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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital terminal equipments – Principal characteristics of multiplexing equipment for the synchronous digital hierarchy

Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks

ITU-T Recommendation G.783

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ITU-T Recommendation G.783

Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks

Summary

This Recommendation specifies both the components and the methodology that should be used in order to specify SDH functionality of network elements; it does not specify an individual SDH equipment as such.

This Recommendation forms part of a suite of Recommendations covering the full functionality of network equipment. Those Recommendations are ITU-T Recs G.806 [13] (Conventions and Generic Equipment Functions), G.783, G.705 (PDH functions) [5], G.781 [9] (Synchronization functions), G.784 (Management function) [10] and I.732 (ATM functions) and follow the principles defined in ITU-T Rec. G.803 [11].

This Recommendation specifies a library of basic building blocks and a set of rules by which they may be combined in order to describe a digital transmission equipment. The library comprises the functional building blocks needed to specify completely the generic functional structure of the Synchronous Digital Hierarchy. In order to be compliant with this Recommendation, equipment needs to be describable as an interconnection of a subset of these functional blocks contained within this Recommendation. The interconnections of these blocks should obey the combination rules given.

The specification method is based on functional decomposition of the equipment into atomic, and compound functions. 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.

Not every atomic function defined in this Recommendation is required for every application. Different subsets of atomic functions may be assembled in different ways according to the combination rules given in this Recommendation to provide a variety of different capabilities. Network operators and equipment suppliers may choose which functions must be implemented for each application.

Source

ITU-T Recommendation G.783 was approved on 6 February 2004 by ITU-T Study Group 15 (2001-2004) under the ITU-T Recommendation A.8 procedure.

FOREWORD

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

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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ITU-T Recommendation G.783

Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks

1 Scope

This Recommendation defines a library of basic building blocks and a set of rules by which they may be combined in order to describe a digital transmission equipment. The library comprises the functional building blocks needed to specify completely the generic functional structure of the Synchronous Digital Hierarchy. These building blocks are illustrated in Figure 1-1. In order to be compliant with this Recommendation, equipment needs to be describable as an interconnection of a subset of these functional blocks contained within this Recommendation. The interconnections of these blocks should obey the combination rules given.

This Recommendation defines both the components and the methodology that should be used in order to specify SDH processing; it does not define an individual SDH equipment as such.

The specification method is based on functional decomposition of the equipment into atomic and compound functions. The equipment is then described by its Equipment Functional Specification (EFS) which lists the constituent atomic and compound functions, their interconnection, and any overall performance objectives (e.g., transfer delay, availability, etc.).

The internal structure of the implementation of this functionality (equipment design) need not be identical to the structure of the functional model, as long as all the details of the externally observable behavior comply with the EFS.

The equipment functionality is consistent with the SDH multiplexing structure given in ITU-T Rec. G.707/Y.1322.

Equipment developed prior to the production of this version of the Recommendation may not comply in all details with this Recommendation.

Equipment which is normally stated to be compliant with this Recommendation may not fulfil all the requirements where it is interworking with old equipment that is not compliant with this Recommendation.

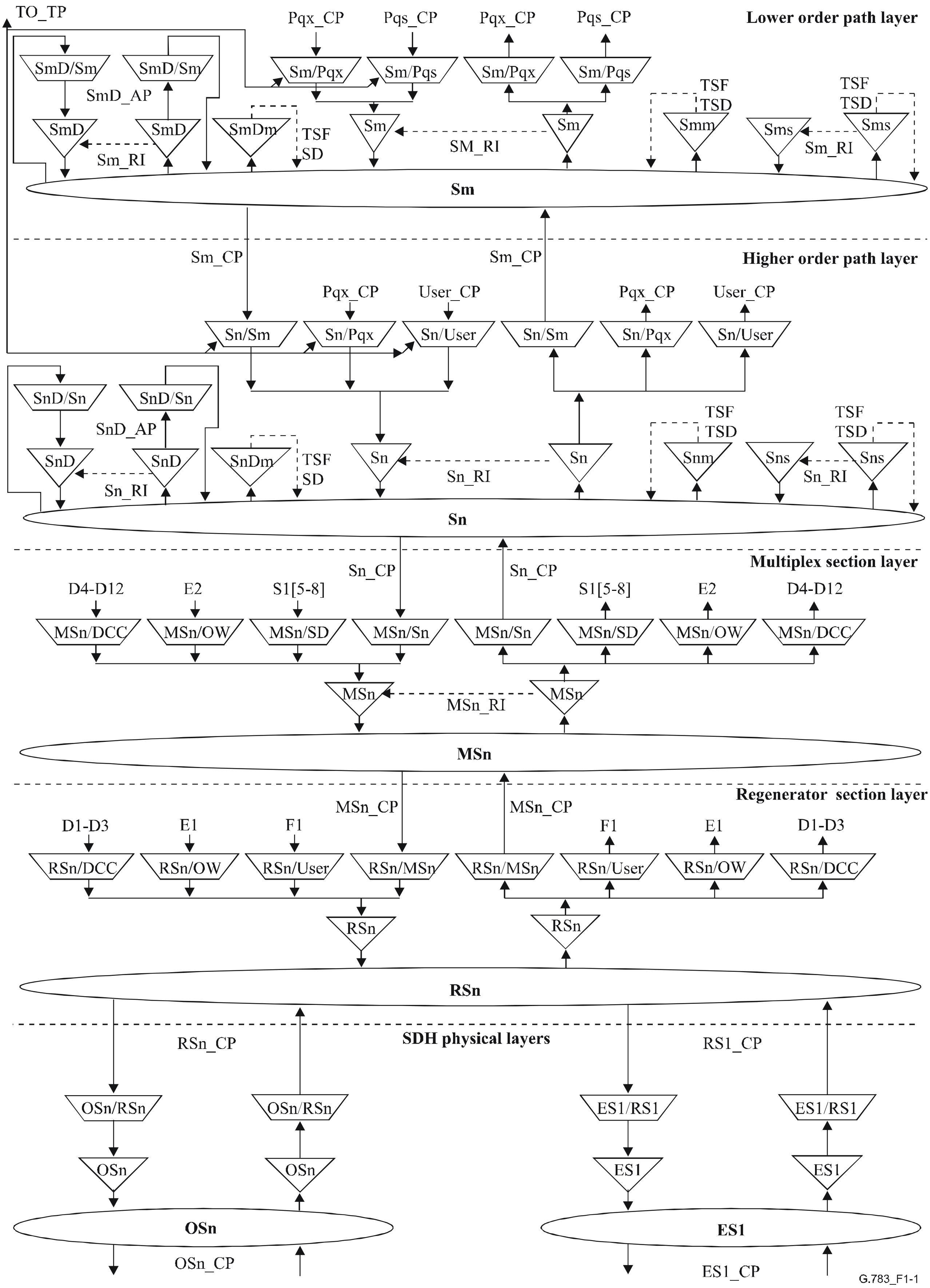


Figure 1-1/G.783 – General Functional Block Diagram

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[1] ITU-T Recommendation G.664 (2003), *Optical safety procedures and requirements for optical transport systems*.

[2] ITU-T Recommendation G.691 (2003), *Optical interfaces for single-channel STM-64 and other SDH systems with optical amplifiers*.

[3] ITU-T Recommendation G.703 (2001), *Physical/electrical characteristics of hierarchical digital interfaces*.

[4] ITU-T Recommendation G.704 (1998), *Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels*.

[5] ITU-T Recommendation G.705 (2000), *Characteristics of plesiochronous digital hierarchy (PDH) equipment functional blocks*.

[6] ITU-T Recommendation G.707/Y.1322 (2003), *Network node interface for the synchronous digital hierarchy (SDH)*.

[7] ITU-T Recommendation G.743 (1988), *Second order digital multiplex equipment operating at 6312 kbit/s and using positive justification*.

[8] ITU-T Recommendation G.752 (1988), *Characteristics of digital multiplex equipments based on a second order bit rate of 6312 kbit/s and using positive justification*.

[9] ITU-T Recommendation G.781 (1999), *Synchronization layer functions*.

[10] ITU-T Recommendation G.784 (1999), *Synchronous digital hierarchy (SDH) management*.

[11] ITU-T Recommendation G.803 (2000), *Architecture of transport networks based on the synchronous digital hierarchy (SDH)*.

[12] ITU-T Recommendation G.805 (2000), *Generic functional architecture of transport networks*.

[13] ITU-T Recommendation G.806 (2004), *Characteristics of transport equipment – Description methodology and generic functionality*.

[14] ITU-T Recommendation G.813 (2003), *Timing characteristics of SDH equipment slave clocks (SEC)*.

[15] ITU-T Recommendation G.823 (2000), *The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy*.

[16] ITU-T Recommendation G.824 (2000), *The control of jitter and wander within digital networks which are based on the 1544 kbit/s hierarchy*.

[17] ITU-T Recommendation G.825 (2000), *The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH)*.

[18] ITU-T Recommendation G.831 (2000), *Management capabilities of transport networks based on the synchronous digital hierarchy (SDH)*.

[19] ITU-T Recommendation G.841 (1998), *Types and characteristics of SDH network protection architectures*.

[20] ITU-T Recommendation G.957 (1999), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*.

[21] ITU-T Recommendation I.732 (2000), *Functional characteristics of ATM equipment*.

[22] ITU-T Recommendation M.3010 (2000), *Principles for a telecommunications management network*.

[23] ITU-T Recommendation O.172 (2001), *Jitter and wander measuring equipment for digital systems which are based on the synchronous digital hierarchy (SDH)*.

3 Terms and definitions

NOTE 1 – The following definitions are relevant in the context of SDH-related recommendations.

NOTE 2 – References to G.703 signals are intended to refer only to PDH signals, and specifically not to an electrical STM-1 interface. The notation G.703 (PDH) has been used to convey this interpretation.

3.1 1 + 1 (protection) architecture: A 1 + 1 protection architecture has one normal traffic signal, one working SNC/trail, one protection SNC/trail and a permanent bridge.

At the source end, the normal traffic signal is permanently bridged to both the working and protection SNC/trail. At the sink end, the normal traffic signal is selected from the better of the two SNCs/trails.

Due to the permanent bridging, the 1 + 1 architecture does not allow an extra unprotected traffic signal to be provided.

3.2 1:n (protection) architecture (n ≥ 1): A **1:n** protection architecture has n normal traffic signals, n working SNCs/trails and 1 protection SNC/trail. It may have 1 extra traffic signal.

The signals on the working SNCs/trails are the normal traffic signals.

The signal on the protection SNC/trail may either be one of the normal traffic signals, an extra traffic signal, or the null signal (e.g., an all-ONEs signal, a test signal, one of the normal traffic signals). At the source end, one of these signals is connected to the protection SNC/trail. At the sink end, the signals from the working SNCs/trails are selected as the normal signals. When a defect condition is detected on a working SNC/trail or under the influence of certain external commands, the transported signal is bridged to the protection SNC/trail. At the sink end, the signal from this protection SNC/trail is then selected instead.

3.3 access point (AP): See ITU-T Rec. G.805 [12].

3.4 access point identifier (APId): See ITU-T Rec. G.831 [18].

3.5 active trail/path/section/SNC/NC: The trail/path/section/SNC from which the signal is selected by the protection selector.

3.6 adaptation function (A): See ITU-T Rec. G.805.

3.7 adapted information (AI): The information passing across an AP.

3.8 administrative unit (AU): See ITU-T Rec. G.707/Y.1322 [6].

3.9 administrative unit group (AUG): See ITU-T Rec. G.707/Y.1322.

3.10 alarm: See ITU-T Rec. G.806 [13].

3.11 All-ONEs: See ITU-T Rec. G.806.

3.12 anomaly: See ITU-T Rec. G.806.

3.13 atomic function: See ITU-T Rec. G.806.

3.14 AUn-AIS: See ITU-T Rec. G.707/Y.1322.

3.15 automatic laser shutdown (ALS): See ITU-T Rec. G.664 [1].

3.16 automatic protection switching (APS): Autonomous switching of a signal between and including two MSn_TT, Sn_TT, or Sm_TT functions, from a failed working trail/SNC to a protection trail/SNC and subsequent restoration using control signals carried by the K-bytes in the MSOH, HO POH, or LO POH.

3.17 bidirectional trail/connection type: See ITU-T Rec. G.806.

3.18 bidirectional (protection) switching: See ITU-T Rec. G.841 [19].

3.19 bit interleaved parity (BIP): See ITU-T Rec. G.707/Y.1322.

3.20 broadcast connection type: See ITU-T Rec. G.806.

3.21 characteristic information (CI): The information passing across a CP or TCP. See also ITU-T Rec. G.805.

3.22 client/server layer: See ITU-T Rec. G.806.

3.23 connection: See ITU-T Rec. G.805.

3.24 connection function (C): See ITU-T Rec. G.806.

3.25 connection matrix (CM): See ITU-T Rec. G.806.

3.26 connection point (CP): See ITU-T Rec. G.806.

3.27 consolidation: See ITU-T Rec. G.806.

3.28 common management information service element (CMISE): See ITU-T Rec. X.710 | ISO/IEC 9595.

3.29 compound function: See ITU-T Rec. G.806.

3.30 data communications channel (DCC): See ITU-T Rec. G.784 [10].

3.31 defect: See ITU-T Rec. G.806.

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

3.33 extra traffic signal: See ITU-T Rec. G.841.

3.34 failure: See ITU-T Rec. G.806.

3.35 fault: See ITU-T Rec. G.806.

3.36 fault cause: See ITU-T Rec. G.806.

3.37 function: See ITU-T Rec. G.806.

3.38 grooming: See ITU-T Rec. G.806.

Thus it is possible to groom Virtual Container, level 12 (VC-12) paths by service type, by destination, or by protection category into particular VC-4 paths which can then be managed accordingly. It is also possible to groom VC-4 paths according to similar criteria into Synchronous Transport Module (STM-N) sections.

3.39 holdoff time: See ITU-T Rec. G.841.

3.40 layer: A concept used to allow the transport network functionality to be described hierarchically as successive levels; each layer being solely concerned with the generation and transfer of its characteristic information.

3.41 management information (MI): See ITU-T Rec. G.806.

3.42 management point (MP): See ITU-T Rec. G.806.

3.43 multiplex section (MS): A multiplex section is the trail between and including two multiplex section trail termination functions.

3.44 multiplex section alarm indication signal (MS-AIS): See ITU-T Rec. G.707/Y.1322.

3.45 multiplex section remote defect indication (MS-RDI): See ITU-T Rec. G.707/Y.1322.

3.46 multiplex section overhead (MSOH): See ITU-T Rec. G.707/Y.1322.

3.47 network connection (NC): See ITU-T Rec. G.805.

3.48 network element function (NEF): See ITU-T Rec. G.784.

3.49 network node interface (NNI): See ITU-T Rec. G.707/Y.1322.

3.50 non-revertive (protection) operation: See ITU-T Rec. G.841.

3.51 normal signal: See ITU-T Rec. G.841.

3.52 outgoing signal fail (OSF): A signal fail indication output at the AP of a tandem connection termination function.

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

3.54 path: See ITU-T Rec. G.806.

3.55 path overhead (POH): See ITU-T Rec. G.707/Y.1322.

3.56 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.

3.57 process: See ITU-T Rec. G.806.

3.58 protection trail/path/section/SNC/NC: See ITU-T Rec. G.841.

3.59 reference point: The delimiter of a function.

3.60 regenerator section (RS): A regenerator section is the trail between and including two regenerator section terminations.

3.61 regenerator section overhead (RSOH): See ITU-T Rec. G.707/Y.1322.

3.62 remote defect indication (RDI): See ITU-T Rec. G.806.

3.63 remote error indication (REI): See ITU-T Rec. G.806.

3.64 remote information (RI): See ITU-T Rec. G.806.

3.65 remote point (RP): See ITU-T Rec. G.806.

3.66 revertive (protection) operation: See ITU-T Rec. G.841.

3.67 section: A trail in a section layer.

3.68 server signal degrade (SSD): See ITU-T Rec. G.806.

3.69 server signal fail (SSF): See ITU-T Rec. G.806.

3.70 signal degrade (SD): See ITU-T Rec. G.806.

3.71 signal fail (SF): See ITU-T Rec. G.806.

3.72 standby trail/path/section/SNC: See ITU-T Rec. G.841.

3.73 sub-network connection (SNC): See ITU-T Rec. G.805.

3.74 supervisory-unequipped VC: See ITU-T Rec. G.707/Y.1322.

3.75 synchronous transport module (STM): See ITU-T Rec. G.707/Y.1322.

3.76 telecommunications management network (TMN): See ITU-T Rec. M.3010 [22].

3.77 termination connection point (TCP): See ITU-T Rec. G.806.

3.78 timing information (TI): See ITU-T Rec. G.806.

3.79 timing point (TP): See ITU-T Rec. G.806.

3.80 trail: See ITU-T Rec. G.805.

3.81 trail signal degrade (TSD): See ITU-T Rec. G.806.

3.82 trail signal fail (TSF): See ITU-T Rec. G.806.

3.83 trail termination function (TT): See ITU-T Rec. G.806.

3.84 trail trace identifier (TTI): See ITU-T Rec. G.707/Y.1322.

3.85 transit delay: See ITU-T Rec. G.806.

3.86 tributary unit (TU-m): See ITU-T Rec. G.707/Y.1322.

3.87 TUm-AIS: See ITU-T Rec. G.707/Y.1322.

3.88 unprotected: See ITU-T Rec. G.841.

3.89 virtual container (VC-n): See ITU-T Rec. G.707/Y.1322.

3.90 working trail/path/section/SNC/NC: See ITU-T Rec. G.841.

3.91 unequipped VC: See ITU-T Rec. G.707/Y.1322.

3.92 undefined bit: V.

3.93 undefined byte: V.

3.94 unidirectional trail/connection type: See ITU-T Rec. G.806.

3.95 unidirectional (protection) switching: See ITU-T Rec. G.841.

3.96 wait-to-restore time: See ITU-T Rec. G.841.

4 Abbreviations

This Recommendation uses the following abbreviations:

A	Adaptation function
AcSL	Accepted Signal Label
AcTI	Accepted Trace Identifier
ADM	Add-Drop Multiplexer
AI	Adapted Information
AIS	Alarm Indication Signal
ALS	Automatic Laser Shutdown
AP	Access Point
APId	Access Point Identifier
APS	Automatic Protection Switching
APSD	Automatic Power Shutdown
ATM	Asynchronous Transfer Mode
AU	Administrative Unit
AUG	Administrative Unit Group

AU-n	Administrative Unit, level n
BBER	Background Block Error Ratio
BER	Bit Error Ratio
BIP	Bit Interleaved Parity
C	Connection function
CI	Characteristic Information
CK	Clock
CM	Connection Matrix
CMISE	Common Management Information Service Element
CP	Connection Point
CRC	Cyclic Redundancy Check
CRC-N	Cyclic Redundancy Check, width N
CSES	Consecutive Severely Errored Seconds
D	Data
DCC	Data Communications Channel
DEC	Decrement
DEG	Degraded
DEGTHR	Degraded Threshold
DS	Defect Second
DXC	Digital Cross Connect
E0	Electrical interface signal 64 kbit/s
E11	Electrical interface signal 1544 kbit/s
E12	Electrical interface signal 2048 kbit/s
E22	Electrical interface signal 8448 kbit/s
E31	Electrical interface signal 34 368 kbit/s
E32	Electrical interface signal 44 736 kbit/s
E4	Electrical interface signal 139 264 kbit/s
EBC	Errored Block Count
EDC	Error Detection Code
EDCV	Error Detection Code Violation
EMF	Equipment Management Function
EQ	Equipment
Eq	ITU-T Rec. G.703 type electrical signal, bit rate order q (q = 11, 12, 21, 22, 31, 32, 4)
ES	Electrical Section
ES	Errored Second
ES1	Electrical Section, level 1
ExSL	Expected Signal Label
ExTI	Expected Trace Identifier
F_B	Far-end Block
F_DS	Far-end Defect Second
F_EBC	Far-end Errored Block Count

FAS	Frame Alignment Signal
FEC	Forward Error Correction
FIFO	First In First Out
FM	Fault Management
FOP	Failure of Protocol
FS	Forced Switch
FS	Frame Start signal
HO	Higher Order
HOVC	Higher Order Virtual Container
HP	Higher order Path
ID	Identifier
IEC	Incoming Error Count
IF	In Frame state
INC	Increment
IncAIS	Incoming AIS
LC	Link Connection
LO	Lockout
LO	Lower Order
LOA	Loss Of Alignment; generic for LOF, LOM, LOP
LOF	Loss Of Frame
LOM	Loss Of Multiframe
LOP	Loss Of Pointer
LOS	Loss of Signal
LOVC	Lower Order Virtual Container
LP	Lower order Path
LTC	Loss of Tandem Connection
LTI	Loss of all Incoming Timing references
MC	Matrix Connection
MCF	Message Communications Function
MI	Management Information
MON	Monitored
MND	Member not deskewable
MP	Management Point
MRTIE	Maximum Relative Time Interval Error
MS	Manual Switch
MS	Multiplex Section
MSB	Most Significant Bit
MSn	Multiplex Section layer, level n (n = 1, 4, 16)
MSnP2fsh	STM-N Multiplex Section 2-fibre Shared Protection Ring
MSnP4fsh	STM-N Multiplex Section 4-fibre Shared Protection Ring
MSOH	Multiplex Section OverHead

MSP	Multiplex Section Protection
MST	Member Status (signal)
MSU	Member Signal Unavailable
MTIE	Maximum Time Interval Error
N_B	Near-end Block
N_BBE	Near-end Background Block Error
N_DS	Near-end Defect Second
N_EBC	Near-end Errored Block Count
NC	Network Connection
N.C.	Not Connected
NDF	New Data Flag
NE	Network Element
NEF	Network Element Function
NMON	Not Monitored
NNI	Network Node Interface
NU	National Use
NUT	Non-preemptible Unprotected Traffic
OAM	Operation, Administration and Maintenance
ODI	Outgoing Defect Indication
OEI	Outgoing Error Indication
OF_B	Outgoing Far-end Block
OF_BBE	Outgoing Far-end Background Block Error
OF_DS	Outgoing Far-end Defect Second
OF_EBC	Outgoing Far-end Errored Block Count
OFS	Out-of-Frame Second
OHA	OverHead Access
ON_B	Outgoing Near-end Block
ON_BBE	Outgoing Near-end Background Block Error
ON_DS	Outgoing Near-end Defect Second
ON_EBC	Outgoing Near-end Errored Block Count
OOF	Out Of Frame
OS	Optical Section
OSF	Outgoing Signal Fail
OSn	Optical Section layer, level n (n = 1, 4, 16)
OW	Orderwire
P0x	64 kbit/s layer (transparent)
P11x	1544 kbit/s layer (transparent)
P12s	2048 kbit/s PDH path layer with synchronous 125 µs frame structure according to ITU-T Rec. G.704
P12x	2048 kbit/s layer (transparent)
P21x	6312 kbit/s layer (transparent)

