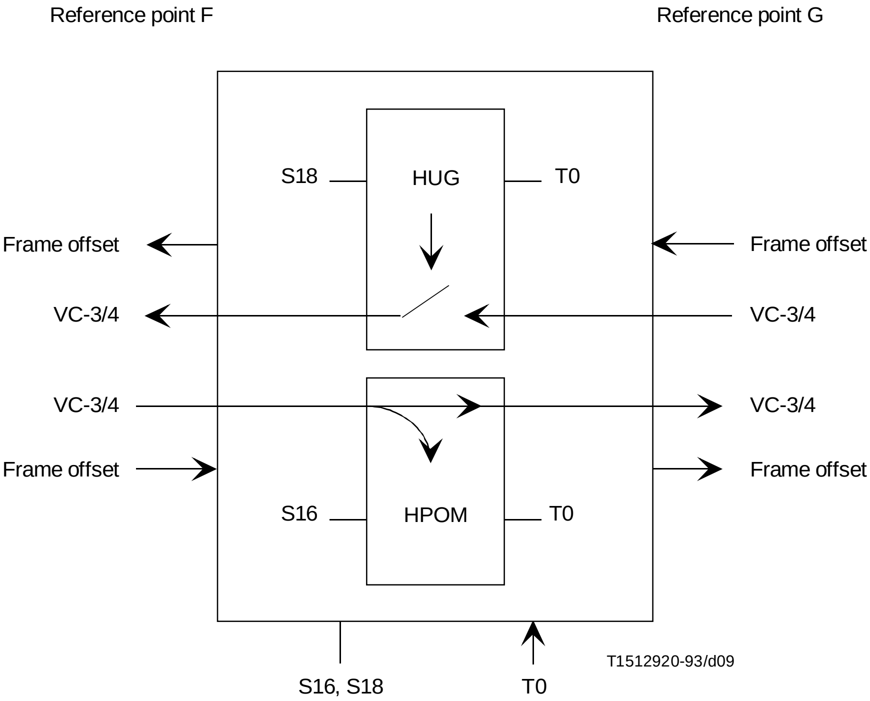


FIGURE 2-9/G.783

Higher order connection supervision function

Active state

Data at F is a VC-*n* (*n* = 3, 4), having a VC-*n* POH and a payload as described in Recommendations G.708 and G.709 or an undefined payload as described in 2.6.2. Parts of the POH bytes are recovered as part of the HPOM sub-function and the VC-*n* is unchanged forwarded to reference point G.

Bytes J1, G1 and C2 are recovered from the VC-*n* POH at F and the corresponding information on path trace, path status and signal label are passed via reference point S16 to the synchronous equipment management function.

Byte B3 is recovered from the VC-*n* POH at F. BIP-8 is computed for the VC-*n* frame. The computed BIP-8 value for the current frame is compared with the recovered B3 byte from the following frame and errors are reported at reference point S16 as number of errors within the B3 byte per frame for connection performance monitoring filtering in the synchronous equipment management function.

NOTE – In the case of an "unused" connection, the termination and the monitoring are identical functions because a "real" physical termination is not necessary (the HPC is in an open state).

Inactive state

Data at F is transparently passed through to G. The path overhead is not monitored.

2.6.2 Signal flow from G to F (HUG function)

At reference point S18, the following primitives are possible:

- Set active/inactive, which is a request from the SEMF to the HUG to select either the active or inactive state, as determined by the SEMF request. The HUG reports its state back to the SEMF (acknowledgement).
- Get active/inactive state, which is a request from the SEMF to the HUG to report its state to the SEMF.

Active state

Receiving an “unequipped” signal at reference point G, the Higher order connection Unequipped Generator HUG-*n* (*n* = 3, 4) generates a VC-*n* with an undefined payload but a full valid POH at reference point F.

Generating a VC-*n* requires the following sequence of operations:

- Generation of a container C-*n* with undefined payload information.
- Generation of a frame offset.
- Setting of the path signal label to “unequipped”.
- Derivation of the path trace and path status information from reference point S18 and insertion in the POH bytes J1 and G1 according to Recommendation G.709.
- Computation of BIP-8 over all bits of the VC-*n* and insertion in the B3 byte position of the following frame.

Receiving a VC-*n* with a signal label not equal to unequipped at reference point G, the VC-*n* at reference point G is passed through the HCS to reference point F without modification.

Inactive state

Data at G is transparently passed through to F.

2.7 Higher order path connection function (HPC-*n*)

HPC-*n* is the function which assigns higher order VCs of level *n* (*n* = 3 or 4) at its input ports to higher order VCs of level *n* at its output ports.

The HPC-*n* connection process is a simple, unidirectional function as illustrated in Figure 2-9. The signal formats at the input and output ports of the function are similar, differing only in the logical sequence of the VC-*n*s. As the process does not affect the nature of the characteristic information of the signal, the reference point on either side of the HPC-*n* function is the same, as illustrated in Figure 2-9.

Incoming VC-*n*s at reference point G are assigned to available outgoing VC-*n* capacity at reference point G. An unequipped VC-*n* (according to 2.3.2/G.709) shall be applied at any outgoing VC-*n* which is not connected to an incoming VC-*n*.

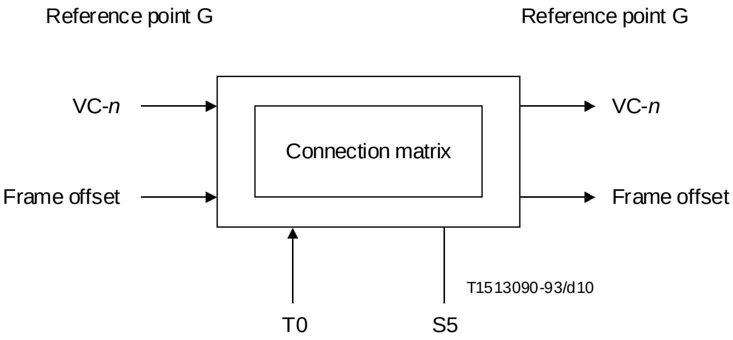


FIGURE 2-10/G.783

General higher order path connection

The assignment of incoming VC-*n*s to outgoing VC-*n*s at reference point G is defined as the “connection pattern” which can be described by an uni-directional connection matrix CM (V_i, V_j), where V_i identifies the i-th incoming VC signal at reference point G and V_j identifies the j-th outgoing VC signal at reference point G. There may be a degree of flexibility in the connection matrix which can be exercised; i.e. the number of fields (V_i, V_j) in the CM representing valid input/output combinations in a particular implementation could be restricted. This is illustrated in 2.7.2.

At reference point S5, the following primitives are possible:

- Set connection matrix, which is a request of the SEMF to the HPC-*n* to assign a particular input port to a particular output port according to the connection matrix (CM). The HPC-*n* reports afterwards the new CM to the SEMF (acknowledgement).
- Get connection matrix, which is a request from the SEMF to the HPC-*n* to report the CM to the SEMF.

A protection switch function may be provided using the HPC-*n*. In that case, an input VC-*n* may be broadcast onto two selected outgoing VC-*n*s; and in the return direction, a selection is performed from the incoming VC-*n*s.

NOTE – Clarification of the definition of unequipped signal and the use of the term “unequipped” is for further study. Alignment between G.708 and G.803 is needed.

2.7.1 Signal flow

There is no signal flow associated with this function. HPC-*n* provides a facility for re-ordering VC-*n* capacity within the signal.

2.7.2 CM configuration examples

The connection function as defined in 2.7 is highly flexible. To illustrate this, examples of a number of basic classes of the connection function are given below.

i) *1-port* – The set of input and output ports is not divided into subsets, as shown in Figure 2-11. This CM allows interconnectivity as given in Table 2-2.

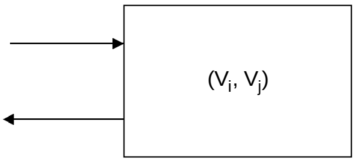


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FIGURE 2-11/G.783

Connection matrix for 1-port HPC-*n*

TABLE 2-2/G.783

Connection matrix for 1-port

		V_i
		G
V_j	G	X
X Indicates V_i-V_j connection possible for any i and j.		

ii) *2-port type I* – The set of input and output ports is divided into two subsets, each containing both input and output ports – G Line (GL) and G Trib (GT) as shown in Figure 2-12. This CM allows interconnectivity as given in Table 2-3.

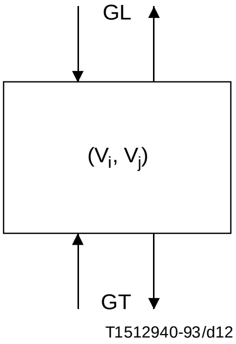


FIGURE 2-12/G.783

Connection matrix for 2-port HPC-*n*

TABLE 2-3/G.783

Connection matrix for 2-port type I

		V_i	
		GL	GT
V_j	GL	i = j	X
	GT	X	i = j

X Indicates V_i-V_j connection possible for any i and j.

i = j Indicates V_i-V_j connections possible only in the case that i = j (e.g. loopback, no reconfiguration).

iii) *3-port type I* – The set of input and output ports is divided into three subsets, each containing both input and output ports – G West (GW), G East (GE), G Drop (GD) as shown in Figure 2-13. This CM allows interconnectivity between any ports in the subsets, as given in Table 2-4.

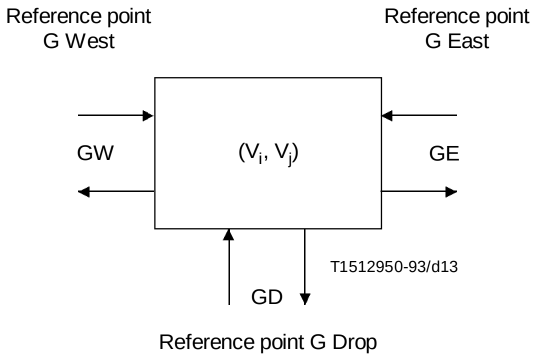


FIGURE 2-13/G.783

Connection matrix for 3-port HPC-*n*

TABLE 2-4/G.783

Connection matrix for 3-port type I

		V_i		
		GW	GE	GD
V_j	GW	i = j	X	X
	GE	X	i = j	X
	GD	X	X	i = j
X	Indicates V_i-V_j connection possible for any i and j.			
i = j	Indicates V_i-V_j connections possible only in the case that i = j (e.g. loopback, no reconfiguration).			

iv) *3-port type II* – The set of input and output ports is divided into three subsets, each containing both input and output ports – G West (GW), G East (GE), G Drop (GD) as shown in Figure 2-13. This CM allows interconnectivity between the GD and GW/GE ports as shown in Table 2-5.

TABLE 2-5/G.783

Connection matrix for 3-port type II

		V_i		
		GW	GE	GD
V_j	GW	i = j	i = j	X
	GE	i = j	i = j	X
	GD	X	X	i = j

X Indicates V_i-V_j connection possible for any i and j.

i = j Indicates V_i-V_j connections possible only in the case that i = j (e.g. loopback, no reconfiguration).

v) *4-port type I* – The set of input and output ports is divided into four subsets, each containing both input and output ports – G West (GW), G East (GE), G Drop East (GDE), and G Drop West (GDW) as shown in Figure 2-14. This CM allows interconnectivity between any ports in the subsets, as given in Table 2-6.

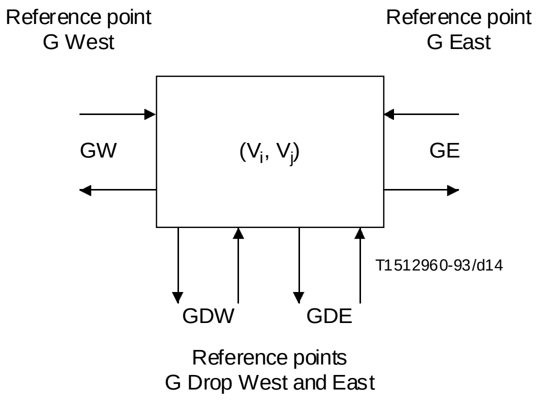


FIGURE 2-14/G.783

Connection matrix for 4-port HPC-*n*

TABLE 2-6/G.783

Connection matrix for 4-port type I

		V_i			
		GW	GE	GDW	GDE
V_j	GW	i = j	X	X	–
	GE	X	i = j	–	X
	GDW	X	–	i = j	–
	GDE	–	X	–	i = j

X Indicates V_i-V_j connection possible for any i and j.

i = j Indicates V_i-V_j connections possible only in the case that i = j (i.e. loopback, no reconfiguration).

– Indicates no connection possible.

vi) *4-port type II* – The set of input and output ports is divided into four subsets, each containing both input and output ports – G West (GW), G East (GE), G Drop East (GDE), and G Drop West (GDW) as shown in Figure 2-14. This CM allows interconnectivity as given in Table 2-7.

TABLE 2-7/G.783

Connection matrix for 4-port type II

		V_i			
		GW	GE	GDW	GDE
V_j	GW	–	i = j	X	–
	GE	i = j	–	–	X
	GDW	X	–	–	–
	GDE	–	X	–	–

X Indicates V_i-V_j connection possible for any i and j.

i = j Indicates V_i-V_j connections possible only in the case that i = j (e.g. loopback, no reconfiguration).

– Indicates no connection possible.

vii) *Degenerate* – The HPC-*n* is a null function; i.e. a fixed connection pattern exists between input and output ports (see Figure 2-15).

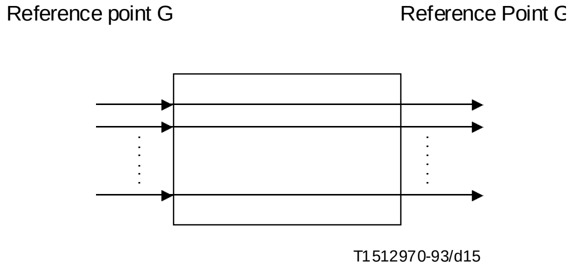


FIGURE 2-15/G.783

Connection matrix for degenerate HPC-*n*

2.8 Higher order path termination function (HPT-*n*)

This function acts as a source and sink for the higher order path overhead (VC-*n* POH, *n* = 3, 4). A higher order path is a maintenance entity defined between two higher order path terminations. The information flows associated with the HPT-*n* function are described with reference to Figures 2-1 and 2-16.

The timing signal is provided from the SETS at the T0 reference point.

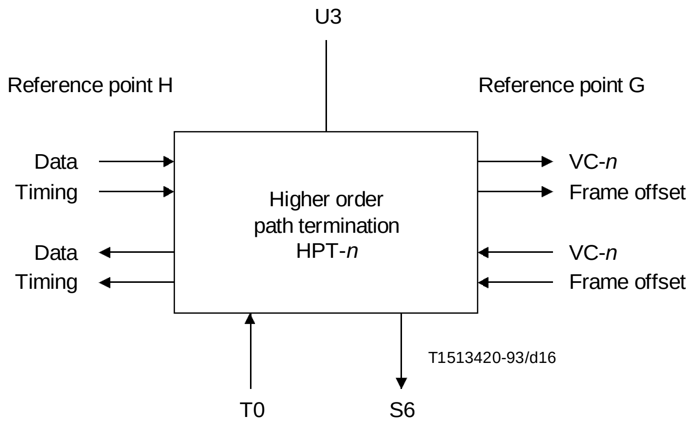


FIGURE 2-16/G.783

Higher order path termination function

2.8.1 Signal flow from H to G

Data at H is a VC-*n* (*n* = 3, 4), having a payload as described in Recommendations G.708 and G.709, but with indeterminate VC-3/4 POH (bytes J1, B3, C2, G1, F2, Z4, Z5). These POH bytes are set as part of the HPT-*n* function and the complete VC-*n* is forwarded to G.

Path trace and signal label information, derived from reference point S6 are placed in J1, and C2 byte positions respectively.

Path status information is placed in the G1 byte position. The number of errors detected by monitoring B3 (see 3.2.1) is encoded in the FEBE (bits 1 to 4 of the G1 byte) according to Figure 4-1/G.709. When there is a logical all-ones signal at reference point G or a TIM or SLM defect is detected in the data signal received at reference point G, HP-FERF indication shall be sent in bit 5 of the G1 byte within 2 frames. Upon termination of the above conditions, the HP-FERF indication shall be removed within 2 frames.