P22e	8448 kbit/s PDH path layer with 4 plesiochronous 2048 kbit/s
P22x	8448 kbit/s layer (transparent)
P31e	34 368 kbit/s PDH path layer with 4 plesiochronous 8448 kbit/s
P31s	34 368 kbit/s PDH path layer with synchronous 125 µs frame structure according to ITU-T Rec. G.832
P31x	34 368 kbit/s layer (transparent)
P32x	44 736 kbit/s layer (transparent)
P4a	139 264 kbit/s PDH path layer with 3 plesiochronous 44 736 kbit/s
P4e	139 264 kbit/s PDH path layer with 4 plesiochronous 34 368 kbit/s
P4s	139 264 kbit/s PDH path layer with synchronous 125 µs frame structure according to ITU-T Rec. G.832
P4x	139 264 kbit/s layer (transparent)
PC	Payload-Carrying
PDH	Plesiochronous Digital Hierarchy
PG	Pointer Generator
PJC	Pointer Justification Count
PJE	Pointer Justification Event
PLCR	Partial Loss of Capacity Receive
PLCT	Partial Loss of Capacity Transmit
PLM	PayLoad Mismatch
PM	Performance Monitoring
POH	Path OverHead
PP	Pointer Processor
Pq	PDH path layer, bit rate order q (q = 11, 12, 21, 22, 31, 32, 4)
PRC	Primary Reference Clock
ProvM	Provisioned Member
PS	Protection Switching
PSE	Protection Switch Event
PTR	Pointer
RDI	Remote Defect Indication
REI	Remote Error Indication
RI	Remote Information
RP	Remote Point
RS	Regenerator Section
RSn	Regenerator Section layer, level n (n = 1, 4, 16)
RSOH	Regenerator Section OverHead
RxSL	Received Signal Label
RxTI	Received Trace Identifier
S11	VC-11 path layer
S11D	VC-11 tandem connection sublayer
S11P	VC-11 path protection sublayer

S12	VC-12 path layer
S12D	VC-12 tandem connection sublayer
S12P	VC-12 path protection sublayer
S2	VC-2 path layer
S2D	VC-2 tandem connection sublayer
S2P	VC-2 path protection sublayer
S3	VC-3 path layer
S3D	VC-3 tandem connection sublayer using TCM definition according to Annex D/G.707/Y.1322 (option 2)
S3P	VC-3 path protection sublayer
S3T	VC-3 tandem connection sublayer using TCM definition according to Annex C/G.707/Y.1322 (option 1)
S4	VC-4 path layer
S4D	VC-4 tandem connection sublayer using TCM definition according to Annex D/G.707/Y.1322 (option 2)
S4P	VC-4 path protection sublayer
S4T	VC-4 tandem connection sublayer using TCM definition according to Annex C/G.707/Y.1322 (option 1)
SD	Signal Degrade
SDH	Synchronous Digital Hierarchy
SDXC	Synchronous Digital hierarchy Cross-Connect
SEC	SDH Equipment Clock
SEMF	Synchronous Equipment Management Function
SES	Severely Errored Second
SF	Signal Fail
Sk	Sink
Sm	lower order VC-m layer (m = 11, 12, 2)
SmD	VC-m (m = 11, 12, 2) tandem connection sublayer
Smm	VC-m (m = 11, 12, 2) path layer non-intrusive monitor
SmP	VC-m (m = 11, 12, 2) path protection sublayer
Sms	VC-m (m = 11, 12, 2) path layer supervisory-unequipped
Sn	higher order VC-n layer (n = 3, 4, 4-Xc) or lower order VC-3 layer
SNC	Sub-Network Connection
SNC/I	Inherently monitored Sub-Network Connection protection
SNC/N	Non-intrusively monitored Sub-Network Connection protection
SNC/S	Sublayer (tandem connection) monitored Sub-Network Connection protection
SnD	VC-n (n = 3, 4, 4-Xc) tandem connection sublayer using TCM definition according to Annex D/G.707/Y.1322 (option 2)
Snm	VC-n (n = 3, 4, 4-Xc) path layer non-intrusive monitor
SnP	VC-n (n = 3, 4, 4-Xc) path protection sublayer
Sns	VC-n (n = 3, 4, 4-Xc) path layer supervisory-unequipped

SnT	VC-n (n = 3, 4, 4-Xc) tandem connection sublayer using TCM definition according to Annex C/G.707/Y.1322 (option 1)
So	Source
SOH	Section Overhead
SQ	Sequence indicator
SQM	Sequence indicator mismatch
SPRING	Shared Protection Ring
SSD	Server Signal Degrade
SSF	Server Signal Fail
SSM	Synchronization Status Message
SSU	Synchronization Supply Unit
STM	Synchronous Transport Module
TCM	Tandem Connection Monitor
TCP	Termination Connection Point
TD	Transmit Degrade
TF	Transmit Fail
TFAS	Trail Trace Identifier Frame Alignment Signal
TI	Timing Information
TIM	Trace Identifier Mismatch
TLCR	Total Loss of Capacity Receive
TLCT	Total Loss of Capacity Transmit
TMN	Telecommunications Management Network
TP	Timing Point
TPmode	Termination Point mode
TS	Time Slot
TSD	Trail Signal Degrade
TSF	Trail Signal Fail
TSL	Trail Signal Label
TT	Trail Termination function
TTI	Trail Trace Identifier
TTP	Trail Termination Point
TTs	Trail Termination supervisory function
TU	Tributary Unit
TUG	Tributary Unit Group
TUG-m	Tributary Unit Group, level m
TU-m	Tributary Unit, level m
TxSL	Transmitted Signal Label
TxTI	Transmitted Trace Identifier
UMST	(Persistent) Unexpected MST
UNEQ	UNEQuipped
UNI	User Network Interface

USR	User channels
VC	Virtual Container
VCG	Virtual Concatenation Group
VC-n	Virtual Container, level n
VLI	VCAT/LCAS Information
VP	Virtual Path
W	Working
WTR	Wait to Restore

5 Conventions

See clause 5/G.806 [13] for methodology and generic conventions.

5.1 SDH-specific transmission layer names

The layer names related to SDH are:

ESn	STM-N Electrical Section (n = 1)
OSn	STM-N Optical Section (n = 1, 4, 16, 64, 256)
RSn	STM-N Regenerator Section (n = 1, 4, 16, 64, 256)
MSn	STM-N Multiplex Section (n = 1, 4, 16, 64, 256)
Sn	VC-n path (n = 3, 4, 4-Xc)
SnP	VC-n (n = 3, 4, 4-Xc) trail protection sublayer
SnD	VC-n path, tandem connection sublayer (n = 3, 4, 4-Xc) using TCM definition according to Annex D/G.707/Y.1322 (option 2) [6]
SnT	VC-n path, tandem connection sublayer (n = 3, 4, 4-Xc) using TCM definition according to Annex C/G.707/Y.1322 (option 1)
Sm	VC-m path (m = 11, 12, 2)
SmD	VC-m path, tandem connection sublayer (m = 11, 12, 2)
Pqs	PDH synchronous user data (q = 11 for 1.5 Mbits, q = 12 for 2 Mbits). This layer is defined in ITU-T Rec. G.705 [5]. The adaptations into SDH are defined in this Recommendation.
Pqx	PDH user data (q = 11 for 1.5 Mbit/s, q = 12 for 2 Mbit/s, q = 2 for 6 Mbit/s, q = 31 for 34 Mbit/s, q = 32 for 45 Mbit/s, q = 4 for 140 Mbit/s). This layer is defined in ITU-T Rec. G.705. The adaptations into SDH are defined in this Recommendation.

5.2 Performance and reliability

See clause 9/G.806 for specifications concerning transit delay, response time, availability and reliability and laser safety.

6 Supervision

Generic behaviour for supervision processes is described in clause 6/G.806.

6.1 Trail termination point mode and port mode

See 6.1/G.806.

6.2 Defects

6.2.1 Continuity supervision

Generic continuity supervision defects are described in 6.2.1/G.806. SDH-specific continuity supervision defects are described here.

6.2.1.1 Loss Of Signal defect (dLOS)

STM-N optical interfaces: This parameter should take on the value "incoming signal absent" when the incoming power level at the receiver has dropped to a level which corresponds to a high error condition. The purpose of monitoring this parameter is to indicate either:

i) transmitter failure;

ii) optical path break.

NOTE – This is a functional specification referring only to the quality of the incoming signal. It does not necessarily imply either the measurement of optical power or BER. The timing requirements for detection of the LOS defect is the province of regional standards. One example is the following: An LOS defect occurs upon detection of no transitions on the incoming signal (before descrambling) for time T, where $2.3 \leq T' \leq 100$ µs. The LOS defect is terminated after a time period equal to the greater of 125 µs or 2.5 T' containing no transition-free intervals of length T', where $2.3 \leq T' \leq 100$ µs.

STM-1 electrical interfaces:

– Option 1: An LOS defect is detected when the incoming signal has "no transitions", i.e., when the signal level is less than or equal to a signal level of 35 dB below nominal, for N consecutive pulse intervals, where $10 \leq N \leq 255$. The LOS defect is cleared when the incoming signal has "transitions", i.e., when the signal level is greater than or equal to a signal level of 15 dB below nominal, for N consecutive pulse intervals, where $10 \leq N \leq 255$. A signal with "transitions" corresponds to a CMI coded signal.

– Option 2: An LOS defect occurs upon detection of no transitions on the incoming signal (before descrambling) for time T, where $2.3 \leq T \leq 100$ µs. The LOS defect is terminated after a time period equal to the greater of 125 µs or 2.5 T' containing no transition-free intervals of length T', where $2.3 \leq T' \leq 100$ µs.

6.2.2 Connectivity supervision

All connectivity supervision processes are generic and described in 6.2.2/G.806.

6.2.3 Signal quality supervision

All signal quality supervision processes are generic and described in 6.2.3/G.806.

6.2.4 Payload type supervision

All signal payload type supervision processes are generic and described in 6.2.4/G.806.

6.2.5 Alignment supervision

Generic alignment supervision defects are described in 6.2.5/G.806. SDH-specific alignment supervision defects are described here.

6.2.5.1 Loss Of Frame defect (dLOF)

STM-N signals: If the OOF state persists for 3 ms, 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 3 ms. Once in a LOF state, this state shall be left when the in-frame state persists continuously for 3 ms.

6.2.5.2 Loss Of Multiframe defect (dLOM) for VC-1/2 mapped into HOVC

If the multiframe alignment process (see 8.2.2) is in the OOM state and the H4 multiframe is not recovered within m VC-3/4 frames, a dLOM defect shall be declared. Once in a dLOM state, this state shall be exited when the multiframe is recovered (multiframe alignment process enter the IM state).

m shall be in the range of 8 to 40 and is not configurable.

6.2.5.3 Loss Of Pointer defect (dLOP)

AU-n dLOP: See Annex A.

TU-m dLOP: See Annex A.

6.2.5.4 Loss Of Multiframe defect (dLOM) for VC-3/4 virtual concatenation

If any of the two multiframe alignment processes is in the out-of-multiframe (OOM1 or OOM2) state (see 8.2.5.1) and the whole H4 two-stage multiframe is not recovered within m VC-3/4 frames, a dLOM defect shall be declared. Once in a dLOM state, this state shall be exited when both multiframe alignment processes are in the in-multiframe state (IM1 and IM2).

m shall be in the range of 40 to 80 and is not configurable.

6.2.5.5 Loss Of Multiframe defect (dLOM) for VC-1/2 virtual concatenation

If any of the two multiframe alignment process (extended overhead multiframe in 8.2.3.1 or virtual concatenation frame counter multiframe in 8.2.5.2) is in the OOM state and the whole virtual concatenation two-stage multiframe is not recovered within m VC-1/2 frames, a dLOM defect shall be declared. Once in a dLOM state, this state shall be exited when both multiframe alignment processes are in the in-multiframe state (IM state).

m shall be in the range of 200 to 400 and is not configurable.

NOTE 1 – A dLOM for the extended overhead multiframe (extended signal label) only is not defined. According to 8.2.3.2 a missing multiframe (OOM state) will result in dPLM.

NOTE 2 – Loss of TCM multiframe is covered by the dLTC defect defined in ITU-T Rec. G.806.

6.2.6 Maintenance signal supervision

Generic maintenance supervision defects are described in 6.2.6/G.806. SDH-specific maintenance supervision defects are described here.

6.2.6.1 AIS defect (dAIS)

MS-n dAIS: See 6.2.6.2/G.806.

AU-n dAIS: See Annex A.

TU-m dAIS: See Annex A.

6.2.7 Protocol supervision

All protocol supervision processes are generic and described in 6.2.7/G.806.

6.3 Consequent actions

All consequent actions are generic and described in 6.3/G.806.

6.4 Defect correlations

All defect correlations are generic and described in 6.4/G.806.

6.5 One-second performance monitoring filter

Generic one-second performance monitoring counts are described in 6.5/G.806. SDH-specific counts are described here.

6.5.1 Pointer Justification Counts (pPJC+, pPJC–)

A positive Pointer Justification Count (pPJC+) is a count of the number of Generated Pointer Increments in a one-second period.

A negative Pointer Justification Count (pPJC–)is a count of the number of Generated Pointer Decrements in a one-second period.

NOTE – pPJC is the input for the 15-minute and 24-hour PJE (pointer justification event) counts.

7 Information flow (XXX_MI) across the XXX_MP reference points

See clause 7/G.806 for generic description of information flow. SDH-specific information flow is described in the applicable atomic functions.

8 Generic processes

8.1 Line coding and scrambling processes

Generic treatment of line coding and scrambling is described in 8.1/G.806. SDH-specific scrambling is included here. Line coding for electrical SDH signals is described in ITU-T Rec. G.703 [3].

8.1.1 STM-N scrambling and descrambling

Scrambling and descrambling is performed according to ITU-T Rec. G.707/Y.1322. The following bytes are excluded from scrambling and descrambling:

– For STM-0, the 3 bytes of the first row of the RSOH (A1, A2, J0) are excluded from scrambling and descrambling.

– For STM-N (N = 1, 4, 16, 64), the first row of the RSOH (9 × N bytes, including A1, A2, J0, and bytes reserved for national use or future international standardization) are excluded from scrambling and descrambling.

– For STM-256, the 64 A1 and 64 A2 bytes in the first row of the RSOH are excluded from scrambling and descrambling.

8.2 Alignment processes

Generic description of alignment processes appears in 8.2/G.806. SDH-specific alignment processes are described here.

8.2.1 STM-N frame alignment

The frame alignment shall be found by searching for the A1, A2 bytes (see ITU-T Rec. G.707/Y.1322) contained in the STM-N signal. The framing pattern searched for may be a subset of the A1 and A2 bytes contained on the STM-N signal. The frame signal shall be continuously checked with the presumed frame start position for the alignment. If in the in-frame state (IF), 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 conditions, a 10^{-3} (Poisson type) error ratio will not cause a false OOF more then once per 6 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 the OOF state shall be such that the probability for false frame recovery with a random unframed signal shall be is no more than 10^{-5} per 250 μs time interval.

8.2.2 Multiframe alignment for VC-1, VC-2 mapped into HOVC

If the TUG structure of a HOVC contains TUG-2s, the 500 μs (multi)frame start phase shall be recovered performing multiframe alignment on bits 7 and 8 of byte H4. Out-of-multiframe (OOM) shall be assumed once when an error is detected in the H4 bit 7 and 8 sequence. Multiframe alignment shall be assumed to be recovered, and the in-multiframe (IM) state shall be entered, when in four consecutive VC-n frames an error-free H4 sequence is found.

8.2.3 Lower order VC-1, VC-2 extended overhead multiframe alignment

Extended overhead for VC-1 and VC-2 provides a set of extended (8 bit) signal codes and carries frame and sequence information for virtual concatenation. This overhead is carried in a length 32 multiframe in K4[1, 2]. This provides 64 bits for additional overhead transmitted every 16 ms.

8.2.3.1 Multiframe generation and recovery

Extended overhead is used in Sm/Client adaptation functions using extended signal label codes and in the Sm/Sm-X adaptation function for virtual concatenation.

Source Direction: The multiframe start indicator "0111 1111 110" is inserted in the first 11 bits of the K4[1] multiframe sequence. The remaining 21 bits of the K4[1] multiframe sequence are available to carry extended overhead, but are defined so that no more than eight consecutive ones appear in the remaining 21 bits. This process need not be performed for signals that do not contain any of the extended overhead.

Sink direction: A bit sequence will be recovered from K4[1] for extended overhead multiframe alignment. The multiframe alignment shall be found by searching for the pattern "0111 1111 110" in K4[1]. The signal shall be continuously checked with the presumed multiframe start position for the alignment.

Frame alignment is deemed to have been lost (entering Out of Multiframe (OOM) state when two consecutive FAS are detected in error (i.e., one error in each FAS).

Frame alignment is deemed to have been recovered (entering the In Multiframe (IM) state) when one non-errored FAS is found.

This process need only be performed where extended overhead is to be received. At present, this includes the following:

– The Sm/Sm-X adaptation sink function where a virtually concatenated signal is to be received (see 8.2.5.2 and 13.5.1.2).

– The Sm/Client adaptation sink functions where an extended signal label is expected and the extended signal label escape code "101" appears in V5[5-7].

8.2.3.2 Extended signal label insertion and recovery

Extended signal labels are inserted and recovered by Sm/Client adaptation functions that use extended signal label codes.

Source Direction: The extended overhead multiframe is generated as described in 8.2.3.1. The extended signal label escape code "101" is transmitted in V5[5-7]. The eight-bit extended signal label code is transmitted as bits [12-19] of the K4[1] multiframe sequence. Bit 20 of the K4[1] multiframe sequence is transmitted as zeros so that extended signal labels cannot imitate the multiframe start indicator.

Sink Direction: Sm/Client adaptation sink functions expecting an extended signal label code shall first recover the 3-bit signal label code from V5[5-7]. The following actions are taken based on V5[5-7]:

000 – dUNEQ shall be declared according to 6.2.1.3/G.806.

001 – The "Equipped Non-Specific" code is accepted according to 6.2.4.2/G.806.

101 – The extended overhead multiframe shall be recovered as described in 8.2.3.1. If the multiframe recovery process is in the OOM state, dPLM shall be declared. If the multiframe recover process is in the IM state, the signal label shall be recovered from bits [12-19] of the K4[1] multiframe sequence. dPLM shall be declared according to 6.2.4.2/G.806 if the accepted signal label does not match the expected signal label.

Other – dPLM shall be declared according to 6.2.4.2/G.806.

8.2.4 Tandem Connection multiframe alignment

VC-3, VC-4: Multiframe alignment shall be performed on bits 7 and 8 of byte N1 to recover the TTI, RDI, and ODI signals transported within the multiframed bits. The multiframe alignment shall be found by searching for the pattern "1111 1111 1111 1110" within the bits 7 and 8 of byte N1. The signal shall be continuously checked with the presumed multiframe start position for the alignment.

NOTE – The frame alignment process described above for the VC-4 and VC-3 is only applicable for TCM option 2.

VC-11, VC-12, VC-2: Multiframe alignment shall be performed on bits 7 and 8 of byte N2 to recover the TTI, RDI, and ODI signals transported within the multiframed bits. The multiframe alignment shall be found by searching for the pattern "1111 1111 1111 1110" within the bits 7 and 8 of byte N2. The signal shall be continuously checked with the presumed multiframe start position for the alignment.

Frame alignment is deemed to have been lost (entering Out of Multiframe (OOM) state) when two consecutive FAS are detected in error (i.e., one error in each FAS).

Frame alignment is deemed to have been recovered (entering In Multiframe (IM) state) when one non-errored FAS is found.

8.2.5 Virtual concatenation multiframe alignment

8.2.5.1 VC-3, VC-4 virtual concatenation multiframe alignment

Source Direction: The two-stage multiframe is generated as defined in ITU-T Rec. G.707/Y.1322. The first stage uses H4, bits 5-8 for the multiframe indication MFI1. MFI1 is incremented every frame and counts from 0 to 15. The second stage uses H4, bits 1-4 in frame 0 (bits 1-4) and 1 (bits 5-8) of the first multiframe stage for the multiframe indication MFI2. MFI2 is incremented once every multiframe of the first stage and counts from 0 to 255. The resulting overall multiframe is 4096 frames (= 512 ms) long.

Sink Direction: The function shall recover the two-stage 512 ms multiframe:

Multiframe stage 1:

The function shall recover the first (16 frame) multiframe performing multiframe alignment on the multiframe indication MFI1 in bits 5 to 8 of byte H4. Out-of-multiframe of stage 1 (OOM1) shall be assumed once when an error is detected in the MFI1 sequence. Multiframe alignment of stage 1 shall be assumed to be recovered and the In-Multiframe state (IM1) shall be entered, when in four consecutive VC-4 frames an error-free MFI1 sequence is found.

Multiframe stage 2:

The function shall recover the second (256 frame) multiframe performing multiframe alignment on the multiframe indication MFI2 in bits 1 to 4 of byte H4 of frame 0 and 1 of the first multiframe stage. Out-of-multiframe of stage 2 (OOM2) shall be assumed once an error is detected in the MFI2 sequence or the first multiframe stage is in the out-of-multiframe (OOM1) state. Recovery of the second multiframe shall start as soon as the first multiframe stage is in the in-multiframe (IM1) state. Multiframe alignment of stage 2 shall be assumed to be recovered and, the In-Multiframe state (IM2) shall be entered when, in two consecutive first-stage multiframes, an error-free MFI2 sequence is found.

8.2.5.2 VC-11, VC-12, VC-2 virtual concatenation multiframe alignment

Multiframe alignment for VC-11, VC-12, and VC-2 virtual concatenation according to ITU-T Rec. G.707/Y.1322 uses the extended overhead to contain a 5-bit frame counter and a 6-bit sequence number. The 5-bit frame counter provides a detection of differential delay of 512 ms by counting 32 times the 16 ms extended overhead multiframe rate. This alignment is performed by the Sm/Sm-X adaptation functions.

Source direction: If the extended overhead multiframe is not already present in Sm-X_CI, it shall be generated according to 8.2.3.1. Otherwise, the existing extended overhead multiframe structure shall be used. The function shall insert the frame number as a 5-bit counter value, incrementing with each extended overhead (16 ms) multiframe into bits 1-5 of the K4[2] multiframe sequence. The virtual concatenation sequence number shall be inserted into bits 6-11 of the K4[2] multiframe sequence. The sequence number for Sm[i] is i-1.

NOTE – As all standardized applications of virtual concatenation are for payloads that use extended signal label codes, the extended overhead multiframe will already be present in the Sm-X_CI having been generated by the Sm/Client adaptation source function for insertion of the extended signal label.

Sink direction: The extended overhead multiframe is recovered according to 8.2.3.1. The virtual concatenation frame number is recovered from bits 1-5 of the K4[2] multiframe sequence. The process will be in the out of multiframe (OOM) state when either the extended overhead multiframe alignment process is in the OOM state or when an error is encountered in the received and expected frame number from bits 1-5 of the K4[2] sequence. The process enters the IM state when the extended overhead multiframe process is in the IM state and two consecutive error-free frame numbers are recovered. The sequence number is recovered from bits 6-11 of the K4[2] sequence. A new sequence number is accepted if the received sequence has the same value in n consecutive extended overhead multiframes, with $3 \le n \le 10$. The accepted sequence number is compared with the expected sequence number for detection of the dSQM defect.

8.3 Signal quality supervision processes

Generic signal quality supervision processes are described in 8.3/G.806. SDH-specific processes are described here.

8.3.1 Tandem connection BIP violation determination

VC-3, VC-4: Even bit parity shall be computed for each bit n of every byte of the preceding HOVC and compared with bit n of B3 recovered from the current frame (n = 1 to 8 inclusive). A difference between the computed and recovered B3 values shall be taken as evidence of one or more errors in the computation block (ON_B). The magnitude (absolute value) of the difference between this calculated number of errors and the number of errors written into the IEC (see Table D.5/G.707/Y.1322 [6]) at the trail termination source shall be used to determine the error performance of the tandem connection for each transmitted VC-n (Figure 8-1). If this magnitude of the difference is one or more, an errored TC block is detected (N_B).

NOTE – The B3 data and the IEC read in the current frame both apply to the previous frame.