Bit interleaved parity (BIP-8) is computed over all bits of the previous VC-*n* and placed in B3 byte position.

The two bytes Z4 and Z5 are derived from the U3 reference point, and are reserved for future use. Currently they have no defined value at G.

2.8.2 Signal flow from G to H

Data at G is a VC-*n* (*n* = 3, 4), having a payload as described in Recommendations G.708 and G.709, with complete VC-3/4 POH (bytes J1, B3, C2, G1, F2, H4, Z3, Z4, Z5). POH bytes J1, B3, C2, G1, Z4, Z5 are recovered as part of the HPT-*n* function and the VC-*n* is forwarded to reference point H.

Bytes J1 (HO path trace) and C2 (HO path signal label) are recovered from VC-*n* POH at G. If an HP trace identifier mismatch or an HP signal label mismatch is detected, then it shall be reported via reference point S6. The accepted values of J1 and C2 are also available at S6.

NOTE – Acceptance criteria and defect detection specification for path trace identifier and signal label are for further study.

If five consecutive VC-*n* (*n* = 3, 4) frames contain the “00000000” pattern in byte C2, an UNEQ defect shall be declared. The UNEQ defect shall be cleared if in five consecutive VC-*n* frames any pattern other than the “00000000” is detected in byte C2.

When an unequipped VC (UNEQ), path trace identifier mismatch (HP-TIM) or a path signal label mismatch (HP-SLM) is detected, a logical all-ones signal shall be applied at the data signal output at reference point H towards the HPA/LPA functions within 2 frames. Upon termination of the above defect conditions, the logical all-ones signal shall be removed within 2 frames.

Byte G1 is recovered from VC-*n* POH at G and the corresponding information on path status is passed via reference point S6 to the SEMF. The G1 byte is illustrated in Recommendation G.709. FEBE information is decoded from bits 1 to 4 of the G1 byte and reported at S6. The path FERF information in bit 5 of the G1 byte is recovered and reported at S6. A persistency check for the detection of path FERF is for further study.

The error monitoring byte B3 is recovered from the VC-*n* frame. BIP-8 is computed for the VC-*n* frame. The computed BIP-8 value for the current frame is compared with the recovered B3 byte from the following frame and errors are reported at reference point S6 as number of errors within the B3 byte per frame for performance monitoring filtering in the synchronous equipment management function.

The two bytes Z4 and Z5 are passed to the OHA function via the U3 reference point, and are reserved for future use. Currently they have no defined value at G.

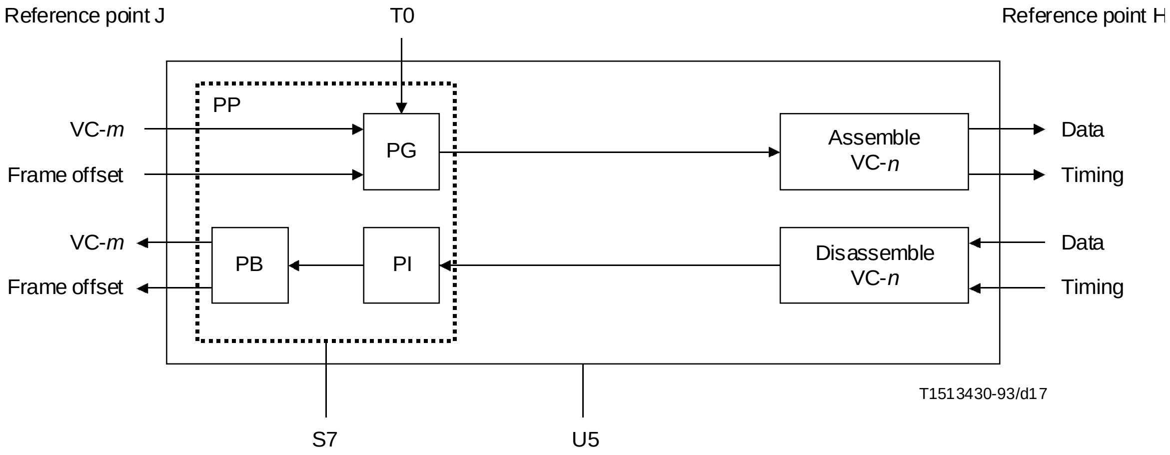
2.9 Higher order path adaptation function (HPA-*m*, HPA-*n*)

HPA-*m/n*, (m =1, 2 or 3; *n* = 3 or 4) defines the TU pointer processing. It may be divided into three functions:

- pointer generation;
- pointer interpretation;
- frequency justification.

The format for TU pointers, their roles for processing, and mappings of VCs are described in Recommendation G.709.

Figure 2-17 illustrates the HPA-*m*/*n* function.



PB	Pointer buffer
PG	Pointer generator
PI	Pointer interpreter
PP	Pointer processor

FIGURE 2-17/G.783

Higher order path adaptation function

2.9.1 Signal flow from J to H

The HPA-*m*/*n* function assembles VCs of lower order *m* (*m* = 11, 12, 2, 3) as TU-*m* into VCs of higher order *n* (*n* = 3 or 4).

The frame offset in bytes between a lower order VC and higher order VC is indicated by a TU pointer which is assigned to that particular lower order VC. The method of pointer generation is described in Recommendation G.709. LOVC data at reference point J is synchronized to timing from the T0 reference point. When an all-ones (AIS) signal is applied at reference point J, an all-ones (TU-AIS) signal shall be applied at reference point H within 2 (multi)frames. Upon termination of the all-ones signal at reference point J, the all-ones (TU-AIS) signal shall be terminated within 2 (multi)frames.

A multiframe indicator is generated as described in Recommendation G.709 and placed in the H4 byte position.

One byte per frame is allocated for user communication purposes. It is derived from reference point U5 and placed in the F2 byte position.

Byte Z3 is derived from reference point U5, and is reserved for future use. Currently it has no defined value at H.

2.9.2 Signal flow from H to J

The HPA-*m*/4 function disassembles VC-4 into VCs of lower order *m* (*m* = 11, 12, 2, 3), performing multiframe alignment if necessary. HPA-*m*/3 disassembles VC-3 into VCs of lower order *m* (*m* = 11, 12, 2), performing multiframe alignment if necessary. The TU pointer of each lower order VC is decoded to provide information about the frame offset in bytes between the higher order VC and the individual lower order VCs. The method of pointer interpretation is described in Recommendation G.709. This process must allow for continuous pointer adjustments when the clock frequency of the node where the TU was assembled is different from the local clock reference. The frequency difference between these clocks affects the required size of the data buffer whose function is described below.

In the case of payloads requiring multiframe alignment, a multiframe indicator is derived from the H4 byte. The received H4 value is compared to the next expected value in the multiframe sequence. The H4 value is assumed to be in phase when it is coincident with the expected value. If several H4 values are received consecutively not as expected but correctly in sequence with a different part of the multiframe sequence, then subsequent H4 values shall be expected to follow this new alignment. If several H4 values are received consecutively not correctly in sequence with any part of the multiframe sequence, then a loss of multiframe (LOM) event shall be reported at S7. When several H4 values have been received consecutively correctly in sequence with part of the multiframe sequence, then the event shall be ceased and subsequent H4 values shall be expected to follow the new alignment.

NOTE – The meaning of several is that the number should be low enough to avoid excessive delay in re-framing but high enough to avoid re-framing due to errors; a value in the range 2 to 10 is suggested.

The PP function can be modeled as a data buffer which is being written with data, timed from the received VC clock, and read by a VC clock derived from reference point T0. When the write clock rate exceeds the read clock rate the buffer gradually fills and vice versa. Upper and lower buffer occupancy thresholds determine when pointer adjustment should take place. The buffer is required to reduce the frequency of pointer adjustments in a network. When the data in the buffer rises above the upper threshold for a particular VC, the associated frame offset is decremented by one byte and an extra byte is read from the buffer. When the data in the buffer falls below the lower threshold for a particular VC, the associated frame offset is incremented by one byte and one read opportunity is canceled. Pointer hysteresis threshold spacing allocation is specified in 6.1.4.2.

The algorithm for pointer detection is defined in Annex B. Two failure conditions can be detected by the pointer interpreter:

- loss of pointer (LOP);
- TU-AIS.

If either of these failure conditions are detected then a logical all-ones (AIS) signal shall be applied at reference point J within 2 (multi)frames. Upon termination of these defects, the all-ones signal shall be removed within 2 (multi)frames. These defects shall be reported at reference point S7 for alarm filtering at the synchronous equipment management function.

It should be noted that a persistent mismatch between provisioned and received TU type will result in a loss of pointer (LOP) defect.

One byte per frame is allocated for user communication purposes. It is derived from the F2 byte and passed via reference point U5 to the overhead access function.

Byte Z3 is passed to the OHA function via reference point U5, and is reserved for future use. Currently it has no defined value.

2.10 Lower order connection supervision (LCS-*m*)

The Lower order Connection Supervision function comprises as a compound function the basic functions Lower order Path Overhead Monitor (LPOM) and Lower order Unequipped Generator (LUG) as illustrated in Figure 2-18.

This function acts as a source and sink for parts of the lower order path overhead (VC-*m* POH, $m = 11, 12, 2, 3$). A lower order connection is a maintenance entity defined between two lower order connection supervision functions or between a lower order path termination (LPT) and a lower order connection supervision function.

NOTE – The LCS-*m* ($m = 11, 12, 2, 3$) function enables supervision of unassigned and assigned LO-connections. Since it has the identical information flows at the reference points K and J, it may be optional.

The LCS-*m* function shall be able to be set to two operational states: the inactive state or the active state. In inactive state, the data is transparently passed through from J to K and vice versa. LPOM and LUG may be set to active/inactive independently. In the active state, the main tasks of the LCS are:

- Monitoring of parts of LO-POH to get alarm and performance information about the path segment; [sub-function LPOM (Lower order Path Overhead Monitor)];

- Termination of “unused” connections which are the free resources of the network.
- Generation of LO-POH with Signal label “unequipped”; [sub-function LUG (Lower order Unequipped Generator)];
- Monitoring parts of LO-POH to supervise the “unused” connections.

These functions are necessary for supervision of the unused direction in unidirectional path, broadcast and connection based automatic path protection switching applications.

Depending on the network application for a specific equipment, the partition of LCS functions to be supported in active state at the same time may vary in the range 0% to 100%.

The timing signal is provided from the SETS at the T0 reference point.

NOTE – Clarification of the definition of unequipped signal and the use of the term “unequipped” is for further study. Alignment between this Recommendation and Recommendations G.709 and G.803 is needed.

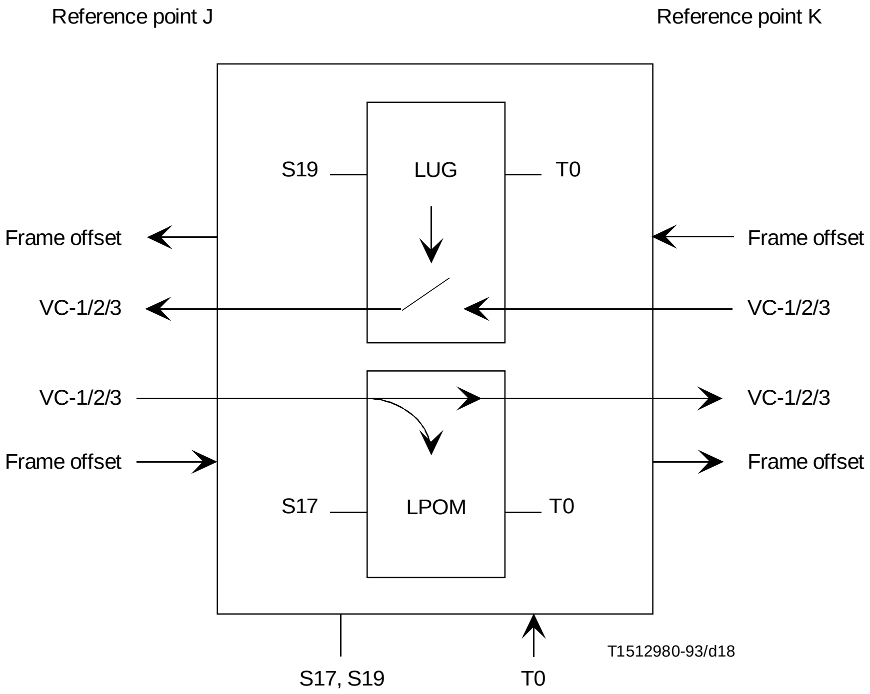


FIGURE 2-18/G.783

Lower order connection supervision function

2.10.1 Signal flow from J to K (LPOM function)

At reference point S17, the following primitives are possible:

- Set active/inactive, which is a request from the SEMF to the LPOM to select either the active or inactive state, as determined by the SEMF request. The LPOM reports its state back to the SEMF (acknowledgement).
- Get active/inactive state, which is a request from the SEMF to the LPOM to report its state to the SEMF.

Active state

Data at J is a VC-*m* (*m* = 11, 12, 2, 3), having a VC-*m* POH and a payload as described in Recommendations G.708 and G.709 or an undefined payload as described in 2.10.2. Parts of the POH bytes are recovered as part of the LPOM sub-function and the VC-*m* is unchanged forwarded to reference point K.

Case of VC-3

Bytes J1, G1 and C2 are recovered from the VC-*m* POH at B and the corresponding information on path trace, path status and signal label are passed via reference point S17 to the synchronous equipment management function.

Byte B3 is recovered from the VC-*m* POH at J. BIP-8 is computed for the VC-*m* frame. The computed BIP-8 value for the current frame is compared with the recovered B3 byte from the following frame and errors are reported at reference point S17 as number of errors within the B3 byte per frame for connection performance monitoring filtering in the synchronous equipment management function.

Case of VC-2, VC-1

Bits 3 to 8 are recovered from the VC-*m* POH (byte V5) at J and the corresponding information on path trace, path status and signal label are passed via reference point S17 to the synchronous equipment management function.

NOTE – Byte J2, lower order path trace, has been provisionally allocated. Defect detection specification is for further study.

Bits 1 to 2 are recovered from the VC-*m* POH (byte V5) at J. BIP-2 is computed for the VC-*m* frame. The computed BIP-2 value for the current frame is compared with the recovered bits 1 to 2 of V5 of the following frame and the number of errors in the block are reported at reference point S17.

Byte Z6 has been provisionally allocated for lower order tandem path monitoring. Its application is for further study; however, its processing will be performed by the LPOM function.

Inactive state

Data at J is transparently passed through to K. The POH is not monitored.

2.10.2 Signal flow from K to J (LUG function)

At reference point S19, the following primitives are possible:

- Set active/inactive, which is a request from the SEMF to the LUG to select either the active or inactive state, as determined by the SEMF request. The LUG reports its state back to the SEMF (acknowledgement).
- Get active/inactive state, which is a request from the SEMF to the LUG to report its state to the SEMF.

Active state

Receiving an "unequipped" signal at reference point K, the Lower order connection Unequipped Generator LUG-*m* (*m* = 11, 12, 2, 3) generates a VC-*m* with full valid POH at reference point J.

Generating a VC-*m* requires the following sequence of operations:

- Generation of a container C-*m* with undefined payload information.
- Generation of a frame offset.
- Setting of the path signal label to "unequipped".
- Derivation of the path trace and path status information from reference point S19 and insertion in the POH bytes J1 and G1 (in the case of VC-3) or V5 (in the case of VC-2/VC-1) according to Recommendation G.709.
- Computation of BIP-8 (VC-3) or BIP-2 (VC-2/VC-1) over all bits of the VC-*m* and insertion in the corresponding position of the following frame.

NOTES

1 Receiving a VC-*m* with a signal label not equal to unequipped at reference point K, the VC-*m* at reference point K is passed through the LCS-*m* to reference point J without modification.

2 Byte J2, lower order path trace, has been provisionally allocated. Its value will be derived from reference point S19.

Inactive state

Data at K is transparently passed through to J.

2.11 Lower order path connection function (LPC-*m*)

LPC-*m* is the function which assigns lower order VCs of level *m* (*m* = 11, 12, 2 or 3) at its input ports to lower order VCs of level *m* at its output ports.

The LPC-*m* connection process is a simple, unidirectional function as illustrated in Figure 2-19. The signal formats at the input and output ports of the function are similar, differing only in the logical sequence of the VC-*m*s. As the process does not affect the nature of the characteristic information of the signal, the reference point on either side of the LPC-*m* function is the same, as illustrated in Figure 2-19.

Incoming VC-*m*s at reference point K are assigned to available outgoing VC-*m* capacity at reference point K. An unequipped VC-*m* (according to 2.3.2/G.709) shall be applied at any outgoing VC-*m* which is not connected to an incoming VC-*m*.

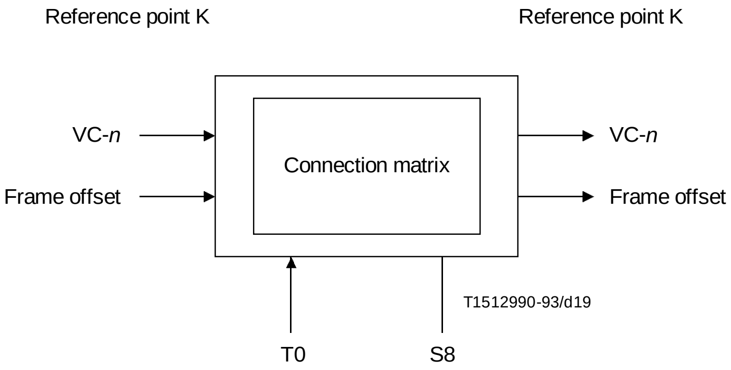


FIGURE 2-19/G.783

General lower order path connection

The assignment of incoming VC-*m*s to outgoing VC-*m*s at reference point K is defined as the "connection pattern" which can be described by an unidirectional connection matrix CM (V_i, V_j), where V_i identifies the i-th incoming VC signal at reference point K and V_j identifies the j-th outgoing VC signal at reference point K. There may be a degree of flexibility in the connection matrix which can be exercised; i.e. the number of fields (V_i, V_j) in the CM representing valid input/output combinations in a particular implementation could be restricted. This is illustrated in 2.11.2.

At reference point S8, the following primitives are possible:

- Set connection matrix, which is a request of the SEMF to the LPC-*n* to assign a particular input port to a particular output port according to the connection matrix (CM). The LPC-*m* reports afterwards the new CM to the SEMF (acknowledgement).
- Get connection matrix, which is a request from the SEMF to the LPC-*m* to report the CM to the SEMF.

A protection switch function may be provided using the LPC-*m*. In that case, an input VC-*m* may be broadcast onto two selected outgoing VC-*m*s; and in the return direction, a selection is performed from the incoming VC-*m*s.

NOTE – Clarification of the definition of unequipped signal and the use of the term "unequipped" is for further study. Alignment between this Recommendation and Recommendations G.709 and G.803 is needed.

2.11.1 Signal flow

There is no signal flow associated with this function. LPC-*m* provides a facility for re-ordering VC-*m* capacity within the signal.

2.11.2 CM configuration examples

Examples of LPC-*m* configurations are the same as the HPC-*n* examples given in 2.7.2, except that they refer to the K reference point rather than the G reference point.

2.12 Lower order path termination function (LPT-*m*)

The LPT-*m* function creates a VC-*m* (*m* = 1, 2, or 3) by generating and adding POH to a container C-*m*. In the other direction of transmission it terminates and processes the POH to determine the status of the defined path attributes. The POH formats are defined in Recommendations G.708 and G.709. The information flows associated with the LPT function are described in Figure 2-20.

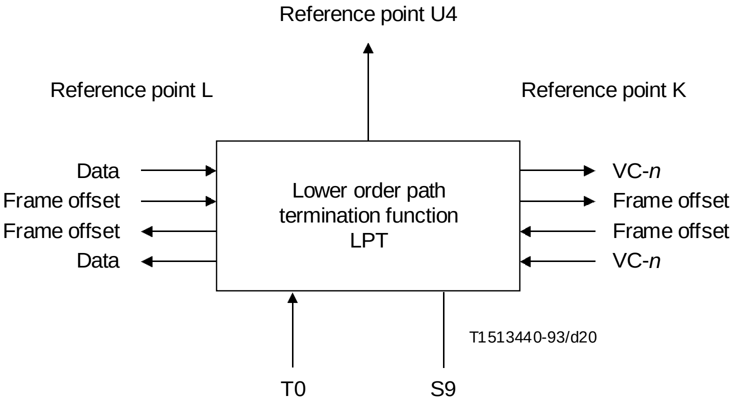


FIGURE 2-20/G.783

Lower order path termination function

Referring to Figure 2-1, data at L takes the form of a container C-*m* (*m* = 1, 2, 3) which is synchronized to the timing reference T0.

Synchronously adapted information in the form of synchronous containers (data) and the associated container frame offset information (frame offset) are received at reference point L. POH is added to form data which together with the frame offset is passed to reference point K.

2.12.1 Path OH at levels 1 and 2

The VC-1/VC-2 POH is carried in the V5 byte as defined in Recommendation G.709.

2.12.1.1 Signal flow from K to L

Bits 5, 6 and 7 of V5 at K shall be detected and reported as signal label at S9.

If five consecutive VC-*m* (*m* = 11, 12, 2) frames contain the “000” pattern in bits 5, 6 and 7 of the V5 byte, an UNEQ defect shall be declared. The UNEQ defect shall be cleared of in five consecutive VC-*n* frames any pattern other than the “000” is detected in bits 5, 6 and 7 of the V5 byte.

The error monitoring bits 1 and 2 of V5 at K shall be recovered. BIP-2 is computed for the VC-*n* frame. The computed BIP-2 value for the current frame is compared with the recovered bits 1 and 2 from the following frame and the number of errors (0, 1 or 2) in bits 1 and 2 of V5 per multiframe shall be reported at S9. Excessive error detection is for further study.

FEBE in bit 3 shall be recovered and reported at S9.

The path FERF information in bit 8 shall be recovered and reported at S9. A persistence check for the detection of path FERF is for further study.

When an unequipped VC (UNEQ), LP trace identifier mismatch (LP-TIM) or an LP signal label mismatch (SLM) is detected, a logical all-ones signal shall be applied at the data signal output at reference point L towards the LPA function within 2 multiframes. Upon termination of the above defect conditions, the logical all-ones signal shall be removed within 2 multiframes.

NOTE – Byte J2, lower order path trace, has been provisionally allocated. Defect detection specification for HP-TIM is for further study.

Bit 4 is passed to the OHA function via the U4 reference point, and is provisionally allocated as a VC-1/VC-2 path Remote Failure Indication (RFI). For applications in which V5 bit 4 is as an RFI, it shall be recovered and reported at S9; otherwise, the receiver must be capable of ignoring the value of this bit.

Byte Z7 has been provisionally allocated as a reserve byte. It shall be passed to the OHA function via the U4 reference point. It is reserved for further study.

2.12.1.2 Signal flow from L to K

The signal label presented at S9 shall be inserted in bits 5, 6 and 7 in the V5 byte.

BIP-2 shall be calculated on data at L on the previous frame or multiframe and the result transmitted in bits 1 and 2 of the V5 byte.

The number of errors detected by monitoring bits 1 and 2 of the V5 byte (see 2.12.1.1) is encoded in the FEBE (bit 3 of the V5 byte) according to Figure 4-2/G.709.

When there is a logical all-ones signal at reference point K, or an LP-TIM or LP-SLM defect is detected at reference point K, LP-FERF indication shall be sent in bit 8 of the V5 byte within two multiframes. Upon termination of the above conditions, the LP-FERF indication shall be removed within two multiframes. Bit 4 of V5 has been provisionally allocated as a Remote Failure Indication (RFI). In the RFI application, its value will be derived from the S9 reference point. In other applications, it can be derived from the U4 reference point.

Byte J2 has been provisionally allocated for lower order path trace. When used, its value will be derived from reference point S9.

Byte Z7 has been provisionally allocated for future use, and can be derived from the U4 reference point.

2.12.2 Path overhead at level 3

The VC-*m* path overhead (for $m = 3$) is the same as the path overhead for VC-*n* ($n = 3$) and is described in 2.8.

2.13 Lower order path adaptation functions (LPA-*m*, LPA-*n*)

LPA operates at the access port to a synchronous network or subnetwork and adapts user data for transport in the synchronous domain. For asynchronous user data, lower order path adaptation involves bit justification. The LPA-*n* ($n = 3$ or 4) function directly maps G.703 signals into a higher order container. The LPA-*m* ($m = 11, 12, 2, 3$) function maps G.703 signals into lower order containers which may subsequently be mapped into higher order containers. The information flows associated with the LPA function are shown in Figure 2-21.

NOTE – Primary rate signals can be mapped directly into higher order paths using the locked mode mappings.

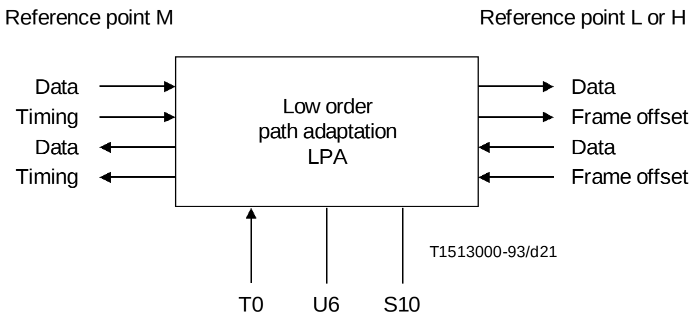


FIGURE 2-21/G.783

Lower order path adaptation function

LPA functions are defined for each of the levels in the existing plesiochronous hierarchies. Each LPA function defines the manner in which a user signal can be mapped into one of a range of synchronous containers C of appropriate size. The container sizes have been chosen for ease of mapping various combinations of sizes into high order containers; see Table 2-8. Detailed specifications for mapping user data into containers are given in Recommendation G.709.

The LPA type is reported on request to the SEMF through the S10 reference point.

TABLE 2-8/G.783

Container sizes

LPA-*m*	LPA-*n*	Container size
LPA-11 bit sync.		C-11
byte sync.		C-11
async.		C-11
locked		C-11
LPA-12 bit sync.		C-12
byte sync.		C-12
async.		C-12
locked		C-12
LPA-2 async.		C-2
LPA-2 sync.		C-2
LPA-3 async.	LPA-3 async.	C-3
	LPA-4 async.	C-4

2.13.1 Signal flow from M to L or H

Data at M is the user information stream delivered by the PPI function. Timing of the data is also delivered as timing at M by the PPI function. Data is adapted according to one of the LPA functions referred to above. This involves synchronization and mapping of the information stream into a container as described in Recommendation G.709.

The container is passed to the reference point L (or H in the case of direct mapping) as data together with frame offset which represents the offset of the container frame with respect to reference point T0. In byte synchronous mappings, the frame offset is obtained from the associated framer. In other mappings, a convenient fixed offset can be generated internally.

Mapping of overhead and maintenance information from byte synchronously mapped G.703 signals is for further study.

Frame alignment loss (FAL) is reported to the synchronous equipment management function through the S10 reference point (byte sync mapping only). The strategy for FAL detection/indication is described in Recommendation G.706.

For the LPA-*n* function in the direction from M to H, one byte per frame is allocated for user communication purposes. It is derived from reference point U6 and placed in the F2 byte position. Byte Z3 is derived from reference point U6, and is reserved for future use. Currently it has no defined value at H.

2.13.2 Signal flow from L or H to M

The information stream data at L (or H in the case of direct mapping) is presented as a container together with frame offset. The user information stream is recovered from the container together with the associated clock suitable for tributary line timing and passed to the reference point M as data and timing. This involves de-mapping and desynchronizing as described in Recommendation G.709.

NOTE – Other signals may be required from L to generate overhead and maintenance information for byte-synchronously mapped G.703 signals. This is for further study.

When AIS is applied at L or H, the LPA function shall generate an all-ones signal (AIS) in accordance with the relevant G.700-Series Recommendations.

For the LPA-*n* function in the direction from H to M, one byte per frame is allocated for user communication purposes. It is derived from the F2 byte and passed via reference point U6 to the overhead access function. Byte Z3 is passed to the OHA function via reference point U6, and is reserved for future use. Currently it has no defined value.

2.14 PDH physical interface (PPI) function

This function provides the interface between the multiplexer and the physical medium carrying a tributary signal which may have any of the physical characteristics of those described in Recommendation G.703 and in some cases the signal structure in Recommendation G.704. The information flows for the PPI function are described with reference to Figure 2-22.

2.14.1 Signal flow from M to tributary interface

The functions performed by the PPI are encoding and adaptation to the physical medium.

The PPI function takes data and timing at M to form the transmit tributary signal. The PPI passes the data and timing information to the tributary interface transparently.

2.14.2 Signal flow from tributary interface to M

The PPI function extracts timing from the received tributary signal and regenerates the data. After decoding, it passes the data and timing information to reference point M. The timing may also be provided at reference point T2 for possible use as a reference in the SETS.

In the event of loss of signal (LOS) at the tributary input, an all-ones (AIS) data signal shall be applied at reference point M accompanied by a suitable reference timing signal within 250 µs. Upon termination of LOS, the all-ones signal shall be terminated within 250 µs. LOS is reported at reference point S11.

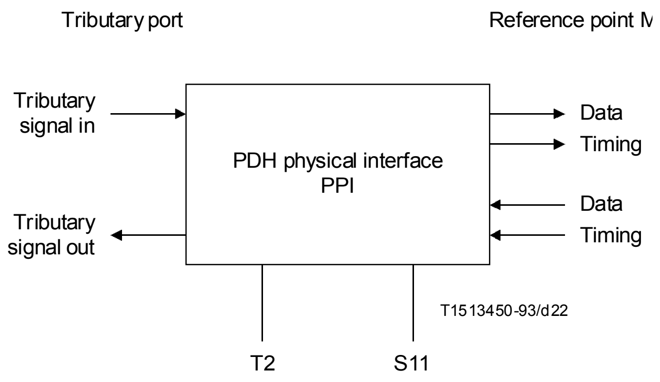


FIGURE 2-22/G.783

PDH physical interface function

3 Compound functions

3.1 Transport terminal function (TTF)

The Transport Terminal Function comprises as a compound function the basic functions SDH Physical Interface (SPI), Regenerator Section Termination (RST), Multiplex Section Termination (MST), Multiplex Section Protection (MSP) and Multiplex Section Adaptation (MSA) as illustrated in Figure 3-1. The basic functions and the information flows across their reference points are described in clause 2.

NOTE – The MSP function enables protection switching of multiplex sections. Since it has the identical information flows at the reference points at both sides, it may be optional or degenerate.

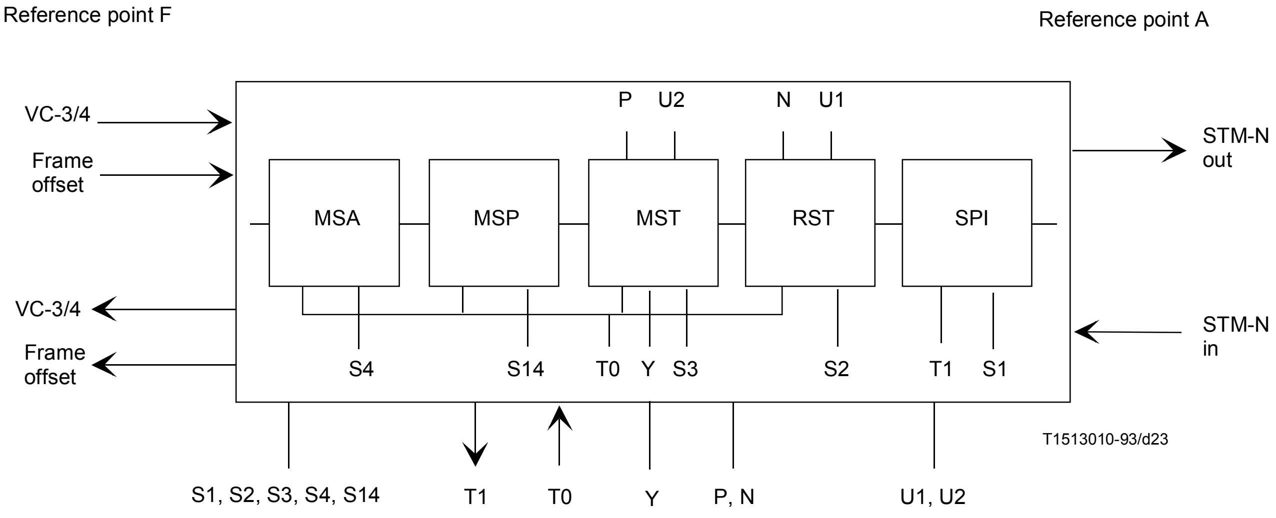


FIGURE 3-1/G.783

Transport terminal function

3.2 Higher order interface (HOI)

The Higher order Interface function comprises as a compound function the basic functions PDH Physical Interface (PPI), Lower order Path Adaptation (LPA) and Higher order Path Termination (HPT) as illustrated in Figure 3-2. The basic functions and the information flows across their reference points are described in clause 2.