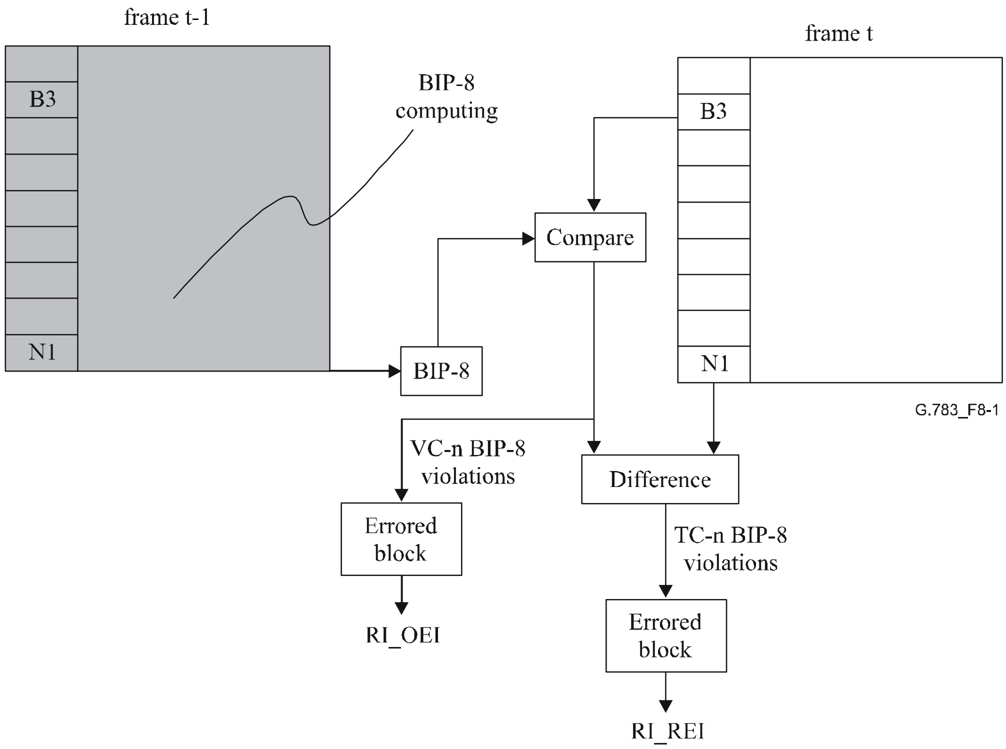


Figure 8-1/G.783 – TC-n and BIP-8 computing and comparison

VC-11, VC-12, VC-2: Even BIP-2 is computed for each bit pair of every byte of the preceding VC-1/2 including V5 and compared with bits 1 and 2 of V5 recovered from the current frame (see Figure 8-2). A difference between the computed and recovered BIP-2 values is taken as evidence of one or more errors (ON_B) in the computation block. Furthermore, the actual BIP-2 is compared with the BIP-2 retrieved from the bits 1 and 2 of N2. A difference not equal to zero indicates that the VC-m has been corrupted within the tandem connection. In this case, an errored TC block is detected (N_B).

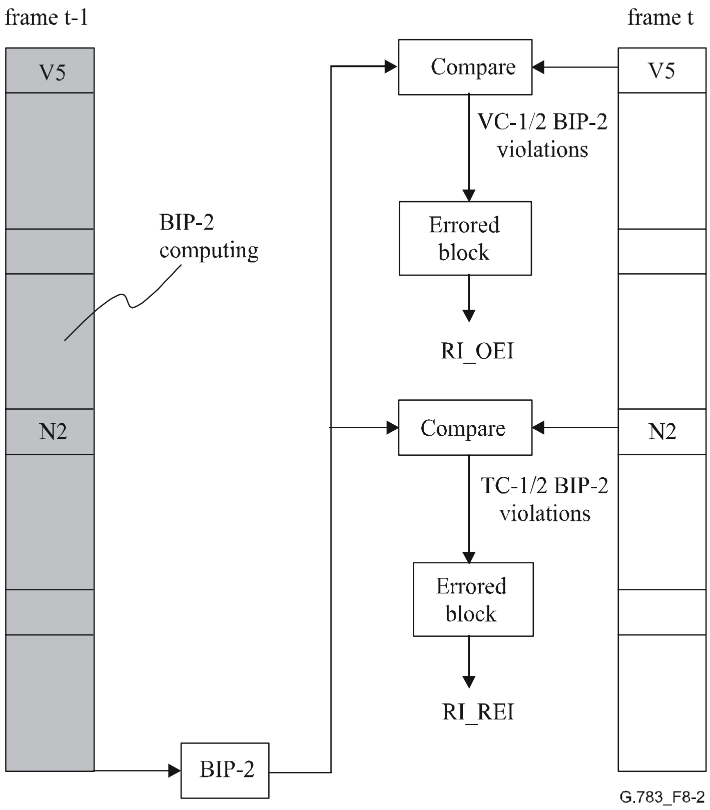


Figure 8-2/G.783 – TC-1/2 and VC-1/2 BIP-2 computing and comparison

8.3.2 Tandem connection incoming error code determination

Even BIP-8 shall be computed for each bit n of every byte of the preceding VC-n (n = 3, 4) including B3 and compared with byte B3 recovered from the current frame. A difference between the computed and recovered BIP-8 values shall be taken as evidence of one or more errors in the computation block, and shall be inserted in bits 1 to 4 of byte N1 (see Figure 8-3, Table C.1/G.707/Y.1322 and Table D.2/G.707/Y.1322). If a SF condition is present, a code as described in Tables C.1/G.707/Y.1322 (TCM option 1) or D.2/G.707/Y.1322 (TCM option 2) shall be inserted in bits 1 to 4 of byte N1 instead of the number of incoming BIP-8 violations.

NOTE – Zero BIP-8 violations detected in the tandem connection incoming signal must be coded with a non-all-ZEROs IEC code. This allows this IEC field to be used at the TC tail end as differentiator between TC incoming unequipped VC and unequipped TC.

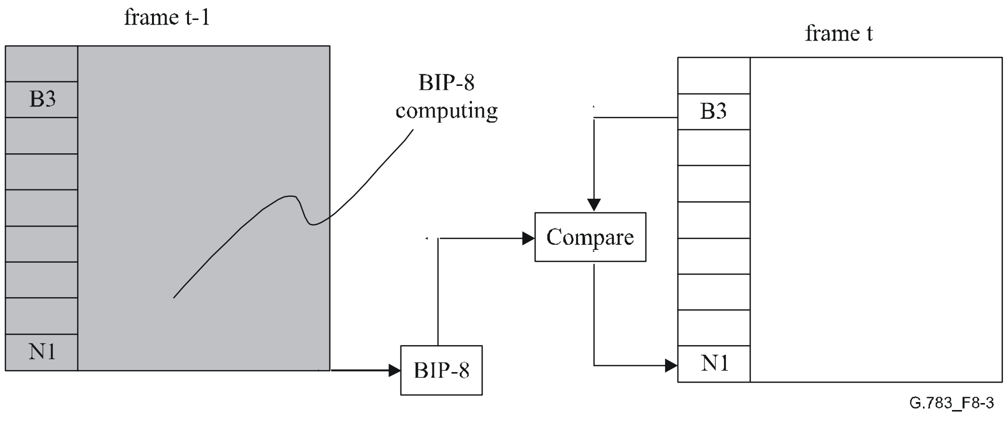


Figure 8-3/G.783 – TC-n IEC computing and insertion

8.4 BIP correction processes

B3 (BIP-8) and V5[1-2] (BIP-2) shall be compensated for the addition/removal of tandem connection overhead (N1, N2) according to the BIP correction process in 8.4/G.806.

9 STM-N Physical section layer (N = 1, 4, 16, 64, 256)

The atomic functions defining the SDH physical interface layer are described below. They describe the physical and logical characteristics of the optical and electrical interfaces used within SDH equipment at the ES1_CP or OSn_CP (where n = 1, 4, 16, 64, 256) as defined in ITU-T Recs G.703 [3], G.707/Y.1322 [6], G.957 [20] and G.691 [2] (see Figures 9-1 and 9-2).

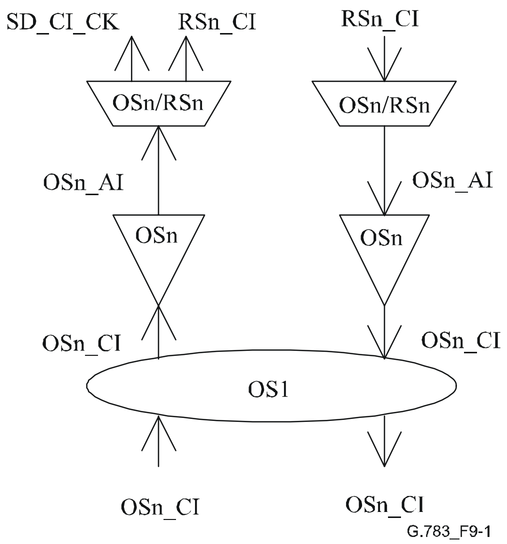


Figure 9-1/G.783 – STM-N Optical Section atomic functions

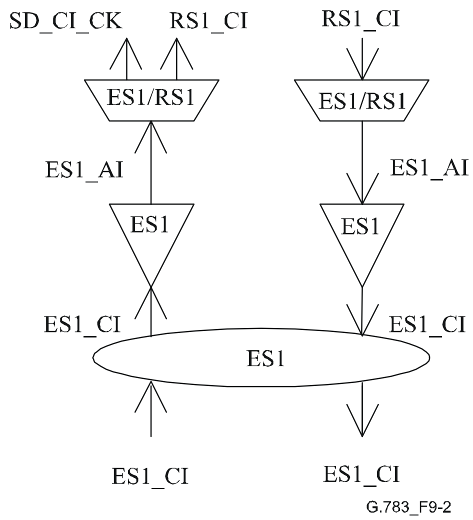


Figure 9-2/G.783 – STM-1 Electrical Section atomic functions

STM-N Electrical/Optical Section Layer CP:

Characteristic Information OSn_CI or ES1_CI at the layer CP is a digital, optical or electrical (coded) signal of defined power, bit rate, pulse width and wavelength. A range of such characteristic signals is defined.

The optical interface signals are defined in ITU-T Recs G.957 and G.691. The electrical interface signals are defined in ITU-T Rec. G.703.

9.1 Connection functions

Not applicable. There are no connection functions defined for this layer.

9.2 Termination functions

9.2.1 STM-N Optical Section Trail Termination OSn_TT

9.2.1.1 STM-N Optical Section Trail Termination Source (OSn-Xy.z_TT_So)

NOTE 1 – Xy.z will be one value out of the set of application codes defined in ITU-T Recs G.957 and G.691: {I-1, S-1.1, S-1.2, L-1.1, L-1.2, L-1.3, I-4, S-4.1, S-4.2, L-4.1, L-4.2, L-4.3, V-4.1, V-4.2, V-4.3, U-4.2, U-4.3, I-16, S-16.1, S-16.2, L-16.1, L-16.2, L-16.3, V-16.1, V-16.2, V-16.3, U-16.2, U-16.3, S-64.1, S-64.2, S-64.3, L-64.1, L-64.2, L-64.3, V-64.1, V-64.2, V-64.3}. Application codes for STM-256 are for further study.

Symbol

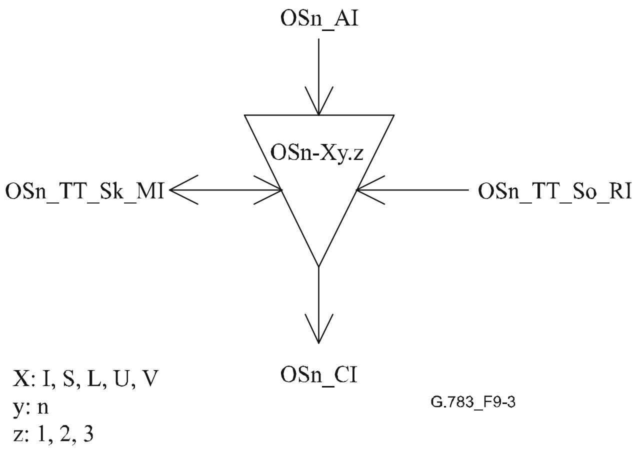


Figure 9-3/G.783 – OSn-Xy.z_TT_So symbol

Interfaces

Table 9-1/G.783 – OSn-Xy.z_TT_So input and output signals

Inputs	Outputs
OSn_AI_Data OSn_RI_LOS	OSn_CI_Data
NOTE 1 – OSn_RI_LOS is used by the APSD mechanism if supported (refer to ITU-T Rec. G.664). NOTE 2 – The definition of OSn_TT_So_MI for interfaces with optical amplifiers is for further study. NOTE 3 – The definition of OSn_TT_So_MI for the APSD mechanism is for further study.	

Processes

The termination function conditions the data for transmission over the optical medium and presents it at the OSn_CP.

Optical characteristics: The function shall generate an optical STM-N signal that meets the Xy.z characteristics defined in ITU-T Recs G.957 or G.691.

Laser safety: refer to ITU-T Rec. G.664 [1].

Defects

None.

NOTE 2 – The TF and TD defects that have been defined in previous versions of this Recommendation and in ITU-T Rec. G.958 are no longer required to be detected and reported as transmission-related defects and alarms. Technology has matured since the introduction of SDH, and the optical transmitters have reached reliability similar to other components in the equipment. Monitoring of problems in optical transmitters should be performed according to equipment specific philosophies and reported as part of a field replaceable unit failure.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

9.2.1.2 STM-N Optical Section Trail Termination Sink OSn-Xy.z_TT_Sk

NOTE – Xy.z will be one value out of the set of application codes defined in ITU-T Recs G.957 and G.691: {I-1, S-1.1, S-1.2, L-1.1, L-1.2, L-1.3, I-4, S-4.1, S-4.2, L-4.1, L-4.2, L-4.3, V-4.1, V-4.2, V-4.3, U-4.2, U-4.3, I-16, S-16.1, S-16.2, L-16.1, L-16.2, L-16.3, V-16.1, V-16.2, V-16.3, U-16.2, U-16.3, S-64.1, S-64.2, S-64.3, L-64.1, L-64.2, L-64.3, V-64.1, V-64.2, V-64.3}. Application codes for STM-256 are for further study.

Symbol

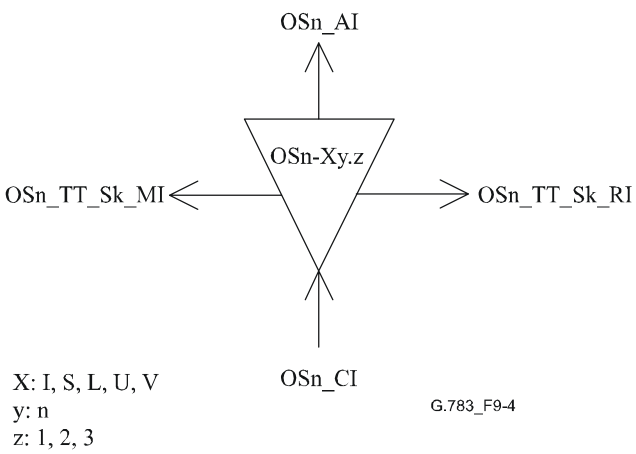


Figure 9-4/G.783 – OSn-Xy.z_TT_Sk symbol

Interfaces

Table 9-2/G.783 – OSn-Xy.z_TT_Sk input and output signals

Inputs	Outputs
OSn_CI_Data OSn_TT_Sk_MP_PortMode	OSn_AI_Data OSn_AI_TSF OSn_RI_LOS OSn_TT_Sk_MI_cLOS
NOTE – OSn_RI_LOS is used by the APSD mechanism if supported (refer to ITU-T Rec. G.664).	

Processes

The STM-N signal at the OSn_CP is a similarly formatted and conditioned signal (as described in 8.4) which is degraded within specific limits by transmission over the physical medium.

This function recovers the optical STM-N signal transmitted over the optical cables. The physical characteristics of the interface signal are defined in ITU-T Recs G.957 or G.691.

The function shall convert the received STM-N signal, normally complying to the Xy.z characteristics defined in ITU-T Recs G.957 or G.691, into the internal OSn_AI signal.

The operation of Portmode is described in 6.1/G.806.

Laser safety: refer to ITU-T Rec. G.664.

Defects

dLOS: see 6.2.1.1.

Consequent actions

aTSF ← dLOS

aRI_LOS ← dLOS

Defect correlations

cLOS ← dLOS and MON

Performance monitoring

None.

9.2.2 STM-1 Electrical Section Trail Termination ES1_TT

9.2.2.1 STM-1 Electrical Section Trail Termination Source ES1_TT_So

Symbol

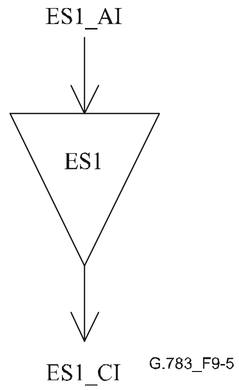


Figure 9-5/G.783 – ES1_TT_So symbol

Interfaces

Table 9-3/G.783 – ES1_TT_So input and output signals

Inputs	Outputs
ES1_AI_Data	ES1_CI_Data

Processes

This function generates the STM-1 electrical Intra-station Section Layer signal as described in ITU-T Rec. G.703.

Pulse shape: The function shall meet the requirement defined in ITU-T Rec. G.703.

Peak-to-peak voltage: The function shall meet the requirement defined in ITU-T Rec. G.703.

Rise time: The function shall meet the requirement defined in ITU-T Rec. G.703.

Pair(s) in each direction: The function shall meet the requirement defined in ITU-T Rec. G.703.

Output return loss: The function shall meet the requirement defined in ITU-T Rec. G.703.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

9.2.2.2 STM-1 Electrical Section Trail Termination Sink ES1_TT_Sk

Symbol

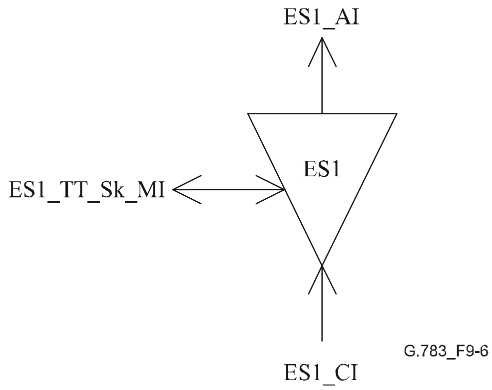


Figure 9-6/G.783 – ES1_TT_Sk symbol

Interfaces

Table 9-4/G.783 – ES1_TT_Sk input and output signals

Inputs	Outputs
ES1_CI_Data ES1_TT_Sk_MI_PortMode	ES1_AI_Data ES1_AI_TSF ES1_TT_Sk_MI_cLOS

Processes

This function recovers the electrical STM-1 Intra-station Section Layer signal as defined in ITU-T Rec. G.703 [3].

Input return loss: The function shall meet the requirement defined in ITU-T Rec. G.703.

Port Mode: The function shall have a port mode as specified by 6.1/G.806.

NOTE – The AUTO state of the port mode process is optional.

Defects

dLOS: see 6.2.1.1.

Consequent actions

The function shall perform the following consequent actions:

aTSF ← dLOS

Defect correlations

The function shall perform the following defect correlations to determine the most probable fault cause. This fault cause shall be reported to the SEMF.

cLOS ← dLOS and MON

Performance monitoring

None.

9.3 Adaptation functions

9.3.1 STM-N Optical Section to Regenerator Section Adaptation OSn/RSn_A

9.3.1.1 STM-N Optical Section to Regenerator Section Adaptation Source OSn/RSn_A_So

Symbol

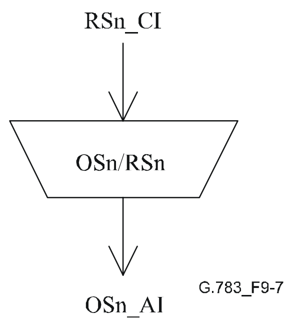


Figure 9-7/G.783 – OSn/RSn_A_So symbol

Interfaces

Table 9-5/G.783 – OSn/RSn_A_So input and output signals

Inputs	Outputs
RSn_CI_Data RSn_CI_Clock	OSn_AI_Data

Processes

This function provides line coding for STM-N signals according to ITU-T Recs G.957 or G.691.

This functions limits the output jitter on the clock information in the OSn_AI_Data signal as given in Tables 9-6 and 9-7 measured over a 60-second interval.

Jitter generation for SDH regenerator: A type A SDH regenerator, deployed in networks optimized for the 2048 kbit/s hierarchy, shall, on its STM-N output, not generate jitter in excess of the values in Table 9-6.

Table 9-6/G.783 – Jitter generation for STM-N type A regenerators in 2048 kbit/s based networks

<table>
<tr><th rowspan="2">Interface</th><th colspan="2">Measurement band
(–3 dB frequencies)
(Notes 1 and 2)</th><th rowspan="2">Peak-peak amplitude
(UI)
(Notes 2 and 3)</th></tr>
<tr><th>high-pass
(kHz)</th><th>low-pass (MHz)
–60 dB/dec</th></tr>
<tr><td rowspan="2">STM-1 optical</td><td>0.5</td><td>1.3</td><td>0.30</td></tr>
<tr><td>65</td><td>1.3</td><td>0.10</td></tr>
<tr><td rowspan="2">STM-4 optical</td><td>1</td><td>5</td><td>0.30</td></tr>
<tr><td>250</td><td>5</td><td>0.10</td></tr>
<tr><td rowspan="2">STM-16 optical</td><td>5</td><td>20</td><td>0.30</td></tr>
<tr><td>1000</td><td>20</td><td>0.10</td></tr>
<tr><td rowspan="2">STM-64 optical</td><td>20</td><td>80</td><td>0.30</td></tr>
<tr><td>4000</td><td>80</td><td>0.10</td></tr>
<tr><td rowspan="2">STM-256 optical
(Note 4)</td><td>FFS</td><td>FFS</td><td>FFS</td></tr>
<tr><td>16 000</td><td>320</td><td>0.10</td></tr>
<tr><td colspan="4">NOTE 1 – The high-pass and low-pass measurement filter transfer functions are defined in clause 35/G.825.
NOTE 2 – For STM-1: 1 UI = 6.43 ns
For STM-4: 1 UI = 1.61 ns
For STM-16: 1 UI = 0.40 ns
For STM-64: 1 UI = 0.10 ns
For STM-256: 1 UI = 0.025 ns
NOTE 3 – The measurement time and pass/fail criteria are defined in clause 5/G.825.
NOTE 4 – Values for STM-256 are provisional and are not present in ITU-T Rec. G.825 at the time of publication of this version of this Recommendation.</td></tr>
</table>

An STM-N (N = 1, 4, 16, 64) regenerator deployed in networks optimized for the particular 1544 kbit/s hierarchy that includes the rates 1544 kbit/s, 6312 kbit/s and 44 736 kbit/s shall, on its STM-N output, not generate jitter in excess of the values in Table 9-7.

Table 9-7/G.783 – Jitter generation for STM-N regenerators in 1544 kbit/s based networks

Interface	Measurement band (–3 dB frequencies)		Limit (Notes 1, 2, and 3)
	high-pass (kHz)	low-pass (MHz) –60 dB/dec	
STM-1 optical	12	1.3	0.1 UIpp/0.01 UIrms
STM-4 optical	12	5	0.1 UIpp/0.01 UIrms
STM-16 optical	12	20	0.1 UIpp/0.01 UIrms
STM-64 optical	20	80	0.30 UIpp
	4000	80	0.10 UIpp
STM-256 optical	FFS	FFS	FFS

NOTE 1 – Both peak-to-peak and rms jitter limits are to be met simultaneously for the rates STM-1, STM-4, and STM-16 (not applicable for STM-64).