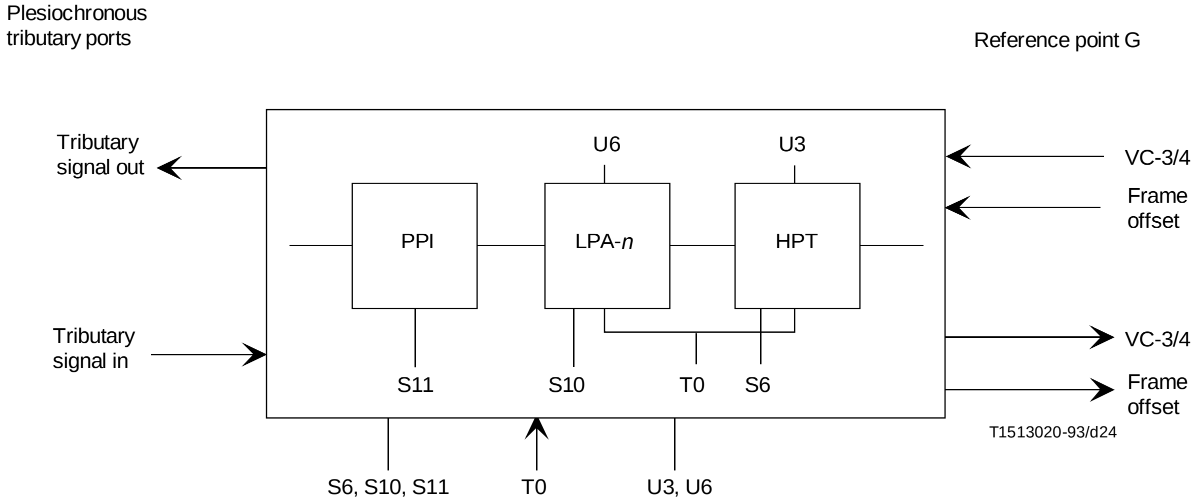


FIGURE 3-2/G.783

Higher order interface function

3.3 Lower order interface (LOI)

The Lower order Interface function comprises as a compound function the basic functions PDH Physical Interface (PPI), Lower order Path Adaptation (LPA) and Lower order Path Termination (LPT) as illustrated in Figure 3-3. The basic functions and the information flows across their reference points are described in clause 2.

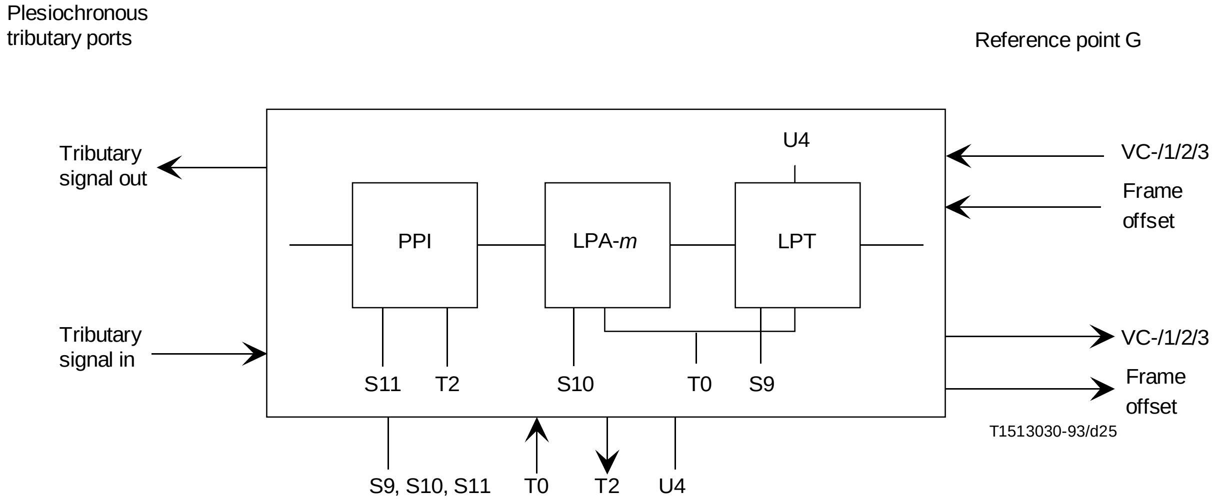


FIGURE 3-3/G.783

Lower order interface function

3.4 Higher order assembler (HOA)

The Higher order Assembler function comprises as a compound function the basic functions Higher order Path Adaptation (HPA) and Higher order Path Termination (HPT) as illustrated in Figure 3-4. The basic functions and the information flows across their reference points are described in clause 2.

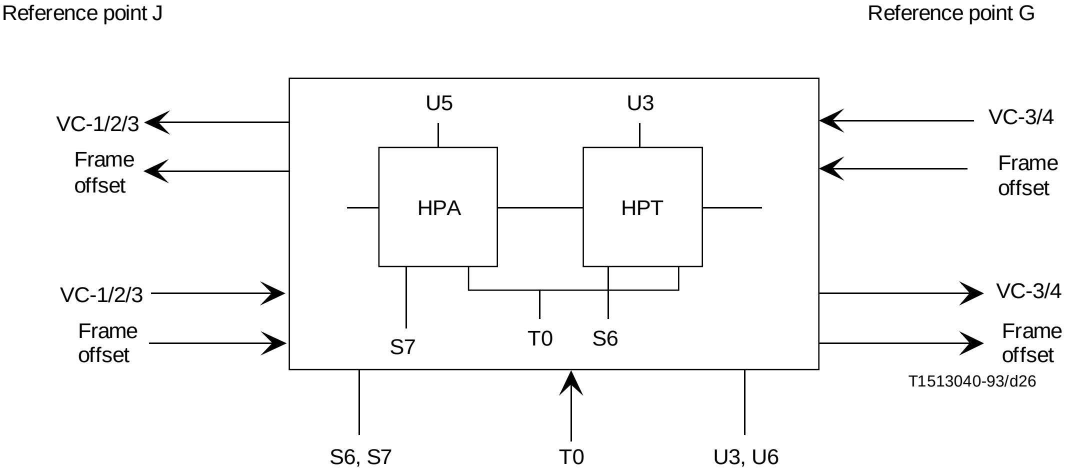


FIGURE 3-4/G.783

Higher order assembler function

4 Synchronous equipment management function

The synchronous equipment management function (SEMF) provides the means through which the synchronous network element function (NEF) is managed by an internal or external manager. If a network element (NE) contains an internal manager, this manager will be part of the SEMF.

The SEMF interacts with the other functional blocks by exchanging information across the S reference points. The SEMF contains a number of filters that provide a data reduction mechanism on the information received across the S reference points. The filter outputs are available to the agent via managed objects which represent this information. The managed objects also present other management information to and from the agent.

Managed objects provide event processing and storage and represent the information in a uniform manner. The agent converts this information to CMISE (common management information service element) messages and responds to CMISE messages from the manager performing the appropriate operations on the managed objects.

This information to and from the agent is passed across the V reference point to the message communications function (MCF).

The event processing and storage provided by the managed objects is described in Recommendation G.784 including the filtering and thresholding of performance and failure information.

In the subsequent sections on the SEMF only the information flowing across the S reference points and the three filters shown in Figure 4-1 is described.

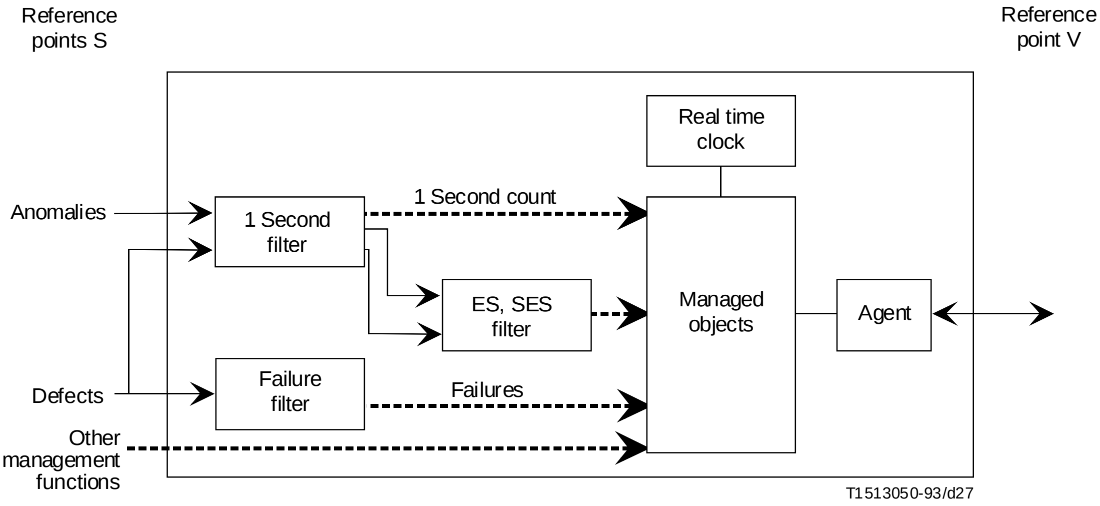


FIGURE 4-1/G.783

Synchronous equipment management function

4.1 Information flow across the S reference points

The information flows described in this subclause are functional. The existence of these information flows in the equipment will depend on the options selected at the external interfaces to the equipment, in particular, the options selected by the TMN.

The information that arises from anomalies and defects detected in the functional blocks is summarized in Tables 4-1 to 4-16. For ease of reference these tables also show the consequent actions that are described in the clauses on the individual functional blocks.

Table 4-17 summarizes the configuration and provisioning information that is passed across the S reference points. The information listed under Set in this table refers to configuration and provisioning data that is passed from the SEMF to the other functional blocks. The information listed under Get refers to status reports made in response to a request from the SEMF for such information.

As an example we may consider the higher order path trace. The higher order path termination may be provisioned for the HO path trace that it should expect by a “Set_Rx_HO_path_trace_ID” command received from the manager. If the HO path trace that is received does not match the expected HO path trace, this will give rise to a report of a mismatch of the HO path trace across the S6 reference point. Having received this mismatch indication, the relevant managed object may then decide to request a report of the HO path trace ID that has been received by a “Get_Rx_HO_path_trace_ID”.

4.2 Filter functions

NOTE – Fixed one second filter processing of the information is considered satisfactory for the purpose of network surveillance and fault identification and sectionalization. This does not preclude the additional use of other filter processing techniques for detailed performance or fault characterization where it is demonstrated that these provide significant additional information on the nature of errored events. If an alternative filter technique is used, it should be in addition to the fixed one second filter.

The filtering functions provide a data reduction mechanism on the anomalies and defects presented at the S reference points. Three types of filters can be distinguished:

4.2.1 One second filters

The one second filters perform a simple integration of reported anomalies by counting during a one second interval. At the end of each one second interval the contents of the counters may be obtained by the relevant managed objects. The following counter outputs will be provided:

- regenerator section (B1) errors;
- regenerator section out of frame (OOF) events;
- multiplex section (B2) errors;
- HO path (B3) errors;
- path errors (B3/V5);
- HO path far-end block errors (G1);
- path far-end block errors (G1/V5);
- AU pointer justification events (detailed specification for further study).

In addition, defects are filtered by the one second filter for performance monitoring purposes.

4.2.2 Failure filter

The defect to failure filter will provide a persistency check on the defects that are reported across the S reference points. Since all of the defects will appear at the input of this filter it may provide correlation to reduce the amount of information offered as failure indications to the agent. The following failure indications will be provided:

- loss of signal;
- loss of frame;
- loss of AU pointer;
- loss of TU pointer;
- multiplex section AIS;
- AU-AIS;
- TU-AIS;
- multiplex section far-end receive failure;
- HP-FERF;
- LP-FERF, etc. (as listed in Tables 4-1 to 4-13 in the anomalies and defects column).

In addition to the transmission failures listed above, equipment failures are also reported at the output of the defect filter for further processing by the agent.

4.2.3 ES, SES filter

The ES, SES filter processes the information available from the one second filter to derive errored seconds and severely errored seconds that are reported to the agent.

ES and SES information will be made available for all the parameters listed in 4.2.1 above, except justification events. In addition, information will be provided on out of frame (OOF) seconds; an OOF second is defined as a second in which one or more out of frame events have occurred.

TABLE 4-1/G.783

SDH physical interface

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions
		S1	Alarm	Performance	All-ones (AIS) inserted
From A to B	Receive loss of signal	Yes	Yes		Yes (Note 1)
From B to A	Transmit fail (Note 2)	Yes	Yes		
	Transmit degraded (Note 2)	Yes		Yes	

NOTES

1 At reference point C.

2 Applicable for optical interfaces only.

TABLE 4-2/G.783

Regenerator section termination

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions
		S2	Alarm	Performance	All-ones (AIS) inserted at C
From B to C	Loss of frame	Yes	Yes		Yes (Note)
	Out of frame events	Yes		Yes	
	Number of errors in B1	Yes		Yes	

NOTE – This is also applicable for D1-D3 to MCF via reference point N and E1, F1, and unused bytes in RSOH to OHA function via reference point U1.

TABLE 4-3/G.783

Multiplex section termination

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions	
		S3	Alarm	Performance	MS-FERF inserted at C	All-ones (AIS) inserted at D
From C to D	Multiplex section AIS	Yes	Yes	Yes	Yes	Yes (Note 1)
	Excessive errors (B2)	Yes	Yes	Yes (Note 2)	Yes (Note 2)	Yes (Notes 1, 2)
	Signal degrade (B2)	Yes	Yes			
	Number of errors in B2	Yes		Yes		
	MS-FERF	Yes	Yes	Yes		

NOTES

1 This is also applicable for D4-D12 to MCF via reference point P and E2, Z1, Z2 and unused bytes in MSOH, to OHA function via reference point U2.

2 It should be possible to disable the insertion of FERF, AIS and the contribution to the PM process on the excessive errors (B2) defect detection by configuration from the SEMF.

TABLE 4-4/G.783

Multiplex section protection

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions
		S14	Alarm	Performance	Selector released
From D to E	Mismatch of sent and received K2 [5]	Yes	Yes		Yes
	Mismatch sent K1 [5-8] and received K2 [1-4]	Yes	Yes		Yes
	Protection mux section in SF condition (Note)				Yes
	PSE	Yes		Yes	

NOTE – Section signal fail: LOS or LOF or excessive errors (B2) or MS-AIS.

TABLE 4-5/G.783

Multiplex section adaptation

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions
		S4	Alarm	Performance	All-ones (AIS) inserted at F
From E to F	Loss of AU pointer	Yes	Yes		Yes
	AU-AIS	Yes	Yes		Yes
	AU pointer justification events (Note 1)	Yes		Yes	
From F to E	Incoming all-ones (AIS) (Note 2)				Yes

NOTES

1 AU PJEs need only be reported for one selected AU-3/4 of an STM-N signal. Positive and negative events shall be reported separately.

2 This incoming all-ones (AIS) signal is due to all-ones insertion on AU-AIS or AU-LOP detection in the MSA function (direction E to F).

TABLE 4-6/G.783

Higher order path connection

Status	Report across	SEMF filtering	Consequent actions
	S5		unequipped VC inserted at G
Output V_j not connected to input V_i			Yes

TABLE 4-7/G.783

Higher order path termination

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions		
		S6	Alarm	Performance	HP-FERF inserted at G	All-ones (AIS) inserted at H	FEBE inserted at G
From G to H	Incoming all-ones (AIS) (Note 1)			Yes	Yes	(Note 3) (Note 2)	
	HP-TIM ID (J1)	Yes	Yes	Yes	Yes	Yes (Note 2)	
	HP-SLM (C2)	Yes	Yes	Yes	Yes	Yes	
	HP-Unequipped VC indication	Yes				Yes	
	HP-FERF (G1 [5])	Yes	Yes	Yes			
	Number of errors in B3	Yes		Yes			Yes
	HP-FEBE (G1 [1-4])	Yes		Yes			

NOTES

1 This incoming all-ones (AIS) signal is due to AU-AIS or AU-LOP detection in the MSA function.

2 This is also applicable for Z4 and Z5 to OHA function (via U3).

3 All-ones (AIS) at reference point H is implicitly applied (passed through) when all-ones (AIS) is applied at reference point G.

TABLE 4-8/G.783

Higher order path adaptation

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions
		S7	Alarm	Performance	All-ones (AIS) inserted at J
From H to J	Loss of TU pointer	Yes	Yes		Yes
	TU-AIS	Yes	Yes		Yes
	Loss of TU multiframe (H4) (Note 1)	Yes	Yes	Yes	Yes (Note 2)
From J to H	Incoming all-ones (AIS) (Note 3)				Yes

NOTES

1 This is only required for HO paths with payloads that require the use of the multiframe indication.

2 Not applicable for TU-3 and optional for TU-1 and TU-2.

3 This incoming all-ones (AIS) signal is due to all-ones insertion on TU-AIS or TU-LOP detection in the HPA function (direction H to J).

TABLE 4-9/G.783

Lower order path connection

Status	Report across	SEMF filtering	Consequent actions
	S8		Unequipped VC inserted at K
Output V_j not connected to input V_i			Yes

TABLE 4-10/G.783

Lower order path termination

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions		
		S9	Alarm	Performance	LP-FERF inserted at K	All-ones (AIS) inserted at L	LP-FEBE inserted at K
From K to L	Incoming all-ones (AIS) (Note 1)			Yes	Yes	(Note 3) (Note 2)	
	LP-TIM (J1/J2)	Yes	Yes	Yes	Yes	Yes (Note 2)	
	LP-SLM (C2/V5 [5-7])	Yes	Yes	Yes	Yes	Yes	
	LP Unequipped VC indication	Yes				Yes	
	LP-FERF (G1 [5]/V5 [8])	Yes	Yes	Yes			
	B3/V5 [1-2] errors	Yes		Yes			Yes
	LP-FEBE (G1 [1-4]/V5 [3])	Yes		Yes			

NOTES

1 This all-ones (AIS) signal is due to TU-AIS or TU-LOP detection in the HPA function.

2 This is also applicable for signals to OHA function (via U4).

3 All-ones (AIS) at reference point L is implicitly applied (passed through) when all-ones (AIS) is applied at reference point K.

TABLE 4-11/G.783

Lower order path adaptation

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions
		S10	Alarm	Performance	All-ones (AIS) inserted
From L or H to M	AIS (Note 1)				Yes
From M to L or H	Frame alignment loss (Note 2)	Yes	Yes		Yes

NOTES

1 Passed on from the HPT/LPT function.

2 For byte synchronous mappings only.

TABLE 4-12/G.783

PDH physical interface

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions
		S11	Alarm	Performance	All-ones (AIS) inserted at tributary interface
From M to tributary interface	AIS (Note)				Yes
From tributary interface to M	Loss of incoming tributary signal	Yes	Yes		Yes

NOTE – Passed on from LPA function.

TABLE 4-13/G.783

Synchronous equipment timing physical interface

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions
		S12	Alarm	Performance	
From synchronization interface to T3	Loss of signal	Yes	Yes		

TABLE 4-14/G.783

Higher order path overhead monitor

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions (Note 2)	
		S16	Alarm	Performance	HP-FERF inserted in HUG	HP-FEBE inserted in HUG
From F to G	Incoming all-ones (AIS) (Note 1)			Yes	Yes	
	HP-TIM (J1)	Yes	Yes	Yes	Yes	
	HP-SLM (C2)	Yes	Yes	Yes	Yes	
	HP-FERF (G1 [5])	Yes	Yes	Yes		
	Number of errors B3	Yes		Yes		Yes
	HP-FEBE (G1 [1-4])	Yes		Yes		

NOTES

1 This incoming all-ones (AIS) signal is due to AU-AIS or AU-LOP detection in the MSA function.

2 Only if HUG is in the "active" state and the VC-*n* received from the HPC at reference point G contains a signal label equal to "unequipped".

TABLE 4-15/G.783

Lower order path overhead monitor

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions (Note 2)	
		S17	Alarm	Performance	LP-FERF inserted in LUG	LP-FEBE inserted in LUG
From J to K	Incoming all-ones (AIS) (Note 1)			Yes	Yes	
	LP-TIM (J1, J2)	Yes	Yes	Yes	Yes	
	LP-SLM (C2/V5 [5-7])	Yes	Yes	Yes	Yes	
	LP-FERF (G1 [5]/V [8])	Yes	Yes	Yes		
	Number of errors in B3/V5 [1-2]	Yes		Yes		Yes
	LP-FEBE (G1 [1-4]/V5 [3])	Yes		Yes		

NOTES

1 This incoming all-ones (AIS) signal is due to TU-AIS or TU-LOP detection in the HPA function.

2 Only if LUG is in the “active” state and the VC-*m* received from the HPC at reference point G contains a signal label equal to “unequipped”.

TABLE 4-16/G.783

Synchronous equipment timing source

Signal flow	Anomalies and defects	Report across	SEMF filtering		Consequent actions
		S15	Alarm	Performance	
From T1, T2, or T3 to T0	Loss of all incoming timing references		Yes		

TABLE 4-17/G.783

Command, configuration and provisioning information flow over S reference points

S reference point	Get	Set
S1 (SPI)	ALS implemented	
	ALS enabled/disabled	ALS enabled/disabled
	Transmitter output on/off	Transmitter output on/off
S2 (RST)		
S3 (MST)		Enable/Disable AIS, FERF, and performance monitoring contribution on excessive errors
S4 (MSA)		Type of HO path multiplexer
S5 (HPC)	Connection matrix	Connection matrix
S6 (HPT)	Rx HO path trace ID (J1)	Tx HO path trace ID (J1) at G
	Rx HO path signal label (C2)	Tx HO path signal label (C2) at G
		Rx HO path trace ID
		Rx HO path signal label
		HO path type (3, 4)
S7 (HPA)		Type of path multiplex
S8 (LPC)	Connection matrix	Connection matrix
S9 (LPT)	Rx LO path trace ID (J1, J2)	Tx LO path trace ID (J1, J2) at K
	Rx LO path signal label (C2, V5 [5-7])	Tx LO path signal label (C2, V5 [5-7]) at K
		Rx LO path trace ID
		Rx LO path signal label
		LO path type (11, 12, 2, 3)
S10 (LPA)	LPA type	LPA type (12 bit sync, 11 byte sync, etc.)
S11 (PPI)		
S12 (SETPI)		
S13 (OHA)		
S14 (MSP)		Type of operation
	Switch status	Switch commands

TABLE 4-17/G.783 *(end)*

Command, configuration and provisioning information flow over S reference points

S reference point	Get	Set
S15 (SETS)	Input status	
	Input selected	Select input
	SETG status	
	SETG selected	Select SETG
	Input fall-back order	Input fall-back order
S16 (HPOM)	Active/inactive status	Select active/inactive
		HO path type (3,4)
	Rx HO path trace ID (J1) at F	Rx HO path trace ID (J1) at F
	Rx HO path signal label (C2) at F	Rx HO path signal label (C2) at F
S17 (LPOM)	Active/inactive status	Select active/inactive
		LO path type (11, 12, 2, 3)
	Rx LO path trace ID (J1, J2) at J	Rx LO path trace ID (J1, J2) at J
	Rx LO path signal label (C2/V5 [5-7]) at J	Rx LO path signal label (C2/V5 [5-7]) at J
S18 (HUG)	Active/inactive status	Select active/inactive
		Tx HO path trace ID (J1) at F
		Tx HO path signal label (C2) at F
		Tx HO path type
S19 (LUG)	Active/inactive status	Select active/inactive
		Tx LO path trace ID (J1, J2) at J
		Tx LO path signal label (C2/V5 [5-7]) at J
		Tx LO path type

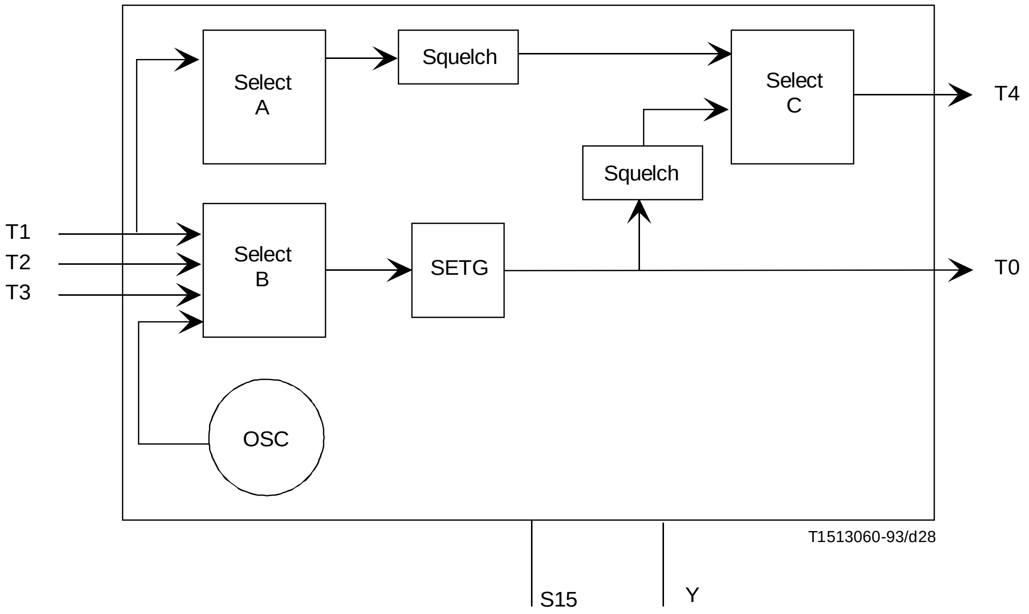
5 Timing functions

5.1 Synchronous equipment timing source function

This function provides timing reference to the following functional blocks: LPA, LPT, LPC, LCS, HPA, HPT, HPC, HCS, MSA, MSP, MST, and RST. The synchronous equipment timing source (SETS) function represents the SDH network element clock. The SETS function includes an internal oscillator function and synchronous equipment timing generator (SETG) function. The information flows associated with the SETS function are described with reference to Figure 5-1.

The synchronization source may be selected from any of the reference points T1, T2, T3 or the internal oscillator. When the SETS is synchronized to a signal carrying a network frequency reference standard the short-term stability requirements at the T0 reference points are specified in Figure 5-2.

Loss of all incoming timing references (LTI) (T1, T2 and T3) shall be reported to the SEMF at reference point S15.



SETG	Synchronous Equipment Timing Generator function
OSC	Internal Oscillator function

NOTES

1 There may be more than one signal at T1, T2 or T3 reference points.

2 The SETG may be replicated.

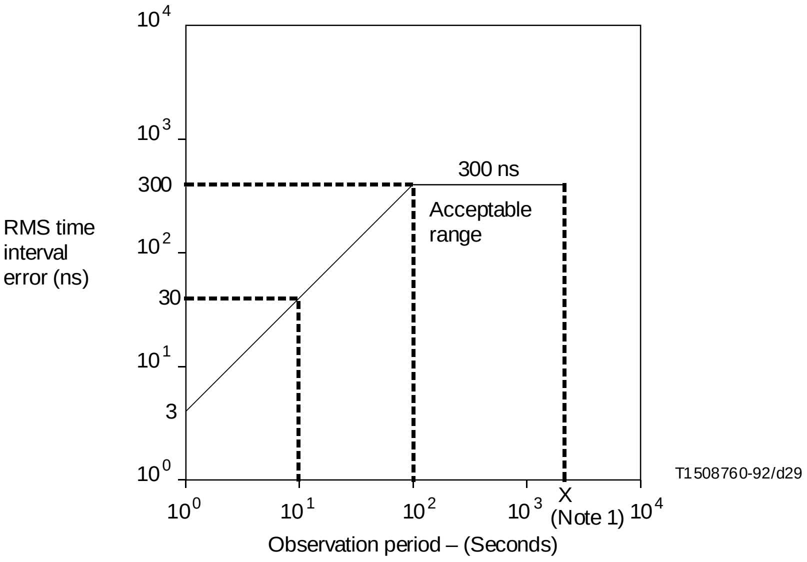
3 Selection criteria for selectors A and B are for further study.

4 Selector C is provisioned by external commands.

5 Criteria for squelching, i.e. inhibiting the signal, are for further study.

FIGURE 5-1/G.783

Synchronous equipment timing source function



NOTES

1 The upper time limit (X) is for further study.

2 The test conditions to verify the performance of the MTS to meet this mask are for further study.

3 An RMS measurement is considered appropriate since clock disturbances are considered to have a white noise characteristic.

FIGURE 5-2/G.783

Clock short-term stability requirements

The SETG function filters the selected timing reference to ensure that the timing requirements at the T reference points are met. Additionally, the SETG filtering function must filter the step change in frequency caused by a change in reference source. This applies to the following three cases:

– change from one reference source to another;

– change from reference source to the internal oscillator;

– change from the internal oscillator to a reference source.

In practice, the last change will be the worst case. A specification for the transient response of the SETG after a change in reference source is for further study.

The long- and short-term stability of the internal oscillator function is for further study.

NOTES

1 The maximum rate of change of frequency must be tracked by the desynchronizer at the SDH/PDH boundary. This will put an upper bound on the rate for practical desynchronizer designs.

2 Desynchronizers must be designed to allow for maximum frequency offset of the internal oscillator. This may set an upper bound on its stability for some desynchronizer designs.

3 Synchronization status messages will be provided over the Y reference point. Details are for further study.

The synchronization signal at reference point T4 may be selected from the filtered timing reference, i.e. the SETG output, or from one of the signals at reference point T1.

The overall quality requirements of the SETS are under study.

5.2 Synchronous equipment timing physical interface (SETPI) function

This function provides the interface between the external synchronization signal and the synchronous equipment timing source and shall have, at the synchronization interface port, the physical characteristics of one of the G.703 synchronization interfaces. (See Figure 5-3.) The 2048 kHz synchronization interface port shall be according to clause 10/G.703. The case of 1544 kHz is for further study.

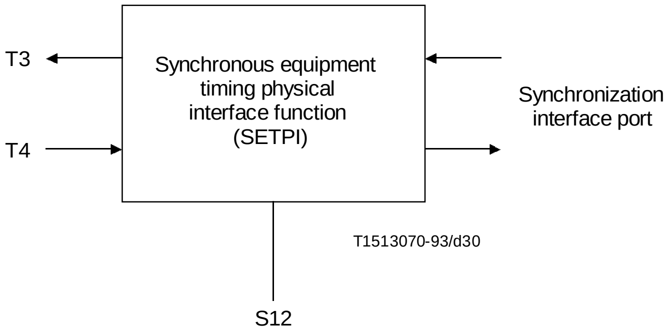


FIGURE 5-3/G.783

Synchronous equipment timing physical interface

5.2.1 Signal flow from SETS to synchronization interface

This signal flow only exists if the SETS can provide external synchronization.

The functions performed by the SETPI are encoding and adaptation to the physical medium.

The SETPI function takes timing at reference point T4 from the SETS to form the transmit synchronization signal. The SETPI passes the timing information to the synchronization interface transparently.

5.2.2 Signal flow from synchronization interface to SETS

The SETPI function extracts timing from the received synchronization signal. After decoding, it passes timing information to the SETS.

6 Specification of jitter and wander

SDH jitter and wander is specified at both STM-N and G.703 interfaces. The SDH equipment's jitter and wander characteristics at such interfaces may be categorized in terms of whether:

- its jitter and wander performance is governed exclusively by the input timing extraction circuitry;
- tributary bit justification is performed in addition to input timing extraction;
- phase smoothing of pointer justifications is performed as well as tributary bit justification and input timing extraction.

In addition, the wander encoded in both the AU and TU pointer adjustments is specified. (This determines the statistics of occurrence of pointer adjustments.)