NOTE 2 – For STM-1: 1 UI = 6.43 ns
For STM-4: 1 UI = 1.61 ns
For STM-16: 1 UI = 0.40 ns
For STM-64: 1 UI = 0.10 ns
For STM-256: 1 UI = 0.025 ns

NOTE 3 – The measurement time and pass/fail criteria are defined in clause 5/G.825.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

9.3.1.2 STM-N Optical Section to Regenerator Section Adaptation Sink OSn/RSn_A_Sk

Symbol

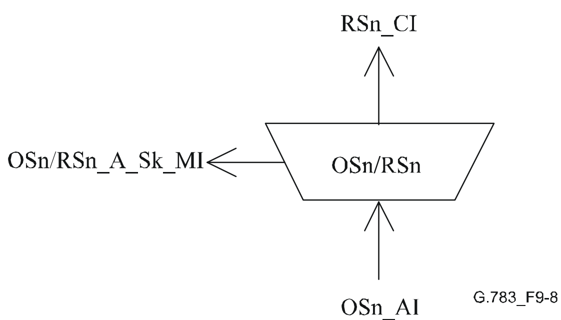


Figure 9-8/G.783 – OSn/RSn_A_Sk symbol

Interfaces

Table 9-8/G.783 – OSn/RSn_A_Sk input and output signals

Inputs	Outputs
OSn_AI_Data OSn_AI_TSF	RSn_CI_Data RSn_CI_Clock RSn_CI_FS RSn_CI_SSF OSn/RSn_A_Sk_MI_cLOF OSn/RSn_A_Sk_MI_pOFS

Processes

The OSn_AI_Data signal, with its contained timing, is receiving by the OSn_AP from the OSn_TT_Sk function. The OSn/RSn function processes this signal to form data and associated timing at the RSn_CP. The function also recovers frame alignment and identifies the frame start positions in the data of the RSn_CP. The framed STM-N data and timing are presented at the RSn_CP.

Regeneration: The function shall operate with a maximum BER of TBD when any combination of the following signal conditions exist at the input:

– any input optical power level within the range specified in ITU-T Recs G.957 or G.691;

– jitter modulation applied to the input signal as specified in ITU-T Rec. G.825;

– the input signal bit rate has any value in the range N × 155 520 kbit/s ± 20 ppm.

NOTE – The frequency and jitter/wander tolerance might be further constrained by the requirements of the client layers.

To ensure adequate immunity against the presence of Consecutive Identical Digits (CID) in the STM-N signal, the function shall comply with the specification in 15.1.4.

The function shall process the signal such that in the absence of input jitter, the intrinsic jitter at the STM-N output interface (in a regenerative repeater) shall not exceed the values specified in 15.1.2.

The function shall process the signal such that the jitter transfer (measured between an STM-N input and STM-N output in a regenerative repeater) shall be as specified in 15.1.3.

The frame alignment process is described in 8.2.1.

Defects

dLOF: see 6.2.5.1.

Consequent actions

The function shall perform the following consequent actions:

aAIS ← dLOF or AI_TSF

aSSF ← dLOF or AI_TSF

On declaration of an aAIS the function shall output an all-ONEs (AIS) signal – complying to the frequency limits for this interface – within 250 µs; on clearing of aAIS, the function shall output normal data within 250 µs.

Defect correlations

The function shall perform the following defect correlations to determine the most probable fault cause. This fault cause shall be reported to the SEMF.

cLOF ← dLOF and (not AI_TSF)

Performance monitoring

The function shall perform the following performance monitoring primitives processing:

Any second with at least one OOF event shall be reported as a pOFS (optional in ITU-T Rec. G.784 [10]).

9.3.2 STM-1 Electrical Section to Regenerator Section Adaptation ES1/RS1_A

9.3.2.1 STM-1 Electrical Section to Regenerator Section Adaptation Source ES1/RS1_A_So

Symbol

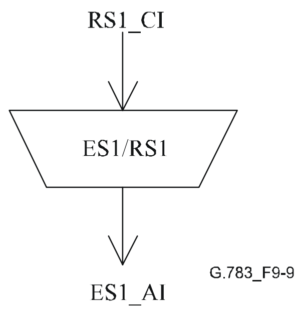


Figure 9-9/G.783 – ES1/RS1_A_So symbol

Interfaces

Table 9-9/G.783 – ES1/RS1_A_So input and output signals

Inputs	Outputs
RS1_CI_Data RS1_CI_Clock	ES1_AI_Data

Processes

This function provides CMI encoding for STM-1 signals according to ITU-T Rec. G.703.

This function limits the output jitter on the clock information in the ES1_AI_Data signal to less than 0.075 UIpp (1 UI = 6.43 ns) between 65 kHz to 1.3 MHz measured over a 60-second interval.

NOTE – The jitter and wander below 65 kHz is determined by the SETS, see ITU-T Rec. G.781 [9].

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

9.3.2.2 STM-1 Electrical Section to Regenerator Section Adaptation Sink (ES1/RS1_A_Sk)

Symbol

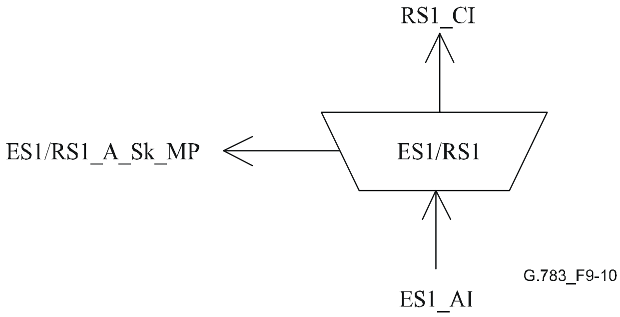


Figure 9-10/G.783 – ES1/RS1_A_Sk symbol

Interfaces

Table 9-10/G.783 – ES1/RS1_A_Sk input and output signals

Inputs	Outputs
ES1_AI_Data ES1_AI_TSF	RS1_CI_Data RS1_CI_Clock RS1_CI_FS RS1_CI_SSF ES1/RS1_A_Sk_MI_cLOF ES1/RS1_A_Sk_MI_pOFS

Processes

The ES1_AI_Data signal, with its contained timing, is received by the ES1_AP from the ES1_TT_Sk function. The ES1/RS1 function processes this signal to form data and associated timing at the ES1_CP. The function also recovers frame alignment and identifies the frame start positions in the data of the RS1_CP. The framed STM-N data and timing are presented at the ES1_CP.

Regeneration: The function shall operate without any errors when any combination of the following signal conditions exist at the input:

– an input electrical amplitude level with any value defined by ITU-T Rec. G.703;

– jitter modulation applied to the input signal with any value defined in ITU-T Rec. G.825 [17];

– the input signal bit rate has any value in the range 155 520 kbit/s ± 20 ppm.

NOTE – The frequency and jitter/wander tolerance might be further constrained by the requirements of the client layers.

CMI decoding: The function shall perform the CMI decoding process according to ITU-T Rec. G.703.

Frame alignment: The STM-N frame alignment process is described in 8.2.1.

Defects

dLOF: see 6.2.5.1.

Consequent actions

The function shall perform the following consequent actions:

aAIS ← dLOF

aSSF ← dLOF

If loss of frame (LOF) is detected, then a logical all-ONEs (AIS) signal shall be applied at the data signal output within 2 frames (250 µs). Upon termination of the above defect conditions, the logical all-ONEs signal shall be removed within 2 frames (250 µs).

Defect correlations

The function shall perform the following defect correlations to determine the most probable fault cause. This fault cause shall be reported to the SEMF.

cLOF ← dLOF and (not AI_TSF)

Performance monitoring

The function shall perform the following performance monitoring primitives processing:

Any second with at least one OOF event shall be reported as a pOFS (optional in ITU-T Rec. G.784).

9.4 Sublayer functions (N/A)

There are no sublayer functions applicable to this clause.

10 STM-N Regenerator Section Layer (N = 1, 4, 16, 64, 256)

The data at the Regenerator Section Layer CP (RS CI) is octet structured with co-directional timing and 125 microsecond frame length. The format is shown in Figures 10-1 to 10-3 (see also Figure 10-4).

The RS CI consists of the A1, A2 framing bytes, the J0 RS trace byte, the B1 BIP-8 byte, the E1 orderwire byte, the F1 RS user byte, the D1-D3 RS DCC bytes and the NU bytes, together with the MS CI as defined in ITU-T Rec. G.707/Y.1322 [6].

1	2	3	4	5	6	7	8	9	(value of b coordinate)
1 to n	1 to n	1 to n	1 to n	1 to n	1 to n	1 to n	1 to n	1 to n	(value of c coordinate)
A1	A1	A1	A2	A2	A2	J0	NU	NU	
B1			E1			F1	NU	NU	
D1			D2			D3			

G.783_F10-1

Figure 10-1/G.783 – STM-N (N = 1, 4, 16, 64) Regenerator Section CI Data Format in S(b, c) format

1 1 to n	2 1 to n	3 1 to n	4 1 to n	5 1 to n	6 1 to n	7 1 to n	8 1 to n	9 1 to n	(value of b coordinate) (value of c coordinate)
		A1	A2			J0	NU	NU	
B1			E1			F1	NU	NU	
D1			D2			D3			

NOTE – The number of A1 and A2 bytes is according to ITU-T Rec. G.707/Y.1322.

G.783_F10-2

Figure 10-2/G.783 – STM-256 Regenerator Section CI Data Format in S(b, c) format

1 1 to n	2 1 to n	3 1 to n	4 1 to n	5 1 to n	6 1 to n	7 1 to n	8 1 to n	9 1 to n	(value of b coordinate) (value of c coordinate)
							NU	NU	
			E1			F1	NU	NU	
D1			D2			D3			

NOTE – The D1-D3, J0, B1, E1 and F1 bytes are only present in columns S(a, b, 1).

G.783_F10-3

Figure 10-3/G.783 – Regenerator Section AI Data Format in S(b, c) format

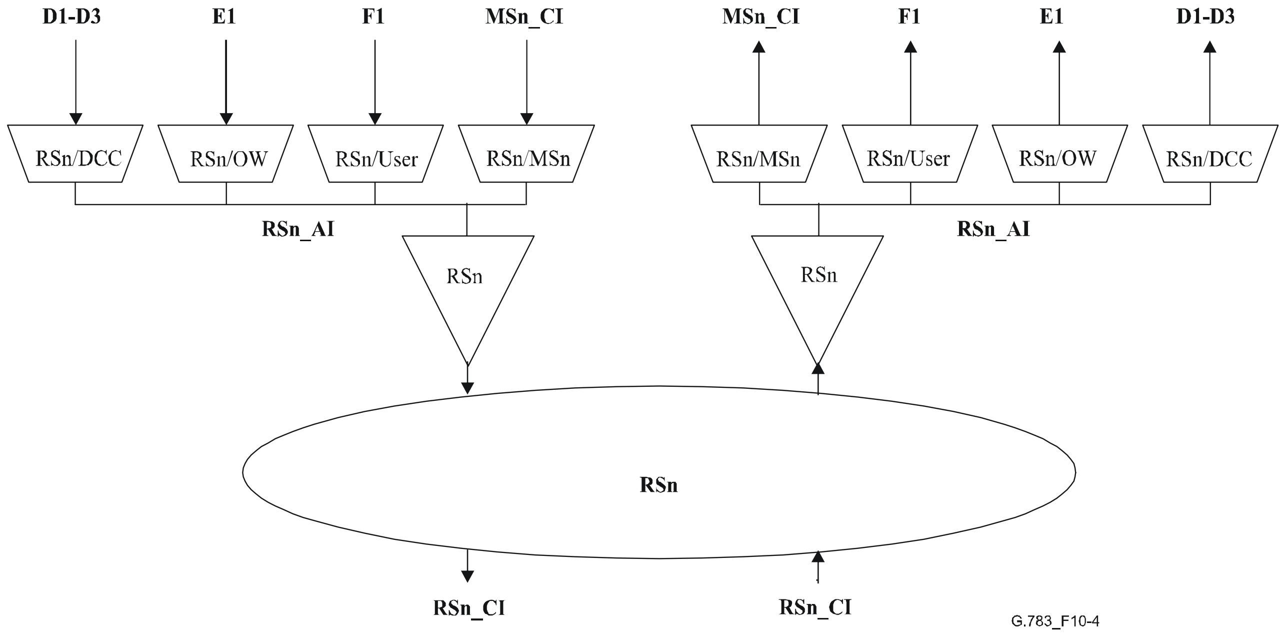


Figure 10-4/G.783 – Regenerator Section functions

10.1 Connection functions

Not applicable.

10.2 Termination functions

10.2.1 STM-N Regenerator Section Trail Termination RSn_TT

The RSn_TT function acts as a source and sink for the regenerator section overhead (RSOH). A regenerator section is a maintenance entity between and including two RSn_TT functions.

NOTE – In regenerators, the A1, A2 and J0 bytes may be relayed (i.e., passed transparently through the regenerator) instead of being terminated and generated as described below. Refer to Appendix IV.

10.2.1.1 STM-N Regenerator Section Trail Termination Source RSn_TT_So

Symbol

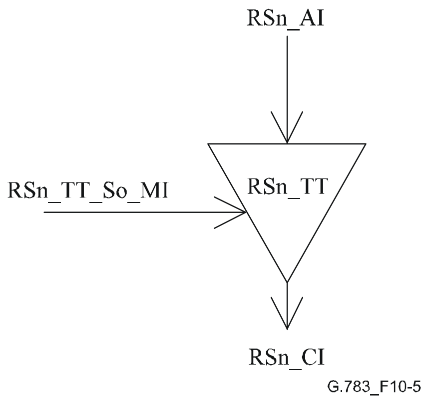


Figure 10-5/G.783 – RSn_TT_So symbol

Interfaces

Table 10-1/G.783 – RSn_TT_So Function inputs and outputs

Inputs	Outputs
RSn_AI_Data RSn_AI_Clock RSn_AI_FrameStart RSn_TT_So_MI_TxTI	RSn_CI_Data RSn_CI_Clock

Processes

Data at the RSn_AP is an STM-N signal as defined in ITU-T Rec. G.707/Y.1322 having a valid multiplex section overhead (MSOH) and E1, D1-D3, F1 and NU bytes. However, the bytes A1, A2, B1, and J0 are indeterminate in this signal. A1, A2, B1, and J0 bytes are set in accordance with ITU-T Rec. G.707/Y.1322 as part of the RSn_TT function to give a fully formatted STM-N data and associated timing at the RSn_CP. After these bytes have been set, the RSn_TT function scrambles the STM-N signal before it is presented to the RSn_CP. Scrambling is performed according to 8.1.1 and ITU-T Rec. G.707/Y.1322.

A1, A2: Frame alignment bytes A1 and A2 are generated and inserted in the first row of the RSOH according to ITU-T Rec. G.707/Y.1322.

J0: Regenerator Section trace information (RSn_TT_So_MI_TxTI) derived from reference point RSn_TT_MP is placed in J0 byte position. The RS trace format is described in ITU-T Rec. G.707/Y.1322.

B1: 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 ITU-T Rec. G.707/Y.1322. The BIP-8 is computed over all bits of the previous STM-N frame at the RSn_CP after scrambling. The result is placed in byte B1 position of the RSOH before scrambling.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

10.2.1.2 STM-N Regenerator Section Trail Termination Sink RSn_TT_Sk

Symbol

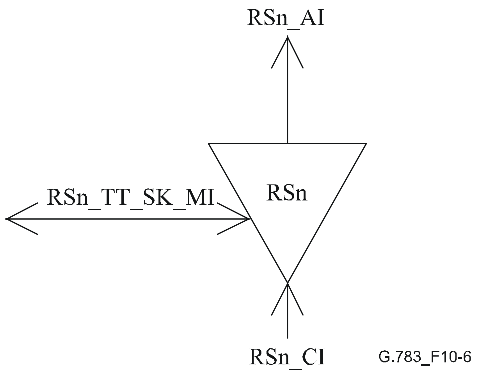


Figure 10-6/G.783 – RSn_TT_Sk symbol

Interfaces

Table 10-2/G.783 – RSn_TT_Sk Function inputs and outputs

Inputs	Outputs
RSn_CI_Data RSn_CI_Clock RSn_CI_FrameStart RSn_CI_SSF RSn_TT_Sk_MI_ExTI RSn_TT_Sk_MI_TPmode RSn_TT_Sk_MI_TIMdis RSn_TT_Sk_MI_TIMAISdis RSn_TT_Sk_MI_ExTImode RSn_TT_Sk_MI_1second RSn_TT_Sk_MI_SSF_Reported	RSn_AI_Data RSn_AI_Clock RSn_AI_FrameStart RSn_AI_TSF RSn_TT_Sk_MI_AcTI RSn_TT_Sk_MI_cTIM RSn_TT_Sk_MI_cSSF RSn_TT_Sk_MI_pN_EBC RSn_TT_Sk_MI_pN_DS

Processes

This function monitors the STM-N signal for RS errors, and recovers the RS trail termination status. It extracts the payload-independent overhead bytes (J0, B1) from the RSn layer Characteristic Information.

Descrambling

The function shall descramble the incoming STM-N signal. The operation of the descrambler is performed according to 8.1.1 and ITU-T Rec. G.707/Y.1322.

J0: Bytes J0 (RS path trace) is recovered from the RSOH at the RSn_CP. If an RS trace identifier mismatch (RSn_TT_Sk_MI_cTIM) is detected, then it shall be reported via reference point RS_TT_MP. The accepted value of J0 (RSn_TT_Sk_MI_AcTI) is also available at the RS_TT_MP. For a description of trace identifier mismatch processing (J0), see 6.2.2.2/G.806.

B1: Even bit parity is computed for each bit n of every byte of the preceding scrambled STM-N frame and compared with bit n of B1 recovered from the current frame (n = 1 to 8 inclusive). In the case of STM-1, a difference between the computed and recovered B1 values is taken as evidence of one errored block (nN_B). In the case of STM-4, STM-16, STM-64 and STM-256, the definition of errored block is for further study.

Defects

dTIM: see 6.2.2.2/G.806.

Consequent actions

The function shall perform the following consequent actions:

aAIS ← CI_SSF or (dTIM and not TIMAISdis)

aTSF ← CI_SSF or (dTIM and not TIMAISdis)

Defect correlations

The function shall perform the following defect correlations to determine the most probable fault cause. This fault cause shall be reported to the SEMF.

cTIM ← dTIM and MON

cSSF ← CI_SSF and SSF_Reported and MON

Performance monitoring

The function shall perform the following performance monitoring primitives processing:

pN_DS ← CI_SSF or dTIM or dEQ

pN_EBC ← ΣnN_B

10.3 Adaptation functions

10.3.1 STM-N Regenerator Section to STM-N Multiplex Section Adaptation RSn/MSn_A

10.3.1.1 STM-N Regenerator Section to STM-N Multiplex Section Adaptation Source RSn/MSn_A_So

Symbol

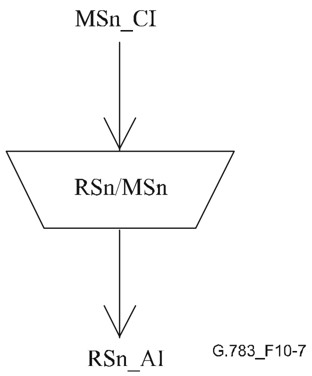


Figure 10-7/G.783 – RSn/MSn_A_So symbol

Interfaces

Table 10-3/G.783 – RSn/MSn_A_So Function inputs and outputs

Inputs	Outputs
MSn_CI_Data MSn_CI_Clock MSn_CI_FrameStart MSn_CI_SSF	RSn_AI_Data RSn_AI_Clock RSn_AI_FrameStart

Processes

The function multiplexes the MSn_CI data into the STM-N byte locations defined in ITU-T Rec. G.707/Y.1322.

Defects

None.

Consequent actions

aAIS ← CI_SSF

NOTE – If CI_SSF is not connected (when RSn/MSn_A_So is connected to a MSn_TT_So), SSF is assumed to be false.

On declaration of aAIS, the function shall output all ONEs signal within 250 µs; on clearing of aAIS, the function shall output normal data within 250 µs. The frequency of the all ONEs signal shall be within the STM-N level frequency ±20 ppm.

Defect correlations

None.

Performance monitoring

None.

10.3.1.2 STM-N Regenerator Section to STM-N Multiplex Section Adaptation Sink RSn/MSn_A_Sk

Symbol

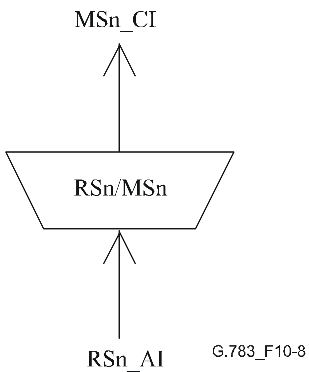


Figure 10-8/G.783 – RSn/MSn_A_Sk symbol

Interfaces

Table 10-4/G.783 – RSn/MSn_A_Sk Function inputs and outputs

Inputs	Outputs
RSn_AI_Data RSn_AI_Clock RSn_AI_FrameStart RSn_AI_TSF	MSn_CI_Data MSn_CI_Clock MSn_CI_FrameStart MSn_CI_SSF

Processes

The function separates MSn_CI data from RSn_AI as depicted in Figures 10-1 to 10-3.

Defects

None.

Consequent actions

aSSF ← AI_TSF

Defect correlations

None.

Performance monitoring

None.

10.3.2 STM-N Regenerator Section to DCC Adaptation RSn/DCC_A

10.3.2.1 STM-N Regenerator Section to DCC Adaptation Source RSn/DCC_A_So

Symbol

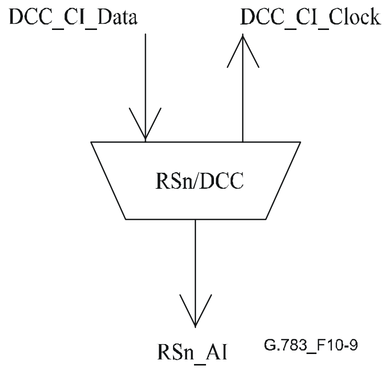


Figure 10-9/G.783 – RSn/DCC_A_So symbol

Interfaces

Table 10-5/G.783 – RSn/DCC_A_So Function inputs and outputs

Inputs	Outputs
DCC_CI_Data RSn_AI_Clock RSn_AI_FrameStart	RSn_AI_Data DCC_CI_Clock

Processes

The DCC data is consecutively 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 RSn_TT functions. This channel is available for internally generated, externally generated, and manufacturer specific messages. The protocol stack used shall be as defined in ITU-T Rec. G.784 [10].

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

10.3.2.2 STM-N Regenerator Section to DCC Adaptation Sink RSn/DCC_A_Sk

Symbol

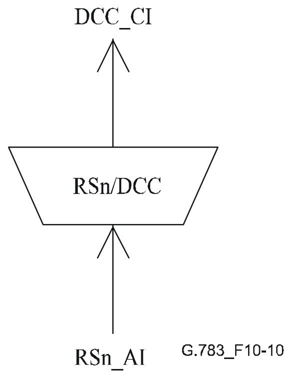


Figure 10-10/G.783 – RSn/DCC_A_Sk symbol

Interfaces

Table 10-6/G.783 – RSn/DCC_A_Sk Function inputs and outputs

Inputs	Outputs
RSn_AI_Data RSn_AI_Clock RSn_AI_FrameStart RSn_AI_TSF	DCC_CI_Data DCC_CI_Clock DCC_CI_SSF

Processes

The DCC data is recovered consecutively from the D1-D3 bytes of the RSOH.