6.1 STM-N interfaces

6.1.1 Input jitter and wander tolerance

Jitter present on the STM-N signal must be accommodated by the SPI. The detailed parameters and limits are given in Recommendation G.958.

The STM-N signal may be used to synchronize the synchronous equipment timing source (SETS), which must be able to accommodate the maximum absolute jitter and wander present on the STM-N signal. This will be primarily affected by wander, and can be specified in terms of maximum time interval error (MTIE), together with its first and second derivatives with respect to time. The detailed parameters and limits are for further study.

6.1.2 Output jitter and wander generation

The output jitter and wander must meet the short-term stability requirements given in Figure 5-2.

When the synchronous equipment timing source is used, the output jitter and wander depends on the inherent properties of the synchronous equipment timing generator as well as the properties of the synchronization input.

When the equipment is loop-timed, the output jitter and wander depends on the incoming jitter and wander as filtered by the jitter and wander transfer characteristics described in 6.1.3.

Further requirements for wander can be specified in terms of MTIE, together with its first and second derivatives with respect to time. The specification of output jitter depends on the demarcation between jitter and wander. The output jitter should be less than or equal to 0.01 UI r.m.s as measured in a 12 kHz high pass filter. A second output jitter requirement as measured in a lower frequency high pass filter is for further study. The measurement technique needs to be specified.

6.1.3 Jitter and wander transfer

The jitter and wander transfer is dependent on whether the equipment is synchronized and the manner in which it is synchronized.

When the equipment is not synchronized, the jitter and wander transfer characteristics have no meaning as the output jitter and wander is determined solely by the internal oscillator.

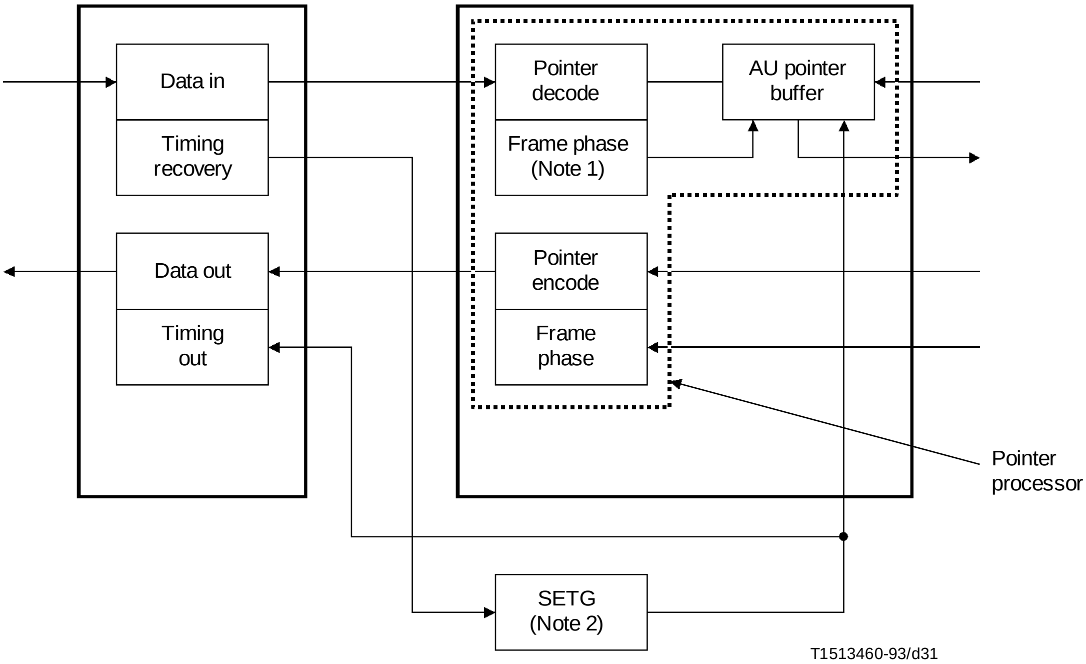
When the equipment is synchronized, the jitter and wander transfer characteristics are determined by the filtering characteristics of the synchronous equipment timing generator (SETG). These filtering characteristics may vary depending on whether the equipment is loop timed or uses a synchronous equipment timing source. Figure 6-1 provides a block diagram of timing functions for SDH equipment using loop timing.

The jitter transfer characteristics (specifically, the ratio of the output jitter to the applied input jitter as a function of frequency) can be tested using sinusoidal input jitter. It should be noted that this may not adequately test some non-linear timing generator implementations. The introduction of some new tests based on broad-band jitter may help to characterize such implementations.

Detailed specifications are for further study.

6.1.4 Transfer of wander encoded in AU and TU pointer adjustments

The transfer of wander encoded in the AU and TU pointer adjustments is controlled by the AU and TU pointer processors, respectively. Wander is affected by the difference between the incoming phase and the fill within the pointer processor buffer. The larger the buffer spacing, the less likely that incoming pointer adjustments will result in outgoing pointer adjustments.



NOTES

1 This element provides both frame phase and gapped clock to the buffer.

2 The characteristics of this synchronous equipment timing generator may be different from those used in a SETS.

FIGURE 6-1/G.783

Block diagram of timing functions for synchronous equipment using loop timing

6.1.4.1 AU pointer processor buffer threshold spacing

The MTIE of the higher-order VC with respect to the clock generating the STM-N frame is quantized and encoded in the AU pointer. When a higher-order VC is transferred from an STM-N to another STM-N derived from a different clock, the AU pointer must be processed. The pointer is first decoded to derive the frame phase and a clock to write to the AU pointer processor buffer. The read clock from the buffer is derived from the synchronous equipment timing source. The buffer fill is monitored and when upper or lower thresholds are crossed, the frame phase is adjusted.

The allocation in the pointer processor buffer for pointer hysteresis threshold spacing should be at least 12 bytes for AU-4 and at least 4 bytes for AU-3 [corresponding to maximum relative time interval error (MRTIE) of 640 ns between reference point T0 and the incoming STM-N line signal].

6.1.4.2 TU pointer processor buffer threshold spacing

The MTIE of the lower-order VC with respect to the clock generating the higher-order VC is quantized and encoded in the TU pointer. When a lower-order VC is transferred from one higher-order VC into another higher-order VC derived from a different clock, the TU pointer must be processed. The pointer is first decoded to derive the frame phase and a clock to write to the TU pointer processor buffer. The read clock from the buffer is derived from the synchronous equipment timing source. The buffer fill is monitored and when upper or lower thresholds are crossed, the frame phase is adjusted.

The allocation in the pointer processor buffer for pointer hysteresis threshold spacing should be at least 4 bytes for TU-3s and at least 2 bytes for TU-1s and TU-2s.

6.2 G.703 interfaces

6.2.1 Input jitter and wander tolerance

Input jitter and wander tolerance for 2048 kbit/s hierarchy based signals are specified in Recommendation G.823. Input jitter and wander tolerance of 1544 kbit/s hierarchy based signals are specified in Recommendations G.824, G.743, and G.752.

NOTE – It may be necessary to specify transmit and receive separately for multi-vendor systems.

6.2.2 Jitter and wander transfer

As a minimum requirement, the jitter transfer specifications in any corresponding plesiochronous equipment Recommendations must be met.

NOTES

1 Equipment jitter and wander transfer may be difficult to specify for multi-vendor systems. Desynchronizer jitter and wander transfer may be more amenable to specification.

2 The above-mentioned specifications are not sufficient to assure that SDH equipment provide adequate overall jitter and wander attenuation. Specifically, attenuation of the jitter and wander arising from decoded pointer adjustments places more stringent requirements on the SDH desynchronizer transfer characteristic.

6.2.3 Jitter and wander generation

6.2.3.1 Jitter and wander from tributary mapping

Specifications for jitter arising from mapping G.703 tributaries into containers, described in Recommendation G.709, should be specified in terms of peak-to-peak amplitude over a given frequency band over a given measurement interval. Detailed specifications are for further study.

NOTE – Tributary mapping jitter is measured in the absence of pointer adjustments. The output jitter from a 2048 kbit/s synchronizer, in the absence of input jitter and pointer activity, shall not exceed 0.35 UI pk-pk when measured through a digital 10 Hz low pass filter (representing an ideal desynchronizer) followed by a measurement filter which has a high pass corner frequency of 20 Hz and a 20 dB/decade slope.

The output wander should be specified in terms of MTIE together with its first and second derivatives with respect to time. The need for and details of this specification are for further study.

6.2.3.2 Jitter and wander from pointer adjustments

The jitter and wander arising from decoded pointer adjustments must be sufficiently attenuated to ensure that existing plesiochronous network performance is not degraded. Detailed specifications are for further study.

6.2.3.3 Combined jitter and wander from tributary mapping and pointer adjustments

The combined jitter arising from tributary mapping and pointer adjustments should be specified in terms of peak-to-peak amplitude over a given frequency band, under application of representative specified pointer adjustment test sequences, for a given measurement interval. This interval is dependent on the test sequence duration and number of repetitions. A key feature that must be considered in the specification of the effects of pointer adjustments on G.703 interfaces is the demarcation between jitter and wander. Thus, a critical feature is the high-pass filter characteristics. The limits for each G.703 tributary interface and the corresponding filter characteristics for mapping jitter are given in Table 6-1. The limits for combined jitter specification are given in Table 6-2.

Two tests for wander may be necessary; one with a single pole HPF and another with a double pole high pass filter in order to differentiate between the first and second derivatives of MTIE. Detailed specifications are for further study.

The values in Tables 6-1 and 6-2 are only valid if all network elements providing the path are maintained in synchronization. Values under loss of synchronization are for further study.

TABLE 6-1/G.783

Mapping jitter generation specification

		Filter characteristics (Note 3)			Maximum pk-pk jitter	
G.703 inter-face	Bit rate range	f1 high pass	f3 high pass	f4 low pass	Mapping	
					f1-f4	f3-f4
1544 kbit/s		10 Hz 20 dB/dec	(Note 1)	40 kHz –20 dB/dec	(Note 1)	(Note 1)
2048 kbit/s		20 Hz 20 dB/dec	18 kHz (700 Hz) 20 dB/dec	100 kHz –20 dB/dec	(Note 1)	0.075 UI
6312 kbit/s		(Note 1)	(Note 1)	60 kHz –20 dB/dec	(Note 1)	(Note 1)
34 368 kbit/s		100 Hz 20 dB/dec	10 kHz 20 dB/dec	800 kHz –20 dB/dec	(Note 1)	0.075 UI
44 736 kbit/s		(Note 1)	(Note 1)	400 kHz –20 dB/dec	(Note 1)	(Note 1)
139 264 kbit/s		200 Hz 20 dB/dec	10 kHz 20 dB/dec	3500 kHz –20 dB/dec	(Note 1)	(Note 2)

NOTES

1 These values are for further study.

2 For further study. A value of 0.075 UI has been proposed.

3 The frequency value shown in parenthesis only applies to certain national interfaces.

TABLE 6-2/G.783

Combined jitter generation specification

		Filter characteristics (Note 5)			Maximum pk-pk jitter	
G.703 interface	Bit rate range	f1 high pass	f3 high pass	f4 low pass	Combined	
					f1-f4	f3-f4
1544 kbit/s		10 Hz 20 dB/dec	(Note 1)	40 kHz –20 dB/dec	1.5 UI	(Note 1)
2048 kbit/s		20 Hz 20 dB/dec	18 kHz (700 Hz) 20 dB/dec	100 kHz –20 dB/dec	0.4 UI (Note 2)	0.075 UI (Note 2)
6312 kbit/s		(Note 1)	(Note 1)	60 kHz –20 dB/dec	1.5 UI	(Note 1)
34 368 kbit/s		100 Hz 20 dB/dec	10 kHz 20 dB/dec	800 kHz –20 dB/dec	0.4 UI 0.75 UI (Note 3)	0.075 UI (Note 3)
44 736 kbit/s		(Note 1)	(Note 1)	400 kHz –20 dB/dec	(Note 1)	(Note 1)
139 264 kbit/s		200 Hz 20 dB/dec	10 kHz 20 dB/dec	3500 kHz –20 dB/dec	(Note 4)	(Note 4)

NOTES

1 These values are for further study.

2 The limit corresponds to pointer sequences in Figure 6-2 a), b), c). T2 > 0.75 seconds, T3 = 2 ms.

3 The 0.4 UI and 0.075 UI limits correspond to pointer sequences in Figure 6-2 a), b), c). The 0.75 UI limit corresponds to the pointer sequence in Figure 6-2 d). T2 and T3 values are for further study. It is assumed that pointer adjustments of opposite polarities are well spread in time, i.e. the periods between adjustments are greater than the desynchronizer time constant.

4 For further study. Values according to Note 3 have been proposed.

5 The frequency value shown in parenthesis only applies to certain national interfaces.

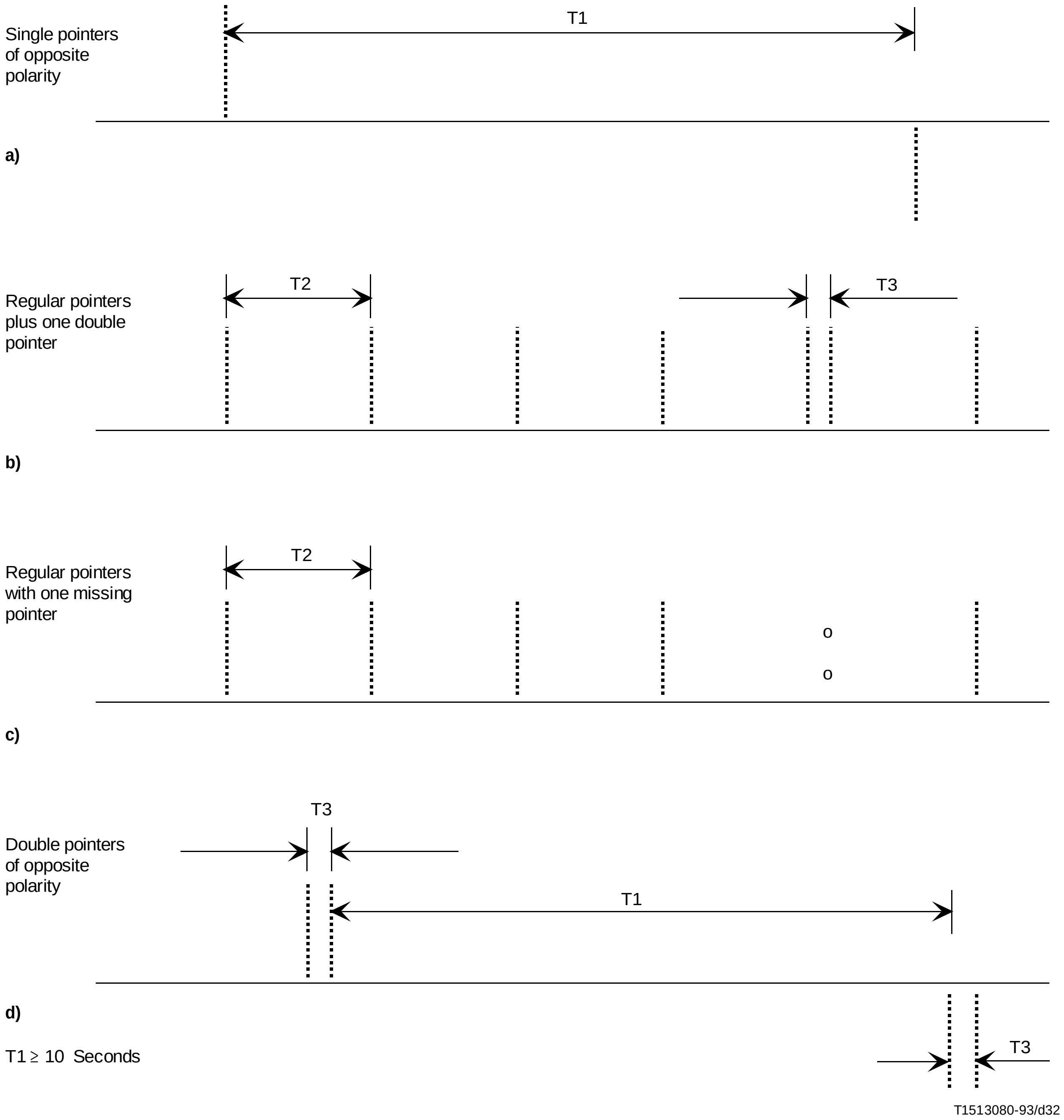


FIGURE 6-2/G.783

Pointer test sequences

7 Overhead access function

In SDH equipment, it may be required to provide access in an integrated manner to transmission overhead functions. This subject is for further study in ITU-T. The present Recommendation defines the U reference points across which information may be exchanged with the other functional blocks.

A particular overhead access function which may be included in SDH NEs is the order-wire function which is used to provide voice contact between SDH NEs for maintenance personnel.

The orderwire function of the OHA block shall be to accept E1 and E2 bytes from the U1 and U2 reference points and present them as data channels at one or more external interfaces as described in Table 7-1.

The use of multiplexed order wire interfaces for NEs terminating a number of order wire channels is for further study.

TABLE 7-1/G.783

Orderwire interface

Bit rate (kbit/s)	Interface standard	Synchronization	Frame structure
64	G.703	Codirectional	Bit 1 of E1/E2 byte in STM-N frame corresponds to bit 1 in the 64 kbit/s channel

Annex A

Multiplex section protection (MSP) protocol, commands and operation

(This annex forms an integral part of this Recommendation)

A.1 MSP protocol

The MSP functions, at the ends of a multiplex section, make requests for and give acknowledgments of switch action by using the MSP bytes (K1 and K2 bytes in the MSOH of the protection section). The bit assignments for these bytes and the bit-oriented protocol are defined as follows.

A.1.1 K1 byte

The K1 byte indicates a request of a channel for switch action.

Bits 1-4 indicate the type of request, as listed in Table A.1. A request can be:

1) a condition (SF and SD) associated with a section. A condition has high or low priority. The priority is set for each corresponding channel;

2) a state (wait-to-restore, do not revert, no request, reverse request) of the MSP function; or

3) an external request (lockout of protection, forced or manual switch, and exercise).

Bits 5-8 indicate the number of the channel for which the request is issued, as shown in Table A.2.

A.1.2 K1 byte generation rules

Local SF and SD conditions, WTR or do not revert state and the external request are evaluated by a priority logic, based on the descending order of request priorities in Table A.1. If local conditions (SF or SD) of the same level are detected on different sections at the same time, the condition with the lowest channel number takes priority. Of these evaluated requests, the one of the highest priority replaces the current local request, only if it is of higher priority.

A.1.2.1 In bi-directional operation

The priorities of the local request and the remote request on the received K1 byte are compared according to the descending order of priorities in Table A.1. Note that a received reverse request is not considered in the comparison.

The sent K1 shall indicate:

a) a reverse request if

  i) the remote request is of higher priority, or if

  ii) the requests are of the same level and the sent K1 byte already indicates reverse request, or if

  iii) the requests are of the same level and the sent K1 byte does not indicate reverse request and the remote request indicates a lower channel number;

b) the local request in all other cases.

TABLE A-1/G.783

Types of request

Bits 1234	Condition, state or external request	Order
1111	Lockout of protection (Note 1)	Highest
1110	Forced switch	|
1101	Signal fail high priority	|
1100	Signal fail low priority	|
1011	Signal degrade high priority	|
1010	Signal degrade low priority	|
1001	Unused (Note 2)	|
1000	Manual switch	|
0111	Unused (Note 2)	|
0110	Wait-to restore	|
0101	Unused (Note 2)	|
0100	Exercise	|
0011	Unused (Note 2)	|
0010	Reverse request	|
0001	Do not revert	|
0000	No request	Lowest

NOTES

1 Only channel number 0 is allowed with a Lockout of Protection request.

2 Some network operators may use these codes for network specific purposes. The receiver shall be capable of ignoring these codes.

3 Requests are selected from the table, depending on the protection switching arrangements; i.e. in any particular case, only a subset of the requests may be required.

TABLE A.2/G.783

K1 channel number

Channel number	Requesting switch action
0	Null channel (no working channel or extra traffic channel). Conditions and associated priority (fixed high) apply to the protection section.
1-14	Working channel (1-14) Conditions and associated priority (high or low) apply to the corresponding working sections. For 1 + 1, only working channel 1 is applicable with fixed high priority.
15	Extra traffic channel Conditions are not applicable. Exists only when provisioned in a 1 : n architecture.

A.1.2.2 In unidirectional operation

The sent K1 byte shall always indicate the local request. Therefore, reverse request is never indicated.

A.1.3 Revertive/non-revertive modes

In revertive mode of operation, when the protection is no longer requested, i.e. the failed section is no longer in SD or SF condition (and assuming no other requesting channels), a local wait-to-restore state shall be activated. Since this state becomes the highest in priority, it is indicated on the sent K1 byte, and maintains the switch on that channel. This state shall normally time out and become a no request null channel (or no request channel 15, if applicable). The wait-to-restore timer deactivates earlier if the sent K1 byte no longer indicates wait-to-restore, i.e. when any request of higher priority pre-empts this state.

In non-revertive mode of operation, applicable only to 1 + 1 architecture, when the failed working section is no longer in SD or SF condition, the selection of that channel from protection is maintained by activating a do not revert state or a wait-to-restore state rather than a no request state.

Both wait-to-restore and do not revert requests in the sent K1 byte are normally acknowledged by a reverse request in the received K1 byte. However, no request is acknowledged by another no request received.

A.1.4 K2 byte

Bits 1-5 indicate the status of the bridge in the MSP switch (see Figures A.1 and A.2). Bits 6 to 8 are reserved for future use to implement drop and insert (nested) switching. Note that codes 111 and 110 will not be assigned for such use, since they are used for MS-AIS detection and MS-FERF indication.

Bits 1-4 indicate a channel number, as shown in Table A.3. Bit 5 indicates the type of the MSP architecture: set 1 indicates 1 : n architecture and set 0 indicates 1 + 1 architecture.

A.1.5 K2 byte generation rules

The sent K2 byte shall indicate in bits 1 to 4, for all architectures and operation modes:

a) null channel (0) if the received K1 byte indicates either null channel or the number of a locked-out working channel;

b) the number of the channel which is bridged, in all other cases.

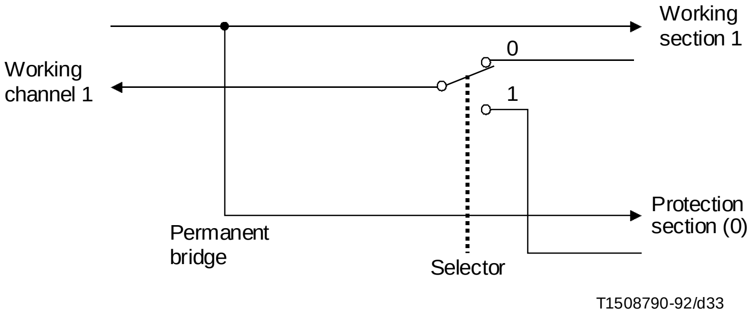


FIGURE A.1/G.783

MSP Switch – 1 + 1 architecture example (shown in released position)

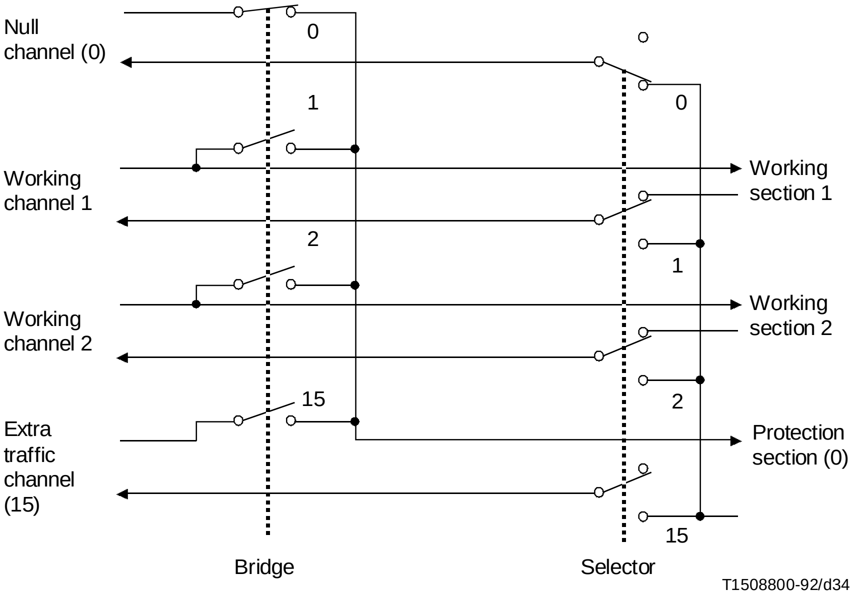


FIGURE A.2/G.783

MSP Switch – 1 : n architecture example (shown in released position)

TABLE A.3/G.783

K2 channel number

Channel number	Indication
0	Null channel
1-14	Working channel (1-14) For 1 + 1, only working channel 1 is applicable.
15	Extra traffic channel Exists only when provisioned in a 1 : n architecture.

The sent K2 byte shall indicate in bit 5:

a) 0 if 1 + 1 architecture;

b) 1 if 1 : n architecture.

Bit 5 of the sent and received K2 bytes may be compared; if a mismatch persists for Y ms, a mismatch is indicated at reference point S14. A provisional value for Y is 50 ms.

A.1.6 Control of the bridge

In 1 : n architecture, the channel number indicated on the received K1 byte controls the bridge. If, at the bridge end, the protection section is in SF condition, the bridge is:

a) frozen (current bridge maintained), if the operation is unidirectional;

b) released, if the operation is bi-directional.

In 1 + 1 architecture, the working channel 1 is permanently bridged to protection.

A.1.7 Control of the selector

In 1 + 1 architecture in unidirectional operation, the selector is controlled by the highest priority local request. If the protection section is in SF condition, the selector is released.

In 1 + 1 architecture in bi-directional operation, and in 1 : n architecture, the selector is controlled by comparing the channel numbers indicated on received K2 and sent K1 bytes. If there is a match, then the indicated channel is selected from the protection section. If there is a mismatch, the selector is released. Note that a match on 0000 also releases the selector. If the mismatch persists for Y ms, a mismatch is indicated at reference point S14. If the protection section is in SF condition, the selector is released and the mismatch indication is disabled.

A.1.8 Transmission and acceptance of MSP bytes

Byte K1 and bits 1 to 5 of byte K2 shall be transmitted on the protection section. Although they may also be transmitted identically on working sections, receivers should not assume so, and should have the capability to ignore this information on the working sections.

MSP bytes shall be accepted as valid only when identical bytes are received in three consecutive frames.

A detected failure of the received K1 or K2 is considered as equivalent to an SF condition on the protection section.

A.2 MSP commands

The MSP function receives MSP control parameters and switch requests from the synchronous equipment management function at the S14 reference point. A switch command issues an appropriate external request at the MSP function. Only one switch request can be issued at S14. A control command sets or modifies MSP parameters or requests the MSP status.

A.2.1 Switch commands

Switch commands are listed below in the descending order of priority and the functionality of each is described.

1) *Clear* – Clears all switch commands listed below.

2) *Lockout of protection* – Denies all working channels (and the extra traffic channel, if applicable) access to the protection section by issuing a lockout of protection request.

3) *Forced switch #* – Switches working channel # to the protection section, unless an equal or higher priority switch command is in effect or SF condition exists on the protection section, by issuing a forced switch request for that channel.

   NOTE 1 – For 1 + 1 non-revertive systems, forced switch no working channel transfers the working channel from protection to the working section, unless an equal or higher priority request is in effect. Since forced switch has higher priority than SF or SD on the working section, this command will be carried out regardless of the condition of the working section.

4) *Manual switch #* – Switches working channel # to the protection section, unless a failure condition exists on other sections (including the protection section) or an equal or higher priority switch command is in effect, by issuing a manual switch request for that channel.

   NOTE 2 – For 1 + 1 non-revertive systems, manual switch no working channel transfers the working channel back from protection to the working section, unless an equal or higher priority request is in effect. Since manual switch has lower priority than SF or SD on a working section, this command will be carried out only if the working section is not in SF or SD condition.

5) *Exercise #* – Issues an exercise request for that channel and checks responses on MSP bytes, unless the protection channel is in use. The switch is not actually completed, i.e. the selector is released by an exercise request on either the sent or the received and acknowledged K1 byte. The exercise functionality may not exist in all MSP functions.

Note that a functionality and a suitable command for freezing the current status of the MSP function is for further study.

A.3 Switch operation

A.3.1 1 : n bi-directional switching

Table A.4 illustrates protection switching action between two multiplexer sites, denoted by A and C, of a 1 : n bi-directional protection switching system, shown in Figure 2-6/G.782.

When the protection section is not in use, null channel is indicated on both sent K1 and K2 bytes. Any working channel may be bridged to the protection section at the head end. The tail end must not assume or require any specific channel. In the example in Table A.4, working channel (Wch) 3 is bridged at site C, and Wch 4 is bridged at site A.

When a fail condition is detected or a switch command is received at the tail end of a multiplex section, the protection logic compares the priority of this new condition with the request priority of the channel (if any) on the protection. The comparison includes the priority of any bridge order; i.e. of a request on received K1 byte. If the new request is of higher priority, then the K1 byte is loaded with the request and the number of the channel requesting use of the protection section. In the example, SD is detected at C on working section 2, and this condition is sent on byte K1 as a bridge order at A.

At the head end, when this new K1 byte has been verified (after being received identically for three successive frames) and evaluated (by the priority logic), byte K1 is set with a reverse request as a confirmation of the channel to use the protection and order a bridge at the tail end for that channel. This initiates a bi-directional switch. Note that a reverse request is returned for exerciser and all other requests of higher priority. This clearly identifies which end originated the switch request. If the head end had also originated an identical request (not yet confirmed by a reverse request) for the same channel, then both ends would continue transmitting the identical K1 byte and perform the requested switch action.

Also, at the head end, the indicated channel is bridged to protection. When the channel is bridged, byte K2 is set to indicate the number of the channel on protection.

At the tail end, when the channel number on received byte K2 matches the number of the channel requesting the switch, that channel is selected from protection. This completes the switch to protection for one direction. The tail end also performs the bridge as ordered by byte K1 and indicates the bridged channel on byte K2.

TABLE A.4/G.783

1 : n bi-directional protection switching example

Failure condition or controller state	APS bytes				Action	
	C → A		A → C			
	Byte K1	Byte K2	Byte K1	Byte K2	At C	At A
No failures (protection section not in use)	00000000	00001000	00000000	00001000	Wch 3 is bridged onto protection to provide a valid signal. Selector is released	Wch 4 is bridged onto protection to provide a valid signal. Selector is released
Working section 2 degraded in direction A → C	10100010	00001000	00000000	00001000	Failure detected. Order Wch 2 bridge – SD	
	10100010	00001000	00100010	00101000		Bridge Wch 2. Reverse order Wch 2 bridge
	10100010	00101000	00100010	00101000	Switch Wch 2. Bridge Wch 2	
	10100010	00101000	00100010	00101000		Switch Wch 2. Bi-directional switch completed
Working section 1 failed in direction C → A (This pre-empts the Wch 2 switch)	10100010	00101000	11000001	00101000		Failure detected. Order Wch 1 bridge – SF. Release Wch 2 switch
	00100001	00011000	11000001	00101000	Bridge Wch 1. Reverse order Wch 1 bridge. Release Wch 2 switch	
	00100001	00011000	11000001	00011000		Switch Wch 1. Bridge Wch 1
	00100001	00011000	11000001	00011000	Switch Wch 1. Bi-directional switch completed	

TABLE A.4/G.783 *(end)*

1 : n bi-directional protection switching example

Failure condition or controller state	APS bytes				Action	
	C → A		A → C			
	Byte K1	Byte K2	Byte K1	Byte K2	AT C	AT A
Working section 1	00100001	00011000	01100001	00011000		Wait to restore
Repaired (Working section 2 still degraded)	10100010	00011000	01100001	00011000	Order Wch 2 bridge. Release Wch 1 switch	
	10100010	00011000	00100010	00101000		Bridge Wch 2. Reverse order Wch 2 bridge. Release Wch 1 switch
	10100010	00101000	00100010	00101000	Bridge Wch 2. Switch Wch 2	
	10100010	00101000	00100010	00101000		Switch Wch 2. Bi-directional switch completed
Working section 2 repaired	01100010	00101000	00100010	00101000	Wait to restore Wch 2	
Wait to restore expired (no failures)	00000000	00101000	00100010	00101000	Drop Wch 2 bridge order. Release Wch 2 switch	
	00000000	00101000	00000000	00001000		Drop Wch 2 bridge Drop. Drop Wch 2 bridge order. Release Wch 2 switch
	00000000	00001000	00000000	00001000	Drop Wch 2 bridge (Wch 3 is bridged)	(Wch 4 is bridged)

The head end completes the bi-directional switch by selecting the channel from protection when it receives a matching K2 byte.