Defects

None.

Consequent actions

aSSF ← AI_TSF

Defect correlations

None.

Performance monitoring

None.

10.3.3 STM-N Regenerator Section to Orderwire Adaptation RSn/OW_A

10.3.3.1 STM-N Regenerator Section to Orderwire Adaptation Source RSn/OW_A_So

Symbol

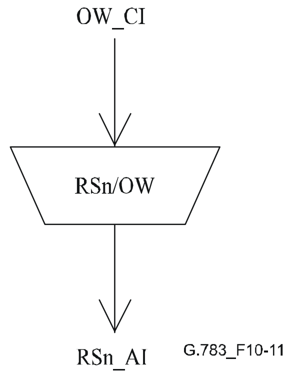


Figure 10-11/G.783 – RSn/OW_A_So symbol

Interfaces

Table 10-7/G.783 – RSn/OW_A_So Function inputs and outputs

Inputs	Outputs
OW_CI_Data OW_CI_Clock OW_CI_FrameStart	RSn_AI_Data

Processes

The orderwire is placed in byte E1 position of the RSOH. It provides an optional 64 kbit/s unrestricted channel and is reserved for voice communication between network elements.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

10.3.3.2 STM-N Regenerator Section to Orderwire Adaptation Sink RSn/OW_A_Sk

Symbol

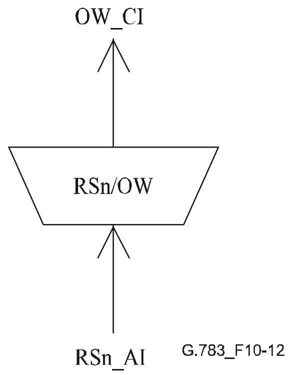


Figure 10-12/G.783 – RSn/OW_A_Sk symbol

Interfaces

Table 10-8/G.783 – RSn/OW_A_Sk Function inputs and outputs

Inputs	Outputs
RSn_AI_Data	OW_CI_Data OW_CI_Clock OW_CI_FrameStart

Processes

The orderwire is recovered from E1 byte position of the RSOH.

Defects

None.

Consequent actions

aSSF ← AI_TSF

aAIS ← AI_TSF

On declaration of aAIS, the function shall output an all-ONEs (AIS) signal – complying to the frequency limits for this signal (a bit rate in range 64 kbit/s ± 100 ppm) within two frames (250 µs). Upon termination of the above failure conditions, the all-ONEs shall be removed within two frames (250 µs).

Defect correlations

None.

Performance monitoring

None.

10.3.4 STM-N Regenerator Section to User channel Adaptation RSn/User_A

10.3.4.1 STM-N Regenerator Section to User channel Adaptation Source RSn/User_A_So

Symbol

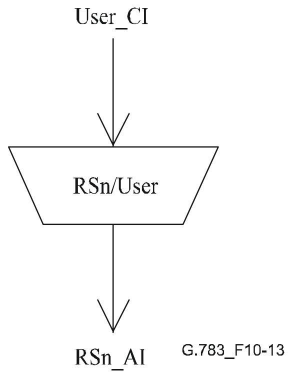


Figure 10-13/G.783 – RSn/User_A_So symbol

Interfaces

Table 10-9/G.783 – RSn/User_A_So Function inputs and outputs

Inputs	Outputs
User_CI_Data User_CI_Clock	RSn_AI_Data

Processes

The user data is placed in byte F1 position of the RSOH. The 64 kbit/s clear channel is reserved for the network provider (for example, for network operations). 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.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

10.3.4.2 STM-N Regenerator Section to User channel Adaptation Sink RSn/User_A_Sk

Symbol

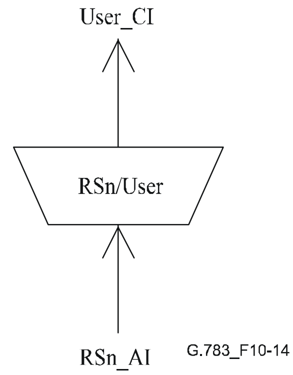


Figure 10-14/G.783 – RSn/User_A_Sk symbol

Interfaces

Table 10-10/G.783 – RSn/User_A_Sk Function inputs and outputs

Inputs	Outputs
RSn_AI_Data RSn_AI_Clock RSn_AI_FrameStart RSn_AI_TSF	User_CI_Data User_CI_Clock User_CI_SSF

Processes

The user data is recovered from the F1 byte position of the RSOH.

Defects

None.

Consequent actions

aSSF ← AI_TSF

aAIS ← AI_TSF

On declaration of aAIS, the function shall output an all-ONEs (AIS) signal – complying to the frequency limits for this signal (a bit rate in range 64 kbit/s ± 100 ppm) within 2 frames (250 µs). Upon termination of the above failure conditions, the all-ONEs shall be removed within two frames (250 µs).

Defect correlations

None.

Performance monitoring

None.

10.3.5 STM-N Regenerator Section to Auxiliary bytes Adaptation RSn/AUX_A

Certain RSOH bytes are presently reserved for national use, media-dependent use or for future international standardization, as defined in ITU-T Rec. G.707/Y.1322. One or more of these bytes may accessed via the RSn/AUX_A function. 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 defined for the other unused bytes when not used for a particular purpose.

10.3.6 STM-N (N ≥ 16) Regenerator Section to STM-N Multiplex Section Adaptation supporting FEC

10.3.6.1 STM-N (N ≥ 16) Regenerator Section to STM-N Multiplex Section Adaptation FEC transparent

10.3.6.1.1 STM-N (N ≥ 16) Regenerator Section to STM-N Multiplex Section Adaptation FEC transparent Source Function RSn/MSF_A _So

Symbol

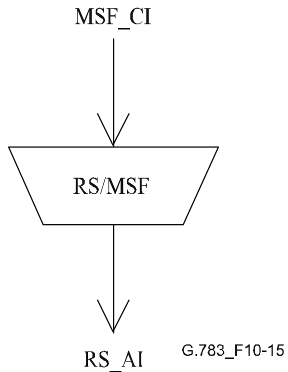


Figure 10-15/G.783 – RS/MSF_A_So symbol

Interfaces

Table 10-11/G.783 – RSn/MSF_A_So input and output signals

Inputs	Outputs
MSF_CI_D MSF_CI_CK MSF_CI_FS MSF_CI_SSF	RSn_AI_D RSn_AI_CK RSn_AI_FS

Processes

The function multiplexes the MSF_CI data into the STM-N byte locations defined in ITU-T Rec. G.707/Y.1322 and as depicted in Figure 10-16.

MSF_CI definition == MS_CI + FEC

A1	A1	A1	A1	A1	A1	A2	A2	A2	A2	A2	A2	J0	Z0	X	X	X	X	**$Payload_1$**
B1	**$P1_1$**	Δ	Δ	Δ	Δ	E1	**$P1_1$**	Δ	Δ		**$P1_1$**	F1	X	X	X	X	X	**$Payload_2$**
D1	**$P1_2$**	Δ	Δ	Δ	Δ	D2	**$P1_2$**	Δ	Δ		**$P1_2$**	D3	**$P1_3$**		**$P1_3$**		**Q1** **$P1_3$**	**$Payload_3$**
H1	**H1**	**H1**	**H1**	**H1**	**H1**	**H2**	**H2**	**H2**	**H2**	**H2**	**H2**	**H3**	**H3**	**H3**	**H3**	**H3**	**H3**	**$Payload_4$**
B2	**B2**	**B2**	**B2**	**B2**	**B2**	**K1**	**$P1_4$**		**$P1_4$**		**$P1_4$**	**K2**	**$P1_5$**		**$P1_5$**		**$P1_5$**	**$Payload_5$**
D4	**D13-D60**					**D5**						**D6**	**$P1_6$**		**$P1_6$**		**$P1_6$**	**$Payload_6$**
D7	**D61-D108**					**D8**						**D9**	**$P1_7$**		**$P1_7$**		**$P1_7$**	**$Payload_7$**
D10	**D109-D156**					**D11**						**D12**	**$P1_8$**		**$P1_8$**		**$P1_8$**	**$Payload_8$**
S1	**$P1_9$**		**$P1_9$**		**$P1_9$**		**M0** **M1**					**E2**	**X**	**X**	**X**	**X**	**X**	**$Payload_9$**

Figure 10-16/G.783 – MSF_CI definition

NOTE – FEC for row b (parity bytes $P1_b$) covers $Payload_b$ (b = 1, ..., 9).

FEC for row 3 covers also bytes Q1. FEC for rows 4, …, 9 also covers the MSOH in row 4, …, 9 resp.

FEC for row 5 excludes parity bytes $P1_4$. M0 is not present for STM-16, optional for STM-64 and included in STM-256.

D13-D156 are only present in STM-256.

Defects

None.

Consequent actions

aAIS ← CI_SSF

On declaration of aAIS, the function shall output an all-ONEs signal within 250 µs; on clearing of aAIS, the function shall output normal data within 250 µs. The frequency of the all-ONEs signal shall be within the STM-N level frequency ± 20 ppm.

Defect correlations

None.

Performance monitoring

None.

10.3.6.1.2 STM-N (N ≥ 16) Regenerator Section to STM-N Multiplex Section Adaptation FEC transparent Sink Function RSn/MSF_A _Sk

Symbol

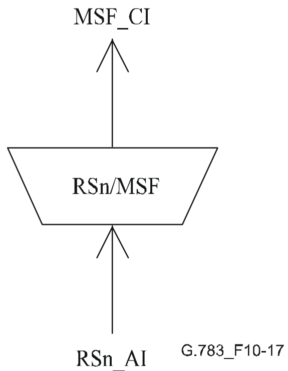


Figure 10-17/G.783 – RSn/MSF_A_Sk symbol

Interfaces

Table 10-12/G.783 – RSn/MSF_A_Sk input and output signals

Inputs	Outputs
RSn_AI_D RSn_AI_CK RSn_AI_FS RSn_AI_TSF	MSF_CI_D MSF_CI_CK MSF_CI_FS MSF_CI_SSF

Processes

The function separates MSF_CI data from RSn_AI as depicted in Figure 10-16.

MSF_AIS == MSn-AIS and additional all FEC and FSI bits set to "1".

Defects

None.

Consequent actions

aSSF ← AI_TSF

Defect correlations

None.

Performance monitoring

None.

10.3.6.2 STM-N (N ≥ 16) Regenerator Section to STM-N Multiplex Section Adaptation FEC generation

Symbol

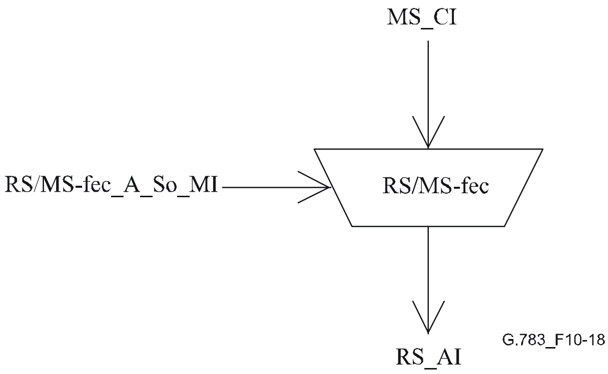


Figure 10-18/G.783 – RS/MS-fec_A_So symbol

Interfaces

Table 10-13/G.783 – RSn/MS-fec_A_So input and output signals

Inputs	Outputs
MSn_CI_D MSn_CI_CK MSn_CI_FS MSn_CI_SSF RS/MS-fec_A_So_MI_FEC RS/MS-fec_A_So_MI_Delay	RSn_AI_D RSn_AI_CK RSn_AI_FS

Processes

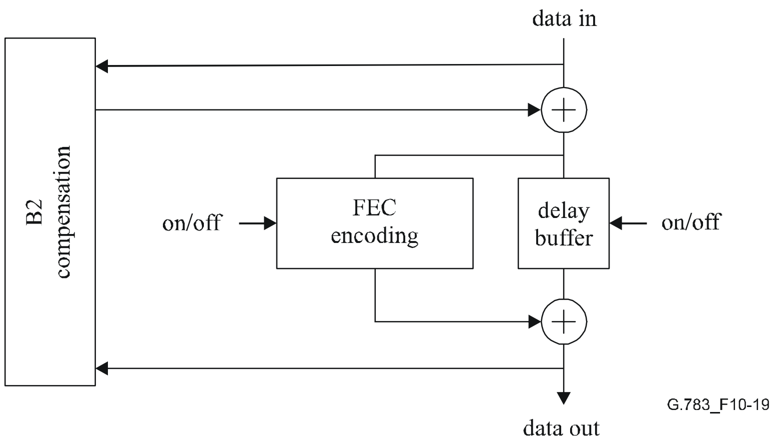


Figure 10-19/G.783 – FEC encoding process

B2 compensation shall correct the MSF BIP according to 8.4/G.806. Note that the FEC calculation is done after the B2 compensation and includes the compensated B2 as shown in Figure 10-19a.

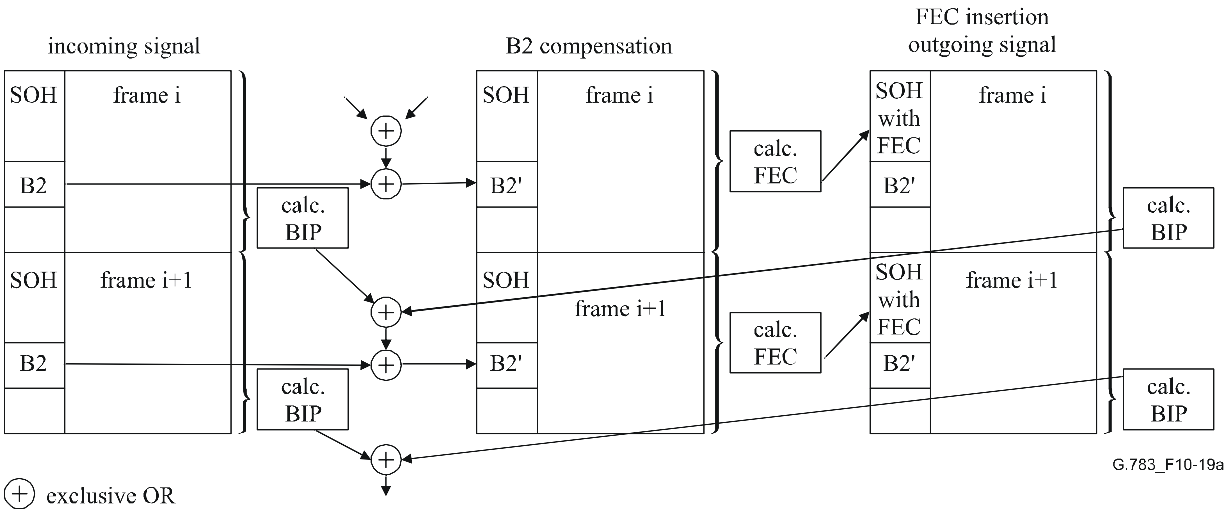


Figure 10-19a/G.783 – B2 compensation and FEC calculation

Defects

None.

Consequent actions

aAIS ← CI_SSF

On declaration of aAIS, the function shall output an all-ONEs signal within 250 µs; on clearing of aAIS, the function shall output normal data within 250 µs. The frequency of the all-ONEs signal shall be within the STM-N level frequency ±20 ppm.

Defect correlations

None.

Performance monitoring

None.

10.3.6.2.1 STM-N (N ≥ 16) Regenerator Section to STM-N Multiplex Section Adaptation FEC generation Sink Function RSn/MSn-fec_A _Sk

Symbol

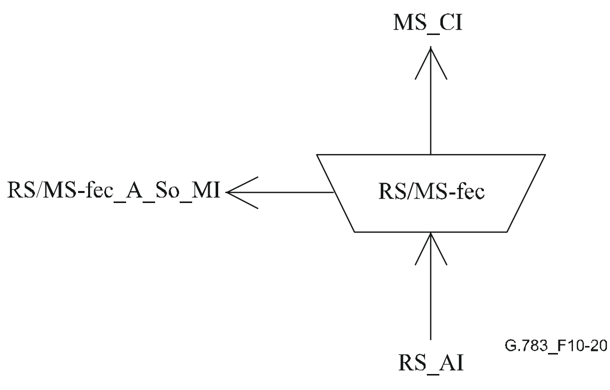


Figure 10-20/G.783 – RS/MS-fec_A_Sk symbol

Interfaces

Table 10-14/G.783 – RSn/MS_fec_A_Sk input and output signals

Inputs	Outputs
RSn_AI_D RSn_AI_CK RSn_AI_FS RSn_AI_TSF	MSn_CI_D MSn_CI_CK MSn_CI_FS MSn_CI_SSF RS/MS-fec_A_Sk_MI_Delay

Processes

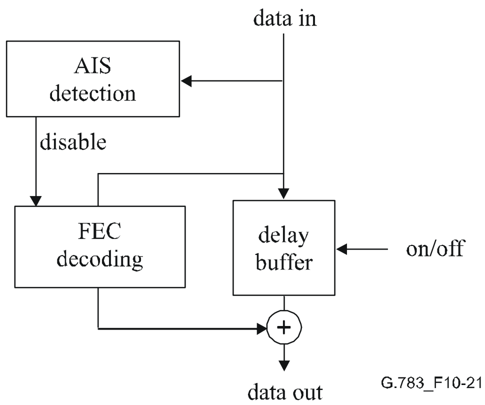


Figure 10-21/G.783 – FEC decoding process

Correction – delay buffers.

The FEC Status Indication (FSI) controls the FEC decoder; the "on" signal will enable the FEC decoding process. The persistency check for FSI is defined in Annex A.6.2.3/G.707/Y.1322.

DEG is for further study.

Defects

MSFdAIS: see 6.2.4.2/G.806.

MSFdAIS detected will disable FEC decoding.

Consequent actions

aSSF ← AI_TSF

Defect correlations

None.

Performance monitoring

None.

10.4 Sublayer functions

Not applicable.

11 STM-N Multiplex Section Layer (N = 1, 4, 16, 64, 256)

The data at the Multiplex Section Layer CP is octet structured with co-directional timing and 125 µm frame length. The format is shown in Figures 11-1 and 11-2 (see also Figure 11-3).

The MS CI consists of the B2 BIP-24 byte, the E2 orderwire byte, the K1/K2 APS bytes, the D4-D12 MS DCC bytes, the S1 SSM byte and the NU bytes, together with the Sn CI as defined in ITU-T Rec. G.707/Y.1322 [6].

1	2	3	4	5	6	7	8	9	(value of b coordinate)
1 to n	1 to n	1 to n	1 to n	1 to n	1 to n	1 to n	1 to n	1 to n	(value of c coordinate)
H1	Y/H1	Y/H1	H2	1/H2	1/H2	H3	H3	H3	
B2	B2	B2	K1			K2			
D4	D13-D60		D5			D6			
D7	D61-D108		D8			D9			
D10	D109-D156		D11			D12			
S1				M0 M1		E2	NU	NU	

NOTE 1 – M0 is not present for MS0, MS1, MS4, and MS16. M0 is optional for STM-64. M0 is mandatory for STM-256.
NOTE 2 – D13-D156 are for MS256 only.

Figure 11-1/G.783 – Multiplex Section CI Data Format

1	2	3	4	5	6	7	8	9	(value of b coordinate)
1 to n	1 to n	1 to n	1 to n	1 to n	1 to n	1 to n	1 to n	1 to n	(value of c coordinate)
H1	Y/H1	Y/H1	H2	1/H2	1/H2	H3	H3	H3	
			K1			K2			
D4	D13-D60		D5			D6			
D7	D61-D108		D8			D9			
D10	D109-D156		D11			D12			
S1						E2	NU	NU	

NOTE – D13-D156 are for MS256 only.

Figure 11-2/G.783 – Multiplex Section AI Data Format

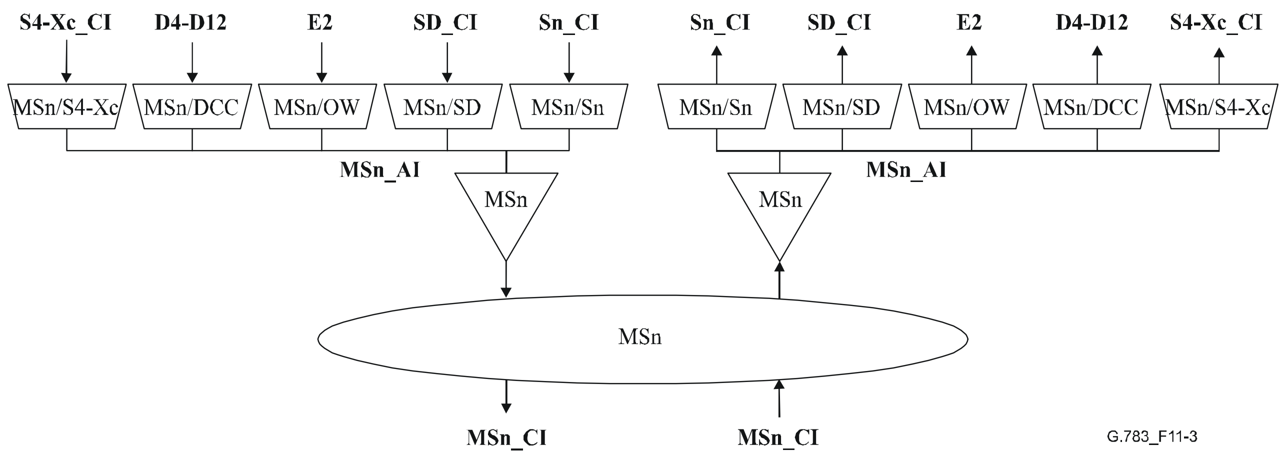


Figure 11-3/G.783 – Multiplex Section Functions

11.1 Connection functions

Not applicable.

11.2 Termination functions

11.2.1 STM-N Multiplex Section Trail Termination MSn_TT

The MSn_TT function acts as a source and sink for the B2, M0 and M1 bytes, and bits 6 to 8 of K2 byte of the multiplex section overhead (MSOH).

11.2.1.1 STM-N Multiplex Section Trail Termination Source MSn_TT_So

Symbol

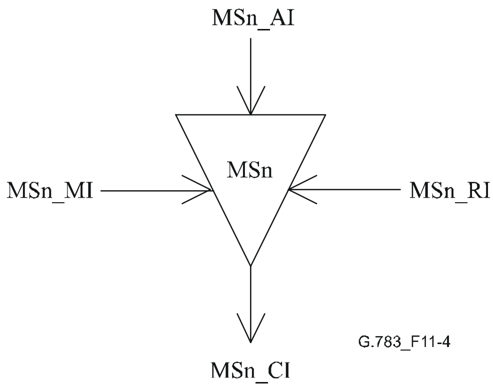


Figure 11-4/G.783 – MSn_TT_So symbol

Interfaces

Table 11-1/G.783 – MSn_TT_So Function inputs and outputs

Inputs	Outputs
MSn_AI_Data MSn_AI_Clock MSn_AI_FrameStart MSn_RI_RDI MSn_RI_REI MSn_MI_M0_Generated	MSn_CI_Data MSn_CI_Clock MSn_CI_FrameStart

Processes

Data at the MSn_AP is an STM-N signal as defined in ITU-T Rec. G.707/Y.1322, having a payload constructed as in ITU-T Rec. G.707/Y.1322, but with indeterminate B2, M0 and M1 MSOH bytes and indeterminate RSOH bytes. The B2, M0 and M1 bytes are set in accordance with ITU-T Rec. G.707/Y.1322 as part of the MSn_TT_So function. The resulting STM-N data and associated timing are presented the MSn_CP.

B2: 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 ITU-T Rec. G.707/Y.1322. 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.