If the switch is not completed because the requested/bridged channels did not match within 50 ms, the selectors would remain released and the failure of the protocol would be indicated. This may occur when one end is provisioned as unidirectional and the other as bi-directional. A mismatch may also occur when a locked-out channel at one end is not locked out at the other. Note that a mismatch may also occur when a 1 + 1 architecture connects to a 1 : 1 architecture (which is not in a provisioned for 1 + 1 state), due to a mismatch of bit 5 on K2 bytes. This may be used to provision the 1 : 1 architecture to operate as 1 + 1.

The example further illustrates a priority switch, when an SF condition on working section 1 pre-empts the Wch 2 switch. Note that selectors are temporarily released before selecting Wch 1, due to temporary channel number mismatch on sent K1 and received K2 bytes. Further in the example, switching back Wch 2 after failed section 1 is repaired is illustrated.

When the switch is no longer required, e.g. the failed working section has recovered from failure and wait-to-restore has expired, the tail end indicates No Request for null channel on byte K1 (00000000). This releases the selector due to channel number mismatch.

The head end then releases the bridge and replies with the same indication on byte K1 and null channel indication on byte K2. The selector at the head end is also released due to mismatch.

Receiving null channel on K1 byte causes the tail end to release the bridge. Since the K2 bytes now indicate null channel which matches the null channel on the K1 bytes, the selectors remain released without any mismatch indicated, and restoration is completed.

A.3.2 1 : n unidirectional switching

All actions are as described in A.3.1 except that the unidirectional switch is completed when the tail end selects from protection the channel for which it issued a request. This difference in operation is obtained by not considering remote requests in the priority logic and therefore not issuing reverse requests.

A.3.3 1 + 1 unidirectional switching

For 1 + 1 unidirectional switching, the channel selection is based on the local conditions and requests. Therefore each end operates independently of the other end, and bytes K1 and K2 are not needed to coordinate switch action. However, byte K1 is still used to inform the other end of the local action, and bit 5 of byte K2 is set to zero.

A.3.4 1 + 1 bi-directional switching

The operation of 1 + 1 bi-directional switching can be optimized for a network in which 1 : n protection switching is widely used and which is therefore based on compatibility with a 1 : n arrangement; alternatively it can be optimized for a network in which predominantly 1 + 1 bi-directional switching is used. This leads to two possible switching operations described below.

A.3.4.1 1 + 1 bi-directional switching compatible with 1 : n bi-directional switching

Bytes K1 and K2 are exchanged as described in A.3.1 to complete a switch. Since the bridge is permanent, i.e. working channel number 1 is always bridged, Wch 1 is indicated on byte K2, unless received K1 indicates null channel (0). Switching is completed when both ends select the channel, and may take less time because K2 indication does not depend on a bridging action.

For revertive switching, the restoration takes place as described in A.3.1. For non-revertive switching, Table A.5 illustrates the operation of a 1 + 1 bi-directional protection switching system, shown in Figure 2-5/G.782.

For non-revertive operation, assuming the working channel is on protection, when the working section is repaired, or a switch command is released, the tail end maintains the selection and indicates do not revert for Wch 1. The head end also maintains the selection and continues indicating reverse request. The do not revert is removed when pre-empted by a failure condition or an external request.

TABLE A.5/G.783

Example of 1 + 1 bi-directional switching compatible with 1 : n bi-directional switching

Failure condition or controller state	APS bytes				Action	
	C → A		A → C			
	Byte K1	Byte K2	Byte K1	Byte K2	At C	At A
No failures (assume protection section not in use)	00000000	00000000	00000000	00000000	Selector is released	Selector is released
Working section 1 failed in direction A → C	11010001	00000000	00000000	00000000	Failure detected. Order Wch 1 bridge – SF	
	11010001	00000000	00100001	00010000		Indicate Wch 1 bridged. Reverse order Wch 1 bridge
	11010001	00010000	00100001	00010000	Indicate Wch 1 bridged. Switch Wch 1	
	11010001	00010000	00100001	00010000		Switch Wch 1. Bi-directional switch completed
Working section 1 repaired. Maintain switch (non-revertive)	00010001	00010000	00100001	00010000	Send Do not revert	
Protection section degraded in direction A → C	10110000	00010000	00100001	00000000	Failure detected. Order null ch bridge – SD. Release Wch 1 switch	
	10110000	00010000	00100000	00000000		Reverse order null ch bridge. Drop Wch 1 bridge. Release Wch 1 switch
	10110000	00000000	00100000	00000000	Drop Wch 1 bridge	
Protection section repaired	00000000	00000000	00100000	00000000	Send no request	

A.3.4.2 1 + 1 bi-directional switching optimized for a network using predominantly 1 + 1 bi-directional switching

Bytes K1 and K2 are exchanged to complete a switch. Since the bridge is permanent, the traffic is always bridged to the working and protection channel. Byte K2 indicates the number of the channel which is carrying the traffic, i.e. the working channel. Therefore the channel number on byte K2 will be changed after switching is completed. Note that for this mode of operation, the use of channel numbers may differ from the description in A.1. Switching is completed when both the receive end switches select the channel and receive no request.

For non-revertive switching, Table A.6 illustrates the operation of a 1 + 1 bi-directional protection switching system, using channel numbers 1 and 2.

TABLE A.6/G.783

Example of 1 + 1 bi-directional switching optimized for a network using predominantly 1 + 1 bi-directional switching

Failure/switch conditions	APS bytes				Action	
	C → A		A → C			
	Byte K1	Byte K2	Byte K1	Byte K2	At C	At A
No fault condition traffic on channel 1	00000000	00010000	00000000	00010000		
Signal fail on channel 1 at side C	11000001	00010000	00000000	00010000		Switch to channel 2
	11000001	00010000	00100001	00010000	Switch to channel 2	
Signal fail on channel 1 at side C cleared and persistence check	01100001	00010000	00100001	00010000		
Wait to restore expires	00000000	00100000	00100001	00010000		
	00000000	00100000	00000000	00100000		

Annex B

Algorithm for pointer detection

(This annex forms an integral part of this Recommendation)

B.1 Pointer interpretation

The pointer processing algorithm can be modelled by a finite state machine. Within the pointer interpretation algorithm three states are defined (as shown in Figure B.1):

- NORM_state;
- AIS_state;
- LOP_state.

The transitions between the states will be consecutive events (indications), e.g. three consecutive AIS indications to go from NORM_state to the AIS_state. The kind and number of consecutive indications activating a transition is chosen such that the behaviour is stable and insensitive to bit errors.

The only transition on a single event is the one from the AIS_state to the NORMAL_state after receiving an NDF enabled with a valid pointer value.

It should be noted that, since the algorithm only contains transitions based on consecutive indications, this implies that non-consecutively received invalid indications do not activate the transitions to the LOP_state.

The following events (indications) are defined:

- Norm_point: Normal NDF AND match of ss bits AND offset value in range.
- NDF_enable: NDF enabled AND match of ss bits AND offset value in range.
- AIS_ind: 11111111 11111111.
- Incr_ind: Normal NDF AND match of ss bits AND majority of I bits inverted AND no majority of D bits inverted AND previous NDF_enable, incr_ind or decr_ind more than 3 times ago.
- Decr_ind: Normal NDF AND match of ss bits AND majority of D bits inverted AND no majority of I bits inverted AND previous NDF_enable, incr_ind or decr_ind more than 3 times ago.
- Inv_point: Any other OR norm_point with offset value not equal to active offset.

NOTE 1 – Active offset is defined as the accepted current phase of the VC in the NORM_state and is undefined in the other states.

NOTE 2 – NDF enabled is equal to 1001, 0001, 1101, 1011, 1000.

NOTE 3 – Normal NDF is equal to 0110, 1110, 0010, 0100, 0111.

The transitions indicated in the state diagram are defined as follows:

- Inc_ind/dec_ind: Offset adjustment (increment or decrement indication).
- 3 x norm_point: Three consecutive equal norm_point indications.
- NDF_enable: Single NDF_enable indication.
- 3 x AIS_ind: Three consecutive AIS indications.
- N x inv_point: N consecutive inv_point (8 ≤ ≤N ≤ ≤10).
- N x NDF_enable: N consecutive NDF_enable (8 ≤ ≤N ≤ ≤10).

NOTE 4 – The transitions from NORM to NORM do not represent changes of state but imply offset changes.

NOTE 5 – 3 x norm_point takes precedence over N x inv_point.

NOTE 6 – In some applications interworking with North American countries may require that the ss-bits in the AU-n pointer be ignored.

B.2 Concatenated payloads

In case of contiguous concatenations, the algorithm to verify the presence of a Concatenation Indicator instead of a normal pointer can be described conveniently in the same way as for a normal pointer. This is shown by the state diagram of Figure B.2. Again, three states have been described:

- CONC_state;
- LOPC_state;
- AISC_state.

The following events (indications) are defined:

- Conc_ind: NDF enabled + dd 1111111111.
- AIS_ind: 11111111 11111111.
- Inv_point: Any other.

NOTE – dd bits are unspecified in Recommendation G.709 and are therefore don’t care for the algorithm.

The transitions indicated in the state diagram are defined as follows:

- 3 x AIS_ind: Three consecutive AIS indications.
- N x inv_point: N consecutive inv_point (8 ≤ ≤N ≤ ≤10).
- 3 x conc_ind: Three consecutive conc_ind.

A failure in one or more of the AUs and TUs of a concatenated payload should be reported across the S reference point as a single failure. Two types of failures can be reported:

- Loss of pointer;
- Path AIS.

A Loss of pointer failure is defined as a transition of the pointer interpreter from the NORM_state to the LOP_state or the AIS_state, or a transition from the CONC_state to the LOPC_state or AISC_state in any concatenated AU/TU. In case both the pointer interpreter is in the AIS_state and the concatenation indicators of all concatenated AU/TUs are in the AISC_state, an AU/TU-AIS failure will be reported. These failures will be reported across the S reference point for alarm filtering at the SEMF.

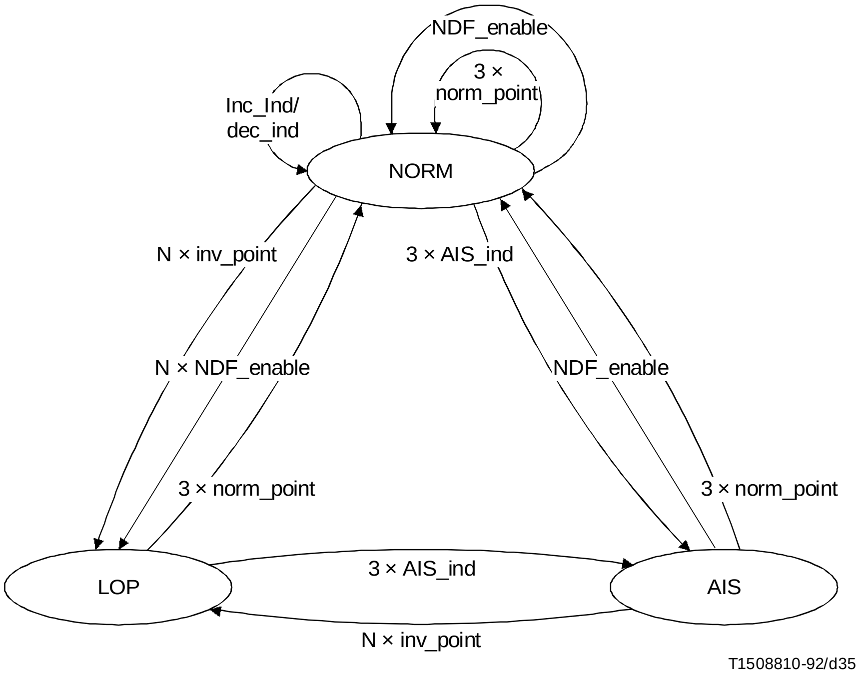


FIGURE B.1/G.783

Pointer interpretation state diagram

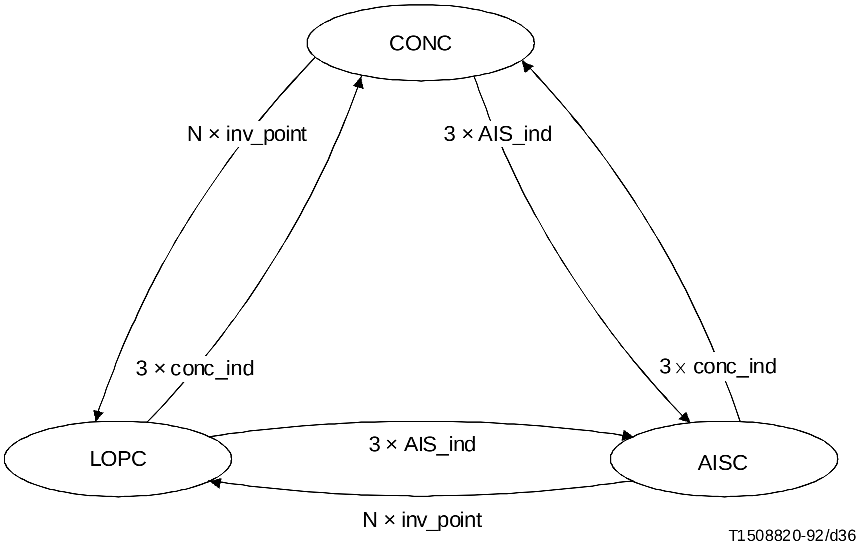


FIGURE B.2/G.783

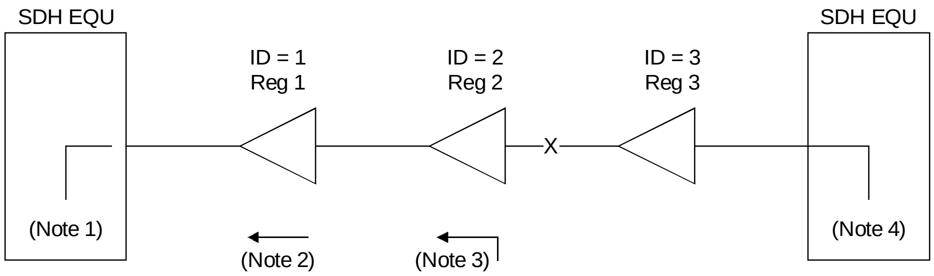
Concatenation indicator state diagram

Appendix I

Example of F1 byte usage

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

The F1 byte can be used to identify a failed section in a chain of regenerator sections. When a regenerator detects a failure in its section, it inserts the regenerator number and the status of its failure into the F1 byte. Figure I.1 illustrates the procedure.



NOTES

1 The SDH equipment detects alarms and transmits them to the operations centre via the TMN.

2 If the regenerator status is normal, it should transfer F1 unchanged.

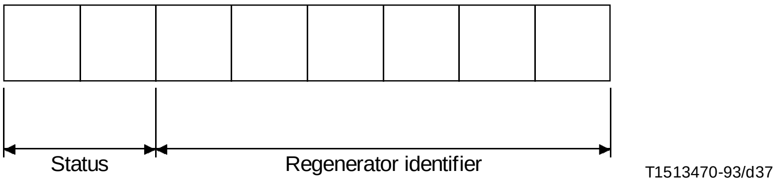
3 If Reg 2 detects REC, MAJ ERR, or ERR MON on the upstream side, then it sends the position and status information on the downstream side using the F1 byte.

These alarms are defined as follows:

REC	Loss of frame alignment or loss of signal.
MAJ ERR	B1 error rate exceeds threshold.
ERR MON	B1 error rate goes below threshold.

4 “Normal” is inserted into F1 byte.

a) Identification of failure



00	Normal
01	MAJ ERR
10	REC
11	ERR MON

b) Definition of F1 byte

FIGURE I.1/G.783

Procedure for F1 byte

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