M0, M1: The number of errors detected by monitoring B2 in the sink side (see 6.5.1/G.806) is passed to the source side via the aREI and is encoded in the MS-REI (byte M1 for MS0, MS1, MS4, MS16, or MS64, bytes M0 and M1 for MS64 or MS256) according to 9.2.2.12/G.707/Y.1322. Upon the detection of a number of errors at the termination sink function, the trail termination source function shall have inserted that value in the REI bits within 1 ms.

K2[6-8]: These bits represent the defect status of the associated MSn_TT_Sk. Upon the declaration/clearing of aRDI at the termination sink function, the trail termination source function shall have inserted/removed the RDI code (110/000) within 1 ms.

Defects

None.

Consequent actions

If an MS-AIS defect at the MSn_AP (see 11.2.1.2) is detected in the sink side, then it is passed to the source side via the aRDI (part of the MSn_RI) and MS-RDI shall be applied within 1 ms at the data signal output at reference point MSn_CP. MS-RDI is defined as an STM-N signal with the code 110 in bit positions 6, 7 and 8 of byte K2. On clearing of the defect, the function shall output normal data within 1 ms.

Defect correlations

None.

Performance monitoring

None.

11.2.1.2 STM-N Multiplex Section Trail Termination Sink MSn_TT_Sk

Symbol

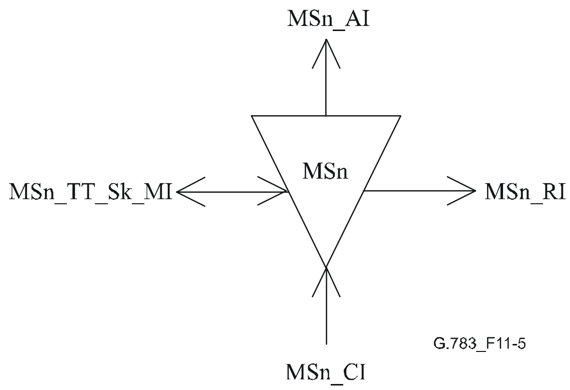


Figure 11-5/G.783 – MSn_TT_Sk symbol

Interfaces

Table 11-2/G.783 – MSn_TT_Sk Function inputs and outputs

Inputs	Outputs
MSn_CI_Data MSn_CI_Clock MSn_CI_FrameStart MSn_CI_SSF MSn_TT_Sk_MI_DEGM MSn_TT_Sk_MI_DEGTHR MSn_TT_Sk_MI_DEG_X MSn_TT_Sk_MI_EXC_X MSn_TT_Sk_MI_TPMode MSn_TT_Sk_MI_1second MSn_TT_Sk_MI_AIS_Reported MSn_TT_Sk_MI_RDI_Reported MSn_TT_Sk_MI_SSF_Reported MSn_TT_Sk_MI_M1_ignored MSn_TT_Sk_MI_M0_ignored	MSn_AI_Data MSn_AI_Clock MSn_AI_FrameStart MSn_AI_TSF MSn_AI_TSD MSn_RI_RDI MSn_RI_REI MSn_TT_Sk_MI_cEXC MSn_TT_Sk_MI_cAIS MSn_TT_Sk_MI_cDEG MSn_TT_Sk_MI_cRDI MSn_TT_Sk_MI_cSSF MSn_TT_Sk_MI_pNEBC MSn_TT_Sk_MI_pFEBC MSn_TT_Sk_MI_pNDS MSn_TT_Sk_MI_pFDS

Processes

The MSn_CI is received at reference point MSn_CP. The MSn_TT function recovers the B2, M0, M1, and K2[6-8] bytes. Then, the STM-N data and associated timing are presented at reference point MSn_AP.

B2: The 3 × 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 MSn_TT_MP as a 1-second count (pN_EBC). The BIP-24N errors are also processed within the MSn_TT function to detect signal degrade (SD) defect. The process for detecting signal degrade is described in 6.2.3.1/G.806 [13].

M0, M1: MS-REI information is decoded according to ITU-T Rec. G.707/Y.1322 from byte M1 (for MS0, MS1, MS4, MS16, or MS64) or from bytes M0 and M1 (for MS64 or MS256) and reported as a 1-second count (pF_EBC) at the MSn_TT_MP. If M1_ignored is true, nF_B shall be forced to "0"; if M1_ignored is false, nF_B shall equal the value in REI.

NOTE – M1_ignored is a parameter provisioned by the operator to indicate the support of the M0/M1 byte in the incoming STM-N signal. For the case where M0/M1 is supported, M1_ignored should be set to false; otherwise, M1_ignored should be set to true.

Defects

dAIS: see 6.2.6.2/G.806.

dRDI: see 6.2.6.3/G.806.

dDEG: see 6.2.3.1/G.806.

dEXC: see 6.2.3.1/G.806.

Consequent actions

The function shall perform the following consequent actions:

aAIS ← dAIS

aRDI ← dAIS

aREI ← "number of error detection code violations"

aTSF ← dAIS

aTSD ← dDEG

aTSFprot ← aTSF or dEXC

If MS-AIS defect is detected, then a logical all-ONEs (AIS) data signal shall be applied at reference point MSn_AP within 250 µs. Upon termination of the above defect condition, the logical all-ONEs signal shall be removed within 250 µs.

If MS-AIS is detected, then a trail signal fail (TSF) condition shall be applied at reference point MSn_AP within 250 µs. Upon termination of the above defect condition, the signal fail condition shall be removed within 250 µs.

If MS-DEG is detected, then a trail signal degrade (TSD) condition shall be applied at the MSn_AP within 250 µs. Upon termination of the above defect condition, the TSD condition shall be removed within 250 µs.

Defect correlations

The function shall perform the following defect correlations to determine the most probable fault cause. This fault cause shall be reported to the SEMF.

cSSF ← CI_SSF and SSF_Reported and MON

cAIS ← dAIS and (not CI_SSF) and AIS_Reported and MON

cDEG ← dDEG and MON

cRDI ← dRDI and RDI_Reported and MON

cEXC ← dEXC and MON

Performance monitoring

The function shall perform the following performance primitives processing:

pN_DS ← aTSF or dEQ

pF_DS ← dRDI

pN_EBC ← ∑nN_B

pF_EBC ← ∑nF_B

11.3 Adaptation functions

11.3.1 STM-N Multiplex Section to Sn layer Adaptation MSn/Sn_A

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.

11.3.1.1 STM-N Multiplex Section to Sn layer Adaptation Source MSn/Sn_A_So

Symbol

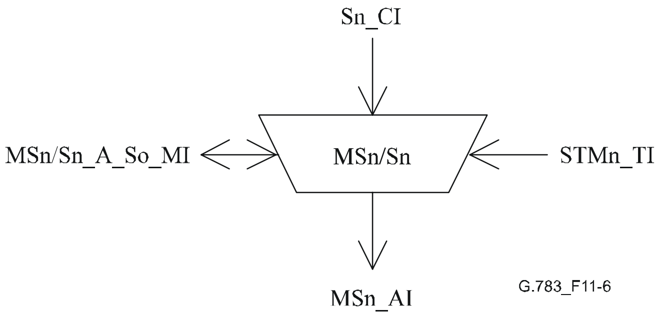


Figure 11-6/G.783 – MSn/Sn_A_So symbol

Interfaces

Table 11-3/G.783 – MSn/Sn_A_So Function inputs and outputs

Inputs	Outputs
Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF STMn_TI_Clock STMn_TI_FrameStart MSn/Sn_A_So_MI_Active	MSn_AI_Data MSn_AI_Clock MSn_AI_FrameStart MSn/Sn_A_So_MI_pPJE+ MSn/Sn_A_So_MI_pPJE–

Processes

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 or if the HP container is generated with the same timing source as the multiplex section.

The PP function can be modelled 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 STMn_TP (see ITU-T Rec. G.781 [9]). 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. 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 STMn_TP and the incoming STM-N line signal]. 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 cancelled.

It may be possible to detect network synchronization degradation by monitoring pointer increments and decrements. Outgoing pointer justification events (PJEs), i.e., pointer values that have been either incremented or decremented, are counted and reported at reference point MSn/Sn_A_MP for performance monitoring filtering. PJE counts are to be reported separately for pointer increments (positive events) and decrements (negative events). PJEs need only be reported for one selected AU-3/4 out of an STM-N signal.

The higher order paths at the Sn_CP are mapped into AUs which are incorporated into AU groups. N such AUGs are byte interleaved to form an STM-N payload at the MSn_AP. The byte interleaving process shall be as defined in ITU-T Rec. G.707/Y.1322. The frame offset information is used by the PG function to generate pointers according to pointer generation rules in ITU-T Rec. G.707/Y.1322. STM-N data the MSn_AP is synchronized to timing from the STMn_TP reference point.

Defects

None.

Consequent actions

The function shall perform the following consequent actions:

aAIS ← CI_SSF

When an all-ONEs signal is applied at reference point Sn_CP, an all-ONEs (AU-AIS) signal shall be applied at reference point MSn_AP within 2 frames (250 µs). Upon termination of the all-ONEs signal at the Sn_CP, the all-ONEs (AU-AIS) signal shall be terminated within 2 frames (250 µs).

Defect correlations

None.

Performance monitoring

Every second the number of generated pointer justification increments within that second shall be counted as the pPJE+. Every second the number of generated pointer justification decrements within that second shall be counted as the pPJE–.

11.3.1.2 STM-N Multiplex Section to Sn layer Adaptation Sink MSn/Sn_A_Sk

Symbol

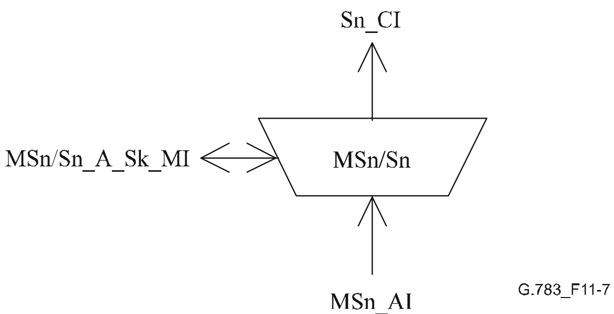


Figure 11-7/G.783 – MSn/Sn_A_Sk symbol

Interfaces

Table 11-4/G.783 – MSn/Sn_A_Sk Function inputs and outputs

Inputs	Outputs
MSn_AI_Data MSn_AI_Clock MSn_AI_FrameStart MSn_AI_TSF MSn/Sn_A_Sk_MI_AIS_Reported MSn/Sn_A_So_MI_Active	Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF MSn/Sn_A_Sk_MI_cAIS MSn/Sn_A_Sk_MI_cLOP

Processes

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

– loss of pointer (LOP);

– AU-AIS.

If either of these defect conditions are detected, then a logical all-ONEs (AIS) signal shall be applied at reference point Sn_CP 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 MS/Sn_A_MP for alarm filtering at the synchronous equipment management function.

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.

Sn payloads received at the MSn_AP are de-interleaved and the phase of 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. The algorithm for pointer interpretation is given in A.3.

Defects

dAIS: see Annex A.

dLOP: see Annex A.

Consequent actions

The function shall perform the following consequent actions:

aAIS ← dAIS or dLOP

aSSF ← dAIS or dLOP

When an SF condition is present at the MSn_AP, a SF condition shall be applied at the Sn_CP within 250 μs. Upon termination of the above defect condition at the MSn_AP, the SF condition shall be removed within 250 μs.

Defect correlations

The function shall perform the following defect correlations to determine the most probable fault cause. This fault cause shall be reported to the SEMF.

cAIS ← dAIS and (not AI_TSF) and AIS_Reported

cLOP ← dLOP

Performance monitoring

None.

11.3.2 STM-N Multiplex Section to DCC Adaptation MSn/DCC_A

The MSn/DCC_A adaptation function multiplexes the D4-D12 bytes of the multiplex section overhead (MSOH) into the MSn_AI in the source direction and demultiplexes the D4-D12 bytes from the MSn_AI in the sink direction. For STM-256, the MS256/DCCX_A adaptation function multiplexes the D13-D156 bytes of the MSOH into the MS256_AI in the source direction and demultiplexes the D13-D156 bytes from the MS256_AI in the sink direction.

11.3.2.1 STM-N Multiplex Section to DCC Adaptation Source MSn/DCC_A_So

Symbol

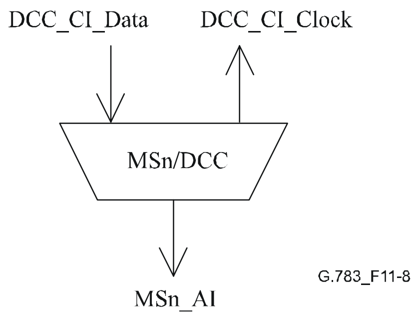


Figure 11-8/G.783 – MSn/DCC_A_So symbol

Interfaces

Table 11-5/G.783 – MSn/DCC_A_So Function inputs and outputs

Inputs	Outputs
DCC_CI_Data STM-N_TI_FrameStart STM-N_TI_Clock	MSn_CI_Data DCC_CI_Clock

Processes

The DCC data is placed consecutively in the D4 to D12 byte positions of the MSOH. This should be considered as a single 576 kbit/s 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 ITU-T Rec. G.784.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

11.3.2.2 STM-N Multiplex Section to DCC Adaptation Sink MSn/DCC_A_Sk

Symbol

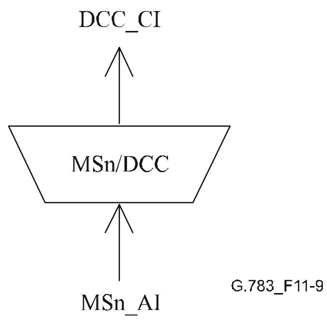


Figure 11-9/G.783 – MSn/DCC_A_Sk symbol

Interfaces

Table 11-6/G.783 – MSn/DCC_A_Sk Function inputs and outputs

Inputs	Outputs
MSn_AI_Data MSn_AI_Clock MSn_AI_FrameStart MSn_AI_TSF	DCC_CI_Data DCC_CI_Clock DCC_CI_SSF

Processes

The DCC data is recovered consecutively from the D4 to D12 byte positions of the MSOH.

Defects

None.

Consequent actions

aSSF ← AI_TSF

Defect correlations

None.

Performance monitoring

None.

11.3.2.3 STM-256 Multiplex Section to DCCX Adaptation Source MS256/DCCX_A_So

Symbol

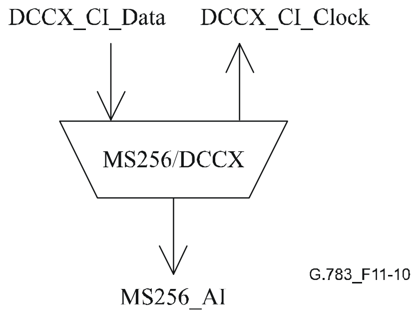


Figure 11-10/G.783 – MS256/DCCX_A_So symbol

Interfaces

Table 11-7/G.783 – MS256/DCCX_A_So Function inputs and outputs

Inputs	Outputs
DCCX_CI_Data STM-256_TI_FrameStart STM-256_TI_Clock	MS256_CI_Data DCCX_CI_Clock

Processes

The DCCX data is placed consecutively in the D13 to D156 byte positions of the MSOH. This should be considered as a single 9216 kbit/s 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 ITU-T Rec. G.784.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

11.3.2.4 STM-256 Multiplex Section to DCCX Adaptation Sink MS256/DCCX_A_Sk

Symbol

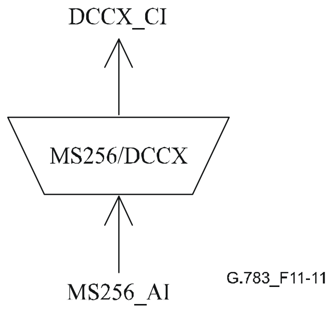


Figure 11-11/G.783 – MS256/DCCX_A_Sk symbol

Interfaces

Table 11-8/G.783 – MS256/DCCX_A_Sk Function inputs and outputs

Inputs	Outputs
MS256_AI_Data MS256_AI_Clock MS256_AI_FrameStart MS256_AI_TSF	DCCX_CI_Data DCCX_CI_Clock DCCX_CI_SSF

Processes

The DCCX data is recovered consecutively from the D13 to D156 byte positions of the MSOH.

Defects

None.

Consequent actions

aSSF ← AI_TSF

Defect correlations

None.

Performance monitoring

None.

11.3.3 STM-N Multiplex Section to Orderwire Adaptation MSn/OW_A

The MSn/OW_A adaptation function multiplexes the E2 bytes of the multiplex section overhead (MSOH) into the MSn_AI in the source direction and demultiplexes the E2 bytes from the MSn_AI in the sink direction.

11.3.3.1 STM-N Multiplex Section to Orderwire Adaptation Source MSn/OW_A_So

Symbol

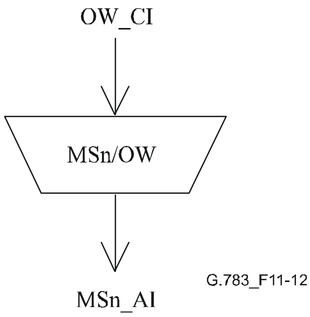


Figure 11-12/G.783 – MSn/OW_A_So symbol

Interfaces

Table 11-9/G.783 – MSn/OW_A_So Function inputs and outputs

Inputs	Outputs
OW_CI_Data OW_CI_Clock OW_CI_FrameStart	MSn_AI_Data

Processes

The orderwire 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.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

11.3.3.2 STM-N Multiplex Section to Orderwire Adaptation Sink MSn/OW_A_Sk

Symbol

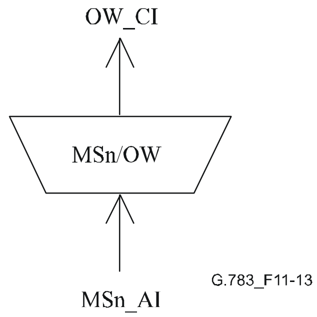


Figure 11-13/G.783 – MSn/OW_A_Sk symbol

Interfaces

Table 11-10/G.783 – MSn/OW_A_Sk Function inputs and outputs

Inputs	Outputs
MSn_AI_Data MSn_AI_Clock MSn_AI_FrameStart MSn_AI_TSF	OW_CI_Data OW_CI_Clock OW_CI_FrameStart OW_CI_SSF

Processes

The orderwire is recovered from the E2 byte position of the MSOH.

Defects

None.

Consequent actions

aSSF ← AI_TSF

aAIS ← AI_TSF

On declaration of aAIS, the function shall output an all-ONEs (AIS) signal – complying to the frequency limits for this signal (a bit rate in range 64 kbit/s ± 100 ppm) within two frames (250 µs). Upon termination of the above failure conditions, the all-ONEs shall be removed within two frames (250 µs).

Defect correlations

None.

Performance monitoring

None.

11.3.4 STM-N Multiplex Section to Synchronization Distribution Adaptation MSn/SD_A

11.3.4.1 STM-N Multiplex Section to Synchronization Distribution Adaptation Source MSn/SD_A_So

This function is described in ITU-T Rec. G.781 [9].

11.3.4.2 STM-N Multiplex Section to Synchronization Distribution Adaptation Sink MSn/SD_A_Sk

This function is described in ITU-T Rec. G.781.

11.3.5 STM-N Multiplex Section to S4-Xc layer Adaptation MSn/S4-Xc_A

11.3.5.1 STM-N Multiplex Section to S4-Xc layer Adaptation Source MSn/S4-Xc_A_So

For further study.

11.3.5.2 STM-N Multiplex Section to S4-Xc layer Adaptation Sink MSn/S4-Xc_A_Sk

For further study.

11.3.6 STM-N Multiplex Section to Auxiliary bytes Adaptation MSn/AUX_A

Certain MSOH bytes are presently reserved for national use, media-dependent use or for future international standardization, as defined in ITU-T Rec. G.707/Y.1322. One or more of these bytes may be accessed via the MSn/AUX_A function. No pattern is defined for the other unused bytes when not used for a particular purpose.

11.4 Sublayer functions

11.4.1 STM-N Multiplex Section Linear Trail Protection functions

See Figures 11-14 and 11-15.

The MSP function provides protection for the STM-N signal against channel-associated failures within a multiplex section, i.e., the RS layer functions, physical section layer functions and the physical medium from one MSn_TT function where section overhead is inserted to the other MSn_TT 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 7.1/G.841, for the various protection switching architectures and modes.

NOTE – The use of the MSP protocol as described in 7.1/G.841 and in this clause over long multiplex sections such as satellite systems, submarine cable systems, radio relay systems, and transmission systems with a large number of regenerators or optical amplifiers, may result in longer switching times due to the additional propagation delay introduced by the physical section. Thus in some applications, it may not be possible to meet the network objective of a 50 ms switching time.

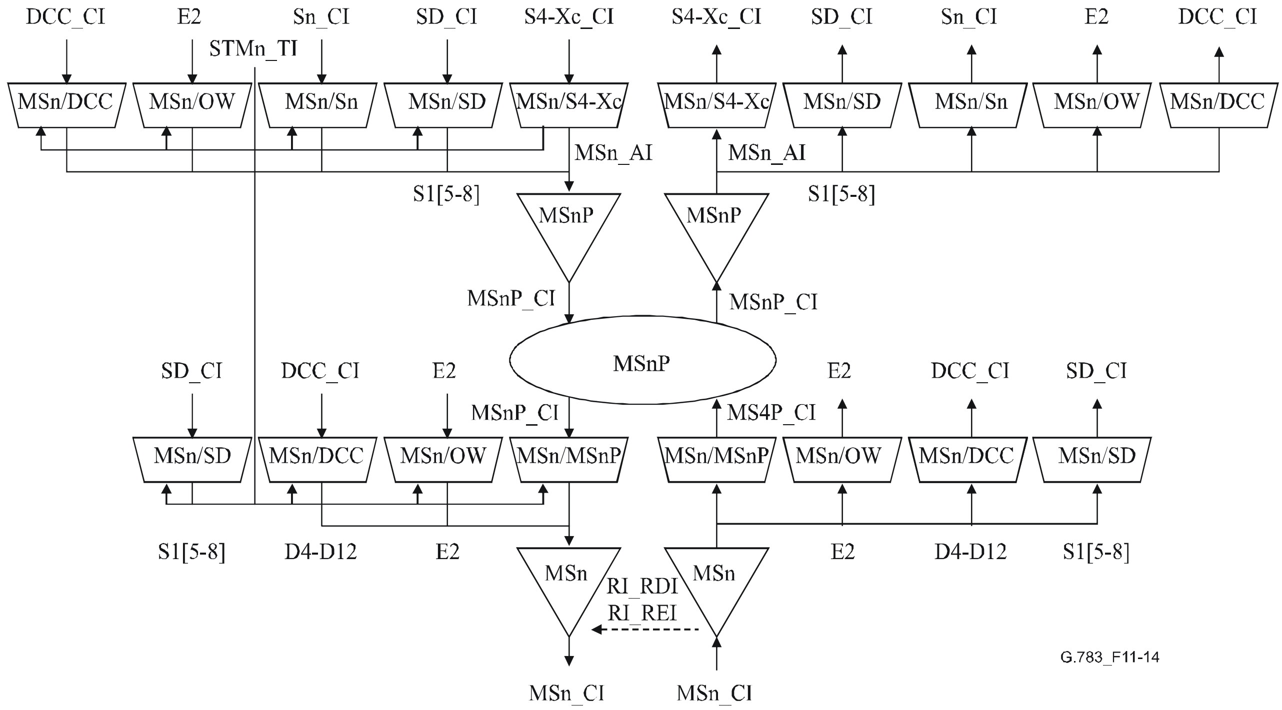


Figure 11-14/G.783 – STM-N Multiplex Section Linear Trail Protection functions

	1	...	3n	3n+1	...	6n	6n+1	...	9n	9n+1 .... 270n
3					1					
4	H1	...	"Y"	H2	2	"1"	H3	...	H3	
5				K1	...		K2*	...		STM-N payload capacity
6	D4	...		D5	...		D6	...		(n × 261 × 9 bytes)
7	D7	...		D8	...		D9	...		
8	D10	...		D11	...		D12	...		
9	S1	...		...	...		E2	NU...	NU	

NOTE – K2* represents bits 1 to 5 of K2.

Figure 11-15/G.783 – MSnP_CI_D

The signal flow associated with the MSP function is described with reference to Table 11-11. The MSP functions receives control parameters and external switch requests at the MSnP_C_MP reference point from the synchronous equipment management function and outputs status indicators at the MSnP_C_MP to the synchronous equipment management function, as a result of switch commands described in 7.1.2/G.841 or in B.2/G.841.

11.4.1.1 STM-N Multiplex Section Linear Trail Protection Connection MSnP_C

Symbol

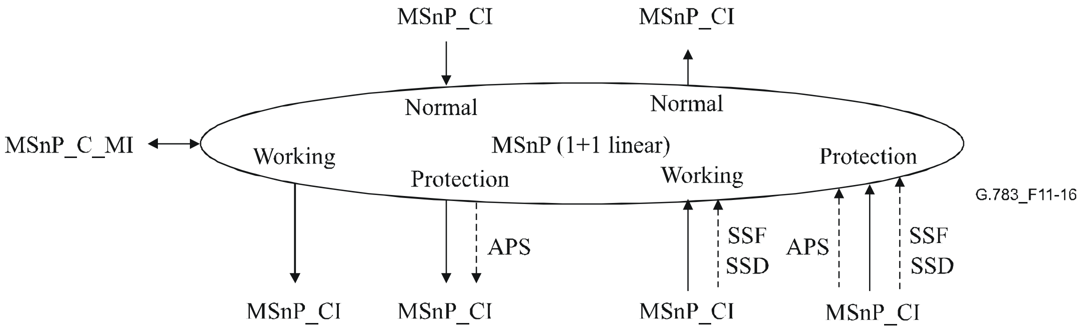


Figure 11-16/G.783 – MSnP1+1_C symbol

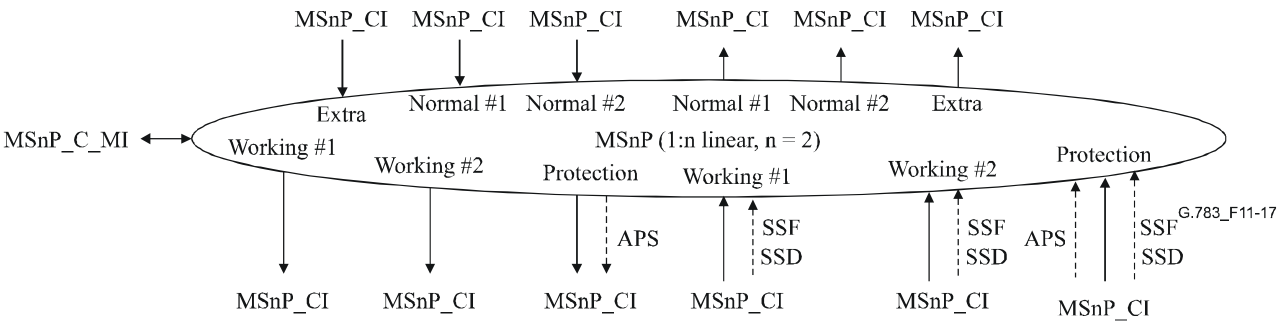


Figure 11-17/G.783 – MSnP1:n_C symbol

Interfaces

Table 11-11/G.783 – MSnP_C Function inputs and outputs

Inputs	Outputs
For connection points W and P: MSnP_CI_Data MSnP_CI_Clock MSnP_CI_FrameStart MSnP_CI_SSF MSnP_CI_SSD MSnP_C_MI_SFpriority MSnP_C_MI_SDpriority For connection points N and E: MSnP_CI_Data MSnP_CI_Clock MSnP_CI_FrameStart Per function: MSnP_CI_APS MSnP_C_MI_SWtype MSnP_C_MI_EXTRAtraffic MSnP_C_MI_WTRTime MSnP_C_MI_EXTCMD	For connection points W and P: MSnP_CI_Data MSnP_CI_Clock MSnP_CI_FrameStart For connection points N and E: MSnP_CI_Data MSnP_CI_Clock MSnP_CI_FrameStart MSnP_CI_SSF Per function: MSnP_CI_APS MSnP_C_MI_cFOP
NOTE – Protection status reporting signals are for further study.	

Processes

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

In the source direction for 1 + 1 architecture, the signal received at the MSn_AP from the MSn/Sn_A function is bridged permanently at the MSn_AP to both working and protection MSn_TT functions. For 1:n architecture, the signal received on the MSn_AP from each working MSn/Sn_A is passed on the MSn_AP to its corresponding MSn_TT. The signal from an extra traffic MSn/Sn_A (if provisioned) is connected to the protection MSn_TT. When a bridge is needed to protect a working channel, the signal at the MSn_AP from that working MSn/Sn_A is bridged at the MSn_AP to the protection MSn_TT and the extra traffic channel is terminated.

In the sink direction, framed STM-N signals (data) whose RSOH and MSOH bytes have already been recovered are presented at the reference point MSn_AP along with incoming timing references. The failure conditions SF and SD are also received at the reference point MSn_AP from all MSn_TT functions.

Under normal conditions, MSnP_C passes the data and timing from the working MSn_TT functions to their corresponding working MSn/Sn_A functions at the reference point MSn_AP. The data and timing from the protection section is passed to the extra traffic MSn/Sn_A, 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 MSn_TT at reference point MSn_AP is switched to the appropriate working channel MSn/Sn_A function at the MSn_AP, and the signal received from the working MSn_TT the MSn_AP is terminated.

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 MSn_TT functions at the MSn_AP. Detection of these conditions is described in 11.2.

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

Switching time

Refer to ITU-T Rec. G.841.

Switch restoration

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. Restoration 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 restoration 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.

Defects

None.

Consequent actions

Where neither an extra traffic nor a normal signal input is to be connected to the protection section output then either an all-ONEs, an Sn unequipped, a working signal input, or other suitable test signal will be connected to the protection section output.

Defect correlations

cFOP ← refer to ITU-T Rec. G.841

Performance monitoring

None.

11.4.1.2 STM-N Multiplex Section Protection Trail Termination MSnP_TT

11.4.1.2.1 STM-N Multiplex Section Protection Trail Termination Source MSnP_TT_So

Symbol

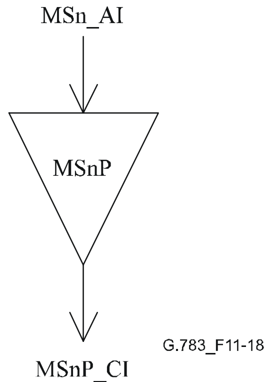


Figure 11-18/G.783 – MSnP_TT_So symbol

Interfaces

Table 11-12/G.783 – MSnP_TT_So Function inputs and outputs

Inputs	Outputs
MSn_AI_Data MSn_AI_Clock MSn_AI_FrameStart	MSnP_CI_Data MSnP_CI_Clock MSnP_CI_FrameStart

Processes

No information processing is required in the MSnP_TT_So, the MSn_AI at its output being identical to the MSnP_CI at its input.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

11.4.1.2.2 STM-N Multiplex Section Protection Trail Termination Sink MSnP_TT_Sk

Symbol

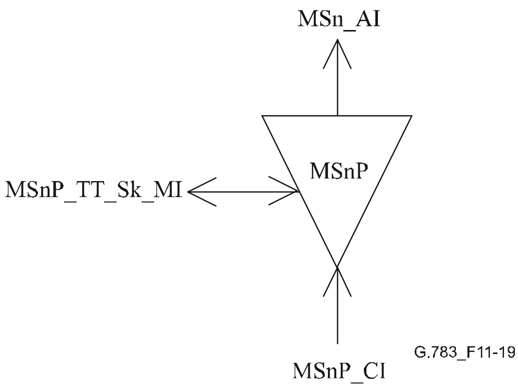


Figure 11-19/G.783 – MSnP_TT_Sk symbol

Interfaces

Table 11-13/G.783 – MSnP_TT_Sk Function inputs and outputs

Inputs	Outputs
MSnP_CI_Data MSnP_CI_Clock MSnP_CI_FrameStart MSnP_CI_SSF MSnP_TT_Sk_MI_SSF_Reported	MSn_AI_Data MSn_AI_Clock MSn_AI_FrameStart MSn_AI_TSF MSnP_TT_Sk_MI_cSSF

Processes

The MSnP_TT_Sk function reports, as part of the MSn layer, the state of the protected MSn trail. In case all connections are unavailable, the MSnP_TT_Sk reports the signal fail condition of the protected trail.

Defects

None.

Consequent actions

aTSF ← CI_SSF

Defect correlations

cSSF ← CI_SSF and SSF_Reported

Performance monitoring

None.

11.4.1.3 STM-N Multiplex Section Linear Trail Protection Adaptation MSn/MSnP_A

11.4.1.3.1 STM-N Multiplex Section to STM-N Multiplex Section Protection layer Adaptation Source MSn/MSnP_A_So

Symbol

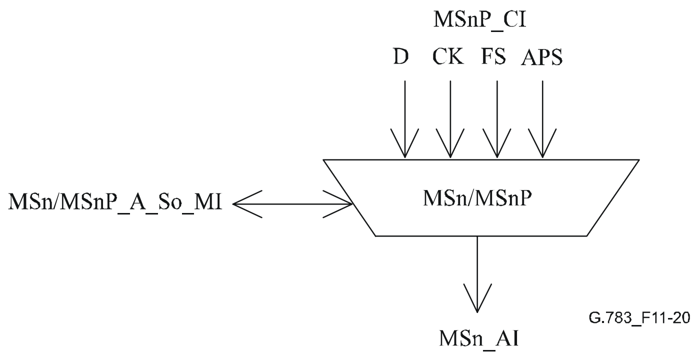


Figure 11-20/G.783 – MSn/MSnP_A_So symbol

Interfaces

Table 11-14/G.783 – MSn/MSnP_A_So Function inputs and outputs

Inputs	Outputs
MSnP_CI_Data MSnP_CI_Clock MSnP_CI_FrameStart MSnP_CI_APS	MSn_AI_Data MSn_AI_Clock MSn_AI_FrameStart

Processes

The function shall multiplex the MS1 APS signal (K1 and K2 bytes generated according to the rules in 7.1.1/G.841) and MS1 data signal onto the MS1 access point. This process is required for the protection section and may also be achieved for the working section(s).

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

11.4.1.3.2 STM-N Multiplex Section to STM-N Multiplex Section Protection layer Adaptation Sink MSn/MSnP_A_Sk

Symbol

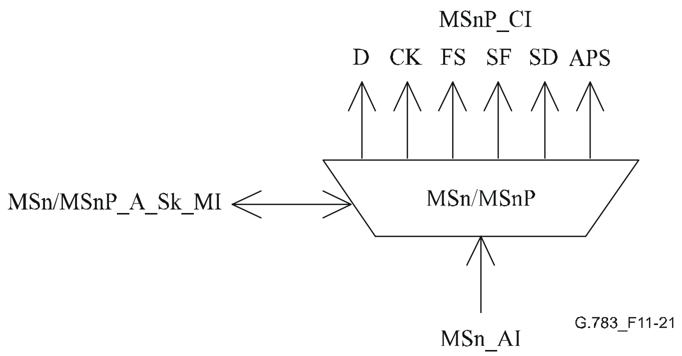


Figure 11-21/G.783 – MSn/MSnP_A_Sk symbol

Interfaces

Table 11-15/G.783 – MSn/MSnP_A_Sk Function inputs and outputs

Inputs	Outputs
MSn_AI_Data MSn_AI_Clock MSn_AI_FrameStart MSn_AI_TSF MSn_AI_TSD	MSnP_CI_Data MSnP_CI_Clock MSnP_CI_FrameStart MSnP_CI_SSF MSnP_CI_SSD MSnP_CI_APS (for Protection signal only)

Processes

The function shall extract the 13 APS bits K1[1-8] and K2[1-5] from the MS1_AI_D signal. A new value shall be accepted when the value is identical for three consecutive frames. This value shall be output via MS1P_CI_APS. This process is required only for the protection section. This function must be able to ignore the APS bytes from the working section(s).

Defects

None.

Consequent actions

aSSF ← AI_TSF

aSSD ← AI_TSD

Defect correlations

None.

Performance monitoring

None.

11.4.2 STM-N Multiplex Section 2-Fibre Shared Protection Ring Functions

This clause specifies the 2-fibre STM-N MS SPRING protection sublayer atomic functions and the 2-fibre MS SPRING protection functional model (see Figure 11-22).

The characteristics of this protection scheme, the protection protocol and operation are specified in ITU-T Rec. G.841.

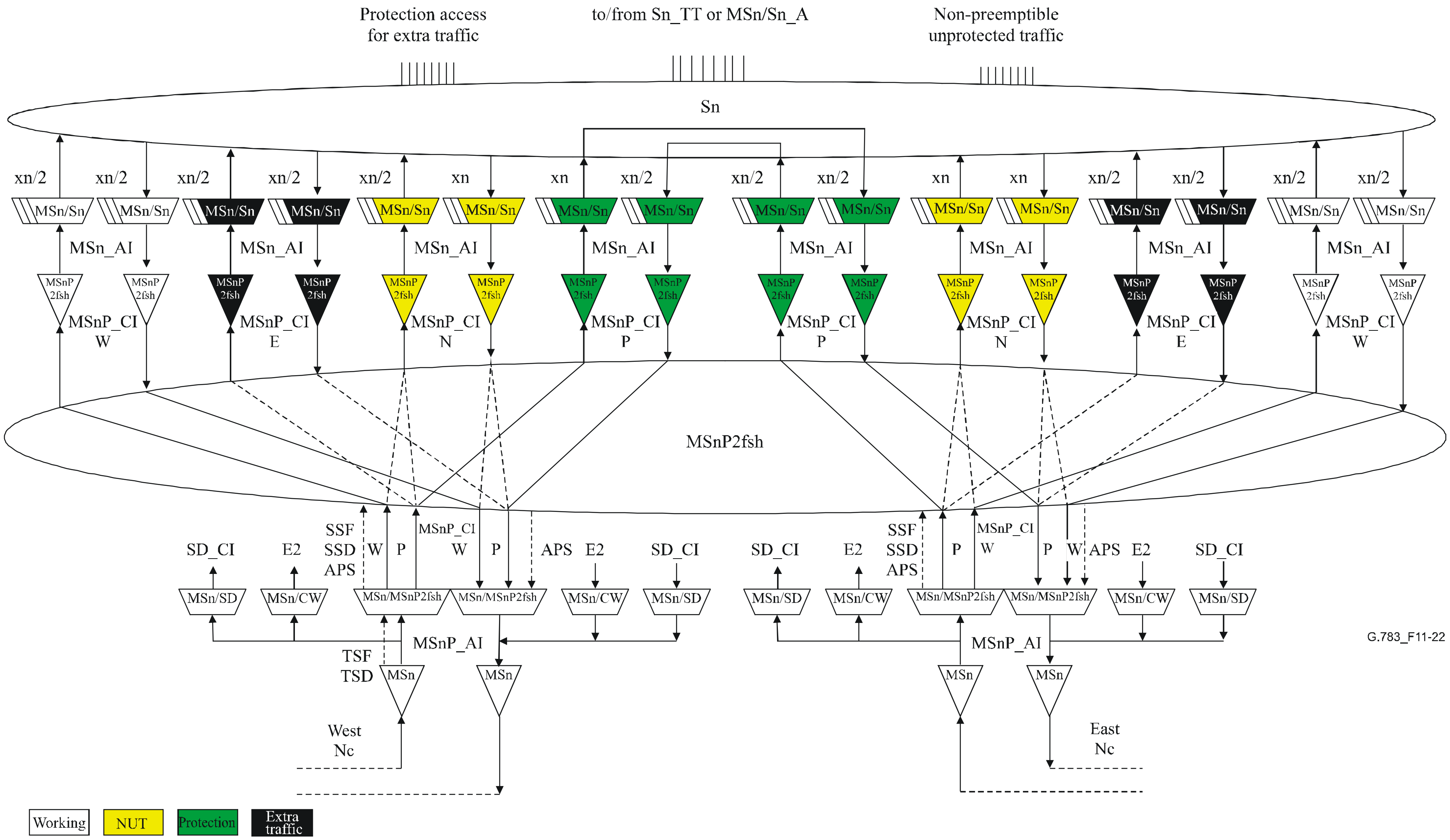


Figure 11-22/G.783 – STM-n Multiplex Section 2-fibre Shared Protection Ring model (working: AUG #1 to AUG #n/2, protection: AUG #(n/2 + 1) to AUG #n)

11.4.2.1 STM-N Multiplex Section 2-Fibre Shared Protection Ring Connection MSnP2fsh_C

Symbol

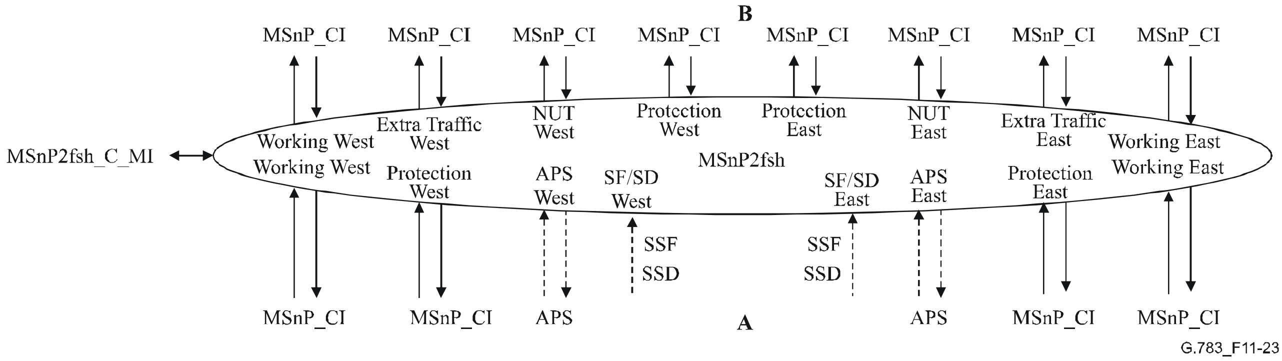


Figure 11-23/G.783 – MSnP2fsh_C symbol

Interfaces

Table 11-16/G.783 – MSnP2fsh_C input and output signals

Inputs	Outputs
For connection points A West and A East: MSnP2fsh_CI_Dw MSnP2fsh_CI_Dp MSnP2fsh_CI_CK MSnP2fsh_CI_FS MSnP2fsh_CI_SSF MSnP2fsh_CI_SSD MSnP2fsh_CI_APS For connection points B West and B East: MSnP2fsh_CI_Dw MSnP2fsh_CI_Dp MSnP2fsh_CI_De MSnP2fsh_CI_Dn MSnP2fsh_CI_CK MSnP2fsh_CI_FS MSnP2fsh_CI_MI_EXTRAtraffic MSnP2fsh_CI_MI_NUTraffic MSnP2fsh_C_MI_WTRTime MSnP2fsh_C_MI_EXTCMD MSnP2fsh_C_MI_RingNodeID MSnP2fsh_C_MI_RingMap	For connection points A West and A East: MSnP2fsh_CI_Dw MSnP2fsh_CI_Dp MSnP2fsh_CI_CK MSnP2fsh_CI_FS MSnP2fsh_CI_APS For connection points B West and B East: MSnP2fsh_CI_Dw MSnP2fsh_CI_CKw MSnP2fsh_CI_FSw MSnP2fsh_CI_SSFw MSnP2fsh_CI_Dp MSnP2fsh_CI_CKp MSnP2fsh_CI_FSp MSnP2fsh_CI_SSFp MSnP2fsh_CI_De MSnP2fsh_CI_CKe MSnP2fsh_CI_FSe MSnP2fsh_CI_SSFe MSnP2fsh_CI_Dn MSnP2fsh_CI_CKn MSnP2fsh_CI_FSn MSnP2fsh_CI_SSFn
NOTE – Protection status reporting signals are for further study.	

Processes

The function is able to route (bridge and select) the Working and Protection group signals between its connection points (inputs/outputs) as specified in ITU-T Rec. G.841, multiplex section 2-fibre shared protection ring operation.

NOTE 1 – The functional model is a maximum model; the extra traffic and NUT related inputs and outputs may not be present in an actual equipment.

Possible Matrix Connections that can be supported are (see Table 11-17):

– connections in normal operation (without fault):

  Ww_A ↔ Ww_B

  We_A ↔ We_B

  Pw_A ↔ Pw_B

  Pe_A ↔ Pe_B

– connections for extra traffic:

  Pw_A ↔ Ew_B

  Pe_A ↔ Ee_B

– connections for NUT:

  Pw_A ↔ Nw_B

  Ww_A ↔ Nw_B

  Pe_A ↔ Ne_B

  We_A ↔ Ne_B

– connections in protection operation (with fault):

  Pw_A ↔ We_B

  Pe_A ↔ Ww_B

– squelching:

  Pw_A [TSx] ← all-ONEs (AIS)

  Pe_A [TSx] ← all-ONEs (AIS)

– unequipped generation:

  Pw_A [TSx] ← unequipped HOVC

  Pe_A [TSx] ← unequipped HOVC

– APS:

  APSw ↔ APSe (APS pass through)

  APSw sourced

  APSe sourced

Legend:

Xy_Z : X = W (Working), P (Protection), E (Extra traffic), N (NUT)

y = w (west), e (east)

Z = A, B

TSx : AU-4 TimeSlot #x (x = 1..n)

Table 11-17/G.783 – MSnP2fsh_C traffic matrix connections

Traffic matrix connections			Outputs											
			A				B							
			Ww	Pw	We	Pe	Ww	Ew	Pw	Nw	We	Ee	Pe	Ne
Inputs	A	Ww					X			X				
		Pw						X	X	X	X			
		We									X			X
		Pe					X					X	X	X
	B	Ww	X			X								
		Ew		X										
		Pw		X										
		Nw	X	X										
		We		X	X									
		Ee				X								
		Pe				X								
		Ne			X	X								

In the sink direction (Figure 11-23, from A to B), the signal output at the West [East] Working B MSnP2fsh connection point can be the signal received via either the associated West [East] Working A capacity or the East [West] Protection A capacity; this is determined by the SF, SD conditions (relayed via CI_SSF, CI_SSD signals), the external commands and the information relayed via the APS signal.

In the source direction, the working A outputs are connected either to the associated working B inputs or to the associated NUT Traffic. The protection A outputs are connected to a local unequipped VC generator, extra traffic input, NUT traffic input or one of the working inputs at B as shown in Figures 11-24 to 11-27.

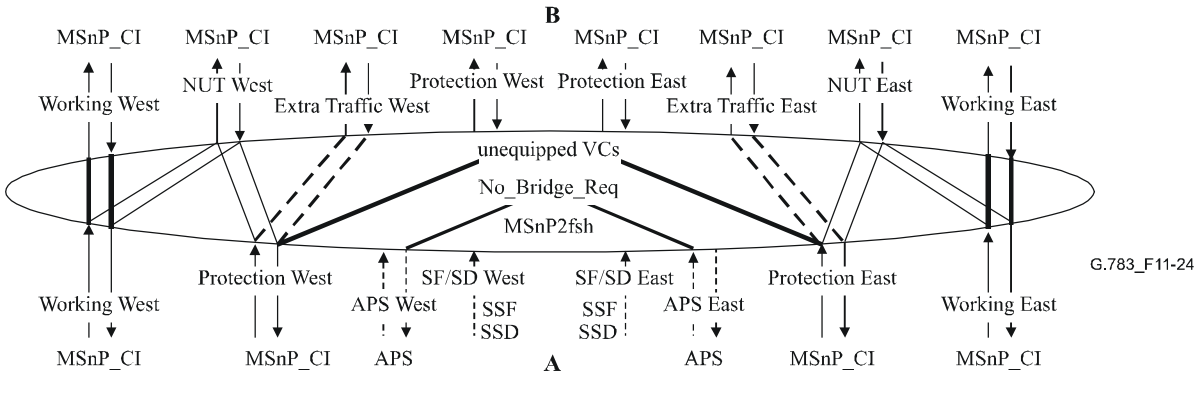


Figure 11-24/G.783 – Matrix connections in a network element within a ring without a fault; dotted lines represent the case of extra traffic support

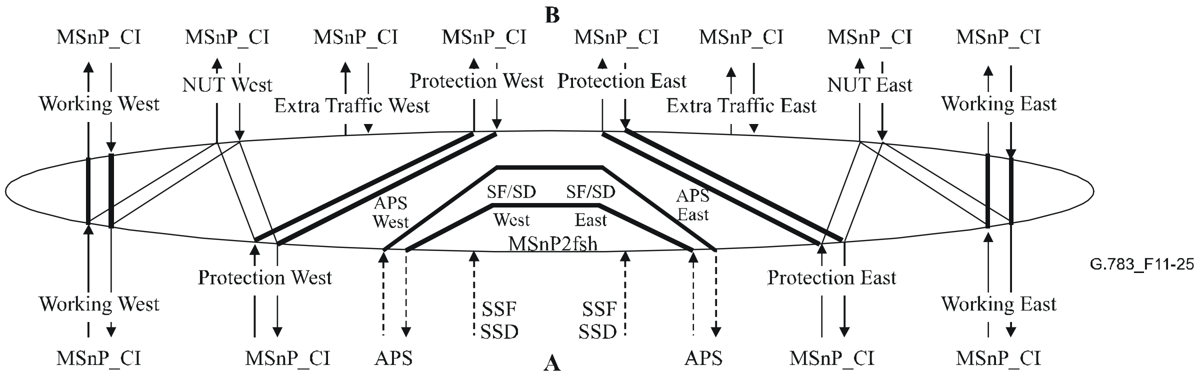


Figure 11-25/G.783 – Matrix connections in a network element not adjacent to a fault

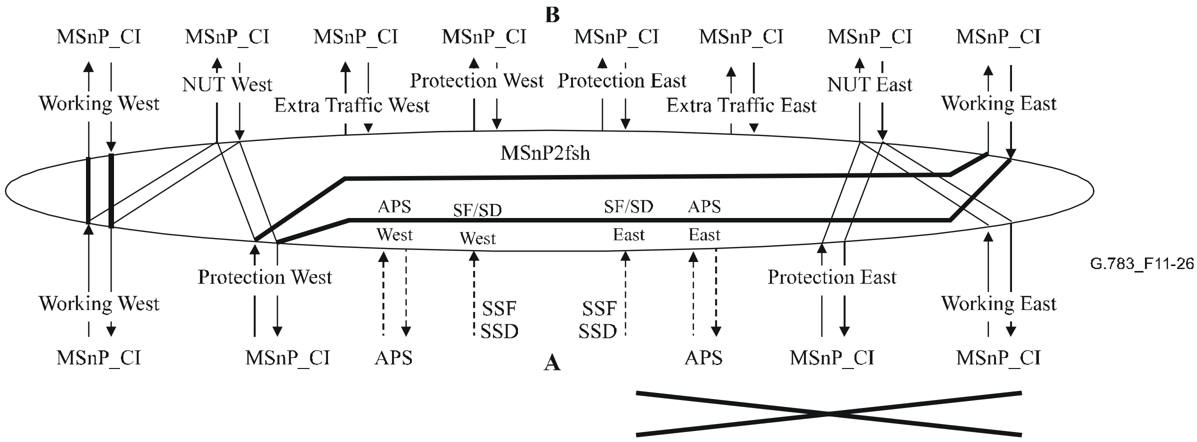


Figure 11-26/G.783 – Matrix connections in a network element adjacent to a fault on its East side

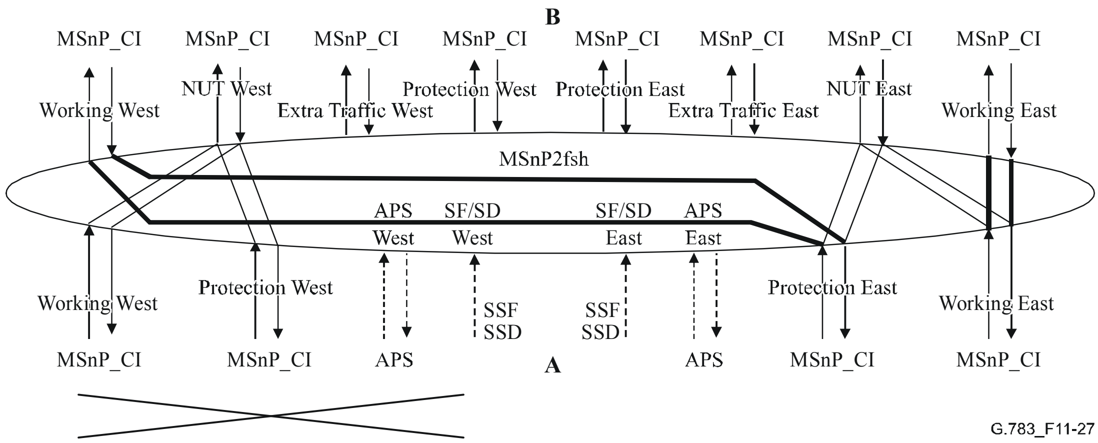


Figure 11-27/G.783 – Matrix connections in a network element adjacent to a fault on its west side

NOTE 2 – ITU-T Rec. G.841 states that protection AUs when not in use (for extra traffic or working traffic) may be sourced by VC unequipped signals. This shall be performed in this MSnP2fsh_C functions as ITU-T Rec. G.841 also shows that the Sn_C (S4-4c_C) functions have permanent matrix connections for the protection timeslot capacity. The protection is a MS layer protection scheme and should not impact client layers. In the functional model, the MSn layer knows the HOVC path multiplex structure, and is able to control HOVC unequipped signal insertion.

If non-preemptible unprotected traffic (NUT) is supported, selected channels on the working A bandwidth and their corresponding protection A channels may be provisioned as non-preemptible unprotected channels. The remaining working A channels are still protected by the corresponding protection A channels. The effect on a selected non-preemptible unprotected channel is that ring switching is disabled on that channel everywhere on the ring. The non-preemptible unprotected channels have no APS protection.

NOTE 3 – When an AU-4 is provisioned to support NUT, during protection operation, the protection matrix MSnP2fsh_C does not modify the connections for this AU-4 and the connections are left unchanged everywhere on the ring for this AU-4.

MS protection operation

The 2-fibre MS shared protection ring trail protection process shall operate as specified in ITU-T Rec. G.841.

Defects

For further study.

Consequent actions

The function shall generate an AUG with VC-n [VC-4-4c] unequipped signal (plus valid AU-n [AU-4-4c] pointer) for each protection timeslot when the protection timeslot is not in use.

The function shall insert all-ONEs (AIS) (squelching) for an AUG [AU-4-4c] within protection timeslots that would otherwise be misconnected.

Defect correlations

For further study.

Performance monitoring

For further study.

11.4.2.2 STM-N Multiplex Section 2-Fibre Shared Protection Ring Trail Termination Functions

11.4.2.2.1 STM-N Multiplex Section 2-Fibre Shared Protection Ring Trail Termination Source MSnP2fsh_TT_So

Symbol

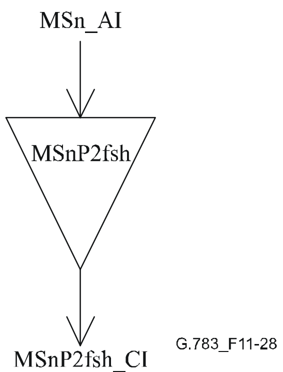


Figure 11-28/G.783 – MSnP2fsh_TT_So symbol

Interfaces

Table 11-18/G.783 – MSnP2fsh_TT_So input and output signals

Inputs	Outputs
MSnP2fsh_AI_D MSnP2fsh_AI_CK MSnP2fsh_AI_FS	MSnP2fsh_CI_D MSnP2fsh_CI_CK MSnP2fsh_CI_FS

Processes

No information processing is required in the MSnP2fsh_TT_So, the MSn_AI at its output being identical to the MSnP2fsh_CI at its input.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

11.4.2.2.2 STM-N Multiplex Section 2-Fibre Shared Protection Ring Trail Termination Sink MSnP2fsh_TT_Sk

Symbol

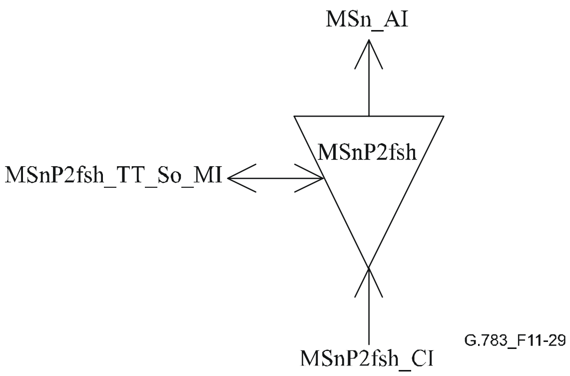


Figure 11-29/G.783 – MSnP2fsh_TT_Sk symbol

Interfaces

Table 11-19/G.783 – MSnP2fsh_TT_Sk input and output signals

Inputs	Outputs
MSnP2fsh_CI_D MSnP2fsh_CI_CK MSnP2fsh_CI_FS MSnP2fsh_CI_SSF MSnP2fsh_TT_Sk_MI_SSF_Reported	MSn_AI_D MSn_AI_CK MSn_AI_FS MSn_AI_TSF MSnP2fsh_TT_Sk_MI_cSSF

Processes

The MSnP2fsh_TT_Sk function reports, as part of the MSn layer, the state of the protected MSn trail. In case all connections are unavailable the MSnP2fsh_TT_Sk reports the signal fail condition of the protected trail. This is applicable only for the working capacity.

Defects

None.

Consequent actions

aTSF ← CI_SSF

Defect correlations

cSSF ← CI_SSF and SSF_Reported

Performance monitoring

None.

11.4.2.3 STM-N Multiplex Section 2-Fibre Shared Protection Ring Adaptation Functions

11.4.2.3.1 STM-N Multiplex Section to STM-N Multiplex Section 2-Fibre Shared Protection Ring Adaptation Source MSn/MSnP2fsh_A_So

Symbol

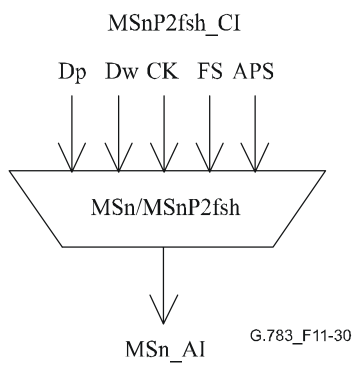


Figure 11-30/G.783 – MSn/MSnP2fsh_A_So symbol

Interfaces

Table 11-20/G.783 – MSn/MSnP2fsh_A_So input and output signals

Inputs	Outputs
MSnP2fsh_CI_Dw MSnP2fsh_CI_Dp MSnP2fsh_CI_CK MSnP2fsh_CI_FS MSnP2fsh_CI_APS	MSn_AI_D MSn_AI_CK MSn_AI_FS

Processes

The function shall multiplex two groups of signals (CI_Dw, CI_Dp) into the MSn payload (n AUG timeslots). The working group signal shall be multiplexed into AUG timeslots 1 to n/2 and the protection group signal shall be multiplexed into AUG timeslots (n/2 + 1) to n.

The function shall map the MSn 2-fibre shared protection ring APS signal into bytes K1 and K2.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

11.4.2.3.2 STM-N Multiplex Section to STM-N Multiplex Section 2-Fibre Shared Protection Ring Adaptation Sink MSn/MSnP2fsh_A_Sk

Symbol

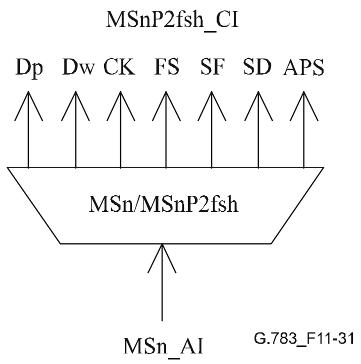


Figure 11-31/G.783 – MSn/MSnP2fsh_A_Sk symbol

Interfaces

Table 11-21/G.783 – MSn/MSnP2fsh_A_Sk input and output signals

Inputs	Outputs
MSn_AI_D MSn_AI_CK MSn_AI_FS MSn_AI_TSF MSn_AI_TSD	MSnP2fsh_CI_Dw MSnP2fsh_CI_Dp MSnP2fsh_CI_CK MSnP2fsh_CI_FS MSnP2fsh_CI_SSF MSnP2fsh_CI_SSD MSnP2fsh_CI_APS

Processes

The function shall split the MSn payload (i.e., n AUG timeslots) into two groups; the working group contains AUG timeslots 1 to n/2 and the protection group contains AUG timeslots (n/2 + 1) to n. The working group shall be output at MSnP2fsh_CI_Dw and the protection group at MSnP2fsh_CI_Dp.

K1, K2: The function shall extract the 16 APS bits K1[1-8] and K2[1-8] from the MSn_AI_D signal. A new value shall be accepted when the value is identical for three consecutive frames. This value shall be output via MSnP2fsh_CI_APS.

Defects

None.

Consequent actions

aSSF ← AI_TSF

aSSD ← AI_TSD

Defect correlations

None.

Performance monitoring

None.

11.4.3 STM-N Multiplex Section 4-Fibre Shared Protection Ring Functions

This clause specifies the 4-fibre STM-N MS SPRING protection sublayer atomic functions and the 4-fibre MS SPRING protection functional model (see Figure 11-32).

The characteristics of this protection scheme, the protection protocol and operation are specified in ITU-T Rec. G.841 [19].

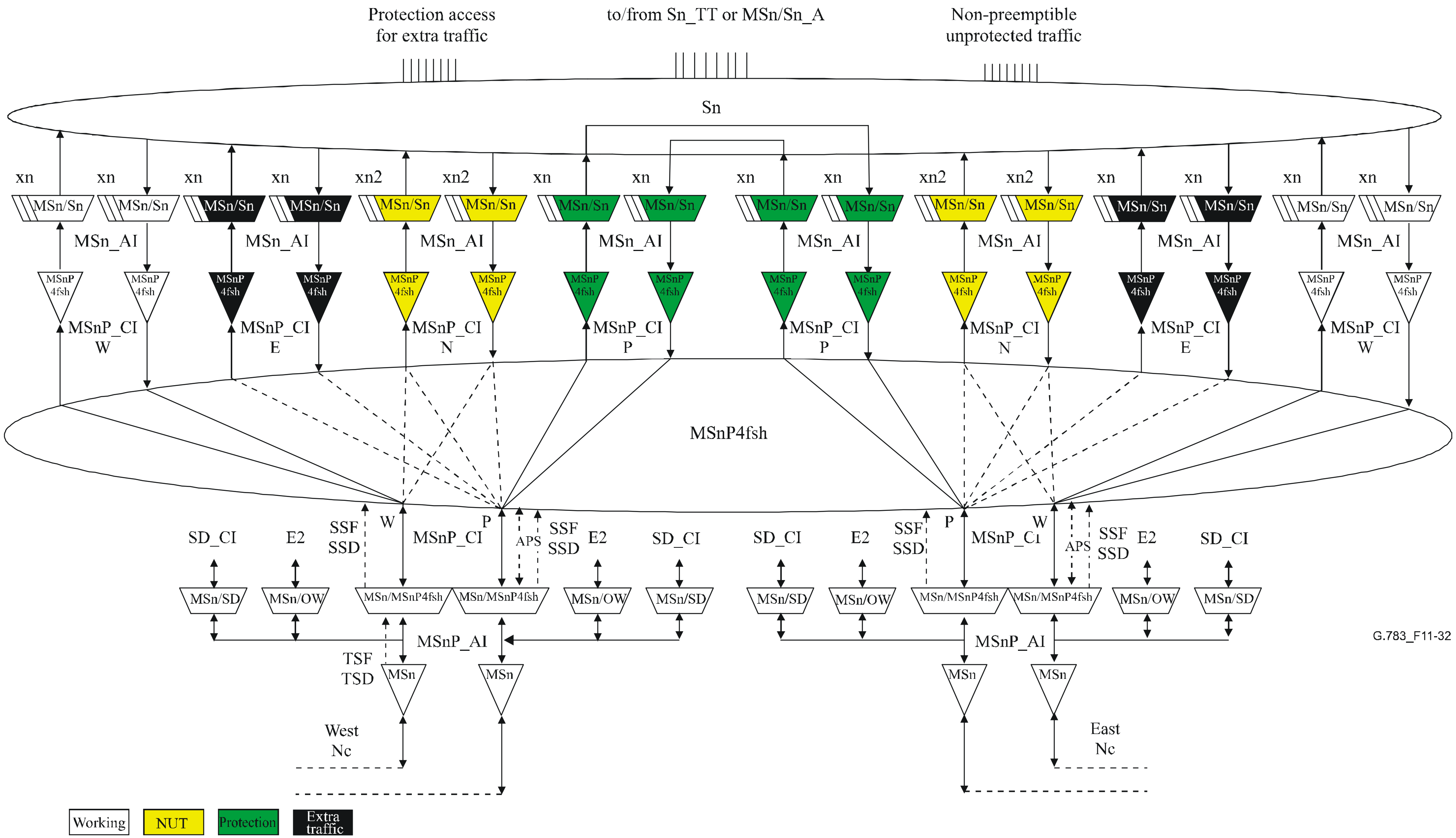


Figure 11-32/G.783 – Multiplex Section 4-fibre Shared Protection Ring model (2 fibres for working and 2 fibres for protection)

11.4.3.1 STM-N Multiplex Section 4-Fibre Shared Protection Ring Connection MSnP4fsh_C

Symbol

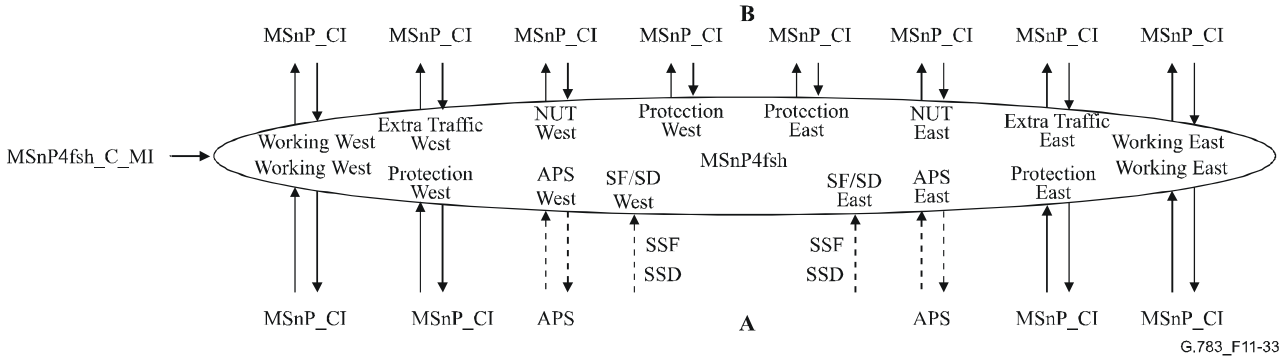


Figure 11-33/G.783 – MSnP4fsh_C symbol

Interfaces

Table 11-22/G.783 – MSnP4fsh_C input and output signals

Inputs	Outputs
For connection points A West and A East: MSnP4fsh_CI_Dw MSnP4fsh_CI_Dp MSnP4fsh_CI_CK MSnP4fsh_CI_FS MSnP4fsh_CI_SSF MSnP4fsh_CI_SSD MSnP4fsh_CI_APS For connection points B West and B East: MSnP4fsh_CI_Dw MSnP4fsh_CI_Dp MSnP4fsh_CI_De MSnP4fsh_CI_Dn MSnP4fsh_CI_CK MSnP4fsh_CI_FS MSnP4fsh_CI_MI_EXTRAtraffic MSnP4fsh_CI_MI_NUTraffic MSnP4fsh_C_MI_WTRTime MSnP4fsh_C_MI_EXTCMD MSnP4fsh_C_MI_RingNodeID MSnP4fsh_C_MI_RingMap	For connection points A West and A East: MSnP4fsh_CI_Dw MSnP4fsh_CI_Dp MSnP4fsh_CI_CK MSnP4fsh_CI_FS MSnP4fsh_CI_APS For connection points B West and B East: MSnP4fsh_CI_Dw MSnP4fsh_CI_CKw MSnP4fsh_CI_FSw MSnP4fsh_CI_SSFw MSnP4fsh_CI_Dp MSnP4fsh_CI_CKp MSnP4fsh_CI_FSp MSnP4fsh_CI_SSFp MSnP4fsh_CI_De MSnP4fsh_CI_Cke MSnP4fsh_CI_Fse MSnP4fsh_CI_SSFe MSnP4fsh_CI_Dn MSnP4fsh_CI_CKn MSnP4fsh_CI_FSn MSnP4fsh_CI_SSFn
NOTE – Protection status reporting signals are for further study.	

Processes

The function is able to route (bridge and select) the Working and Protection signals between its connection points (inputs/outputs) as specified in ITU-T Rec. G.841, multiplex section 4-fibre shared protection ring operation.

NOTE 1 – The functional model is a maximum model; the extra traffic related and NUT inputs and outputs may not be present in an actual equipment.

Possible Matrix Connections that can be supported are (see Table 11-23):

– connections in normal operation (without fault):

  Ww_A ↔ Ww_B

  We_A ↔ We_B

  Pw_A ↔ Pw_B

  Pe_A ↔ Pe_B

– connections for extra traffic:

  Pw_A ↔ Ew_B

  Pe_A ↔ Ee_B

– connections for NUT:

  Pw_A ↔ Nw_B

  Ww_A ↔ Nw_B

  Pe_A ↔ Ne_B

  We_A ↔ Ne_B

– connections in protection operation (with fault):

  Pw_A ↔ We_B (ring switch)

  Pe_A ↔ Ww_B (ring switch)

  Pw_A ↔ Ww_B (span switch)

  Pe_A ↔ We_B (span switch)

– squelching:

  Pw_A [TSx] ← all-ONEs (AIS)

  Pe_A [TSx] ← all-ONEs (AIS)

– unequipped generation:

  Pw_A [TSx] ← unequipped HOVC

  Pe_A [TSx] ← unequipped HOVC

– APS:

  APSw ↔ APSe (APS pass through)

  APSw sourced

  APSe sourced

NOTE 2 – The APS protocol is only active on the fibres carrying protection channels.

Legend:

Xy_Z : X = W (Working), P (Protection), E (Extra traffic), N (NUT)

y = w (west), e (east)

Z = A, B

TSx : AU-4 TimeSlot #x (x = 1..n)

Table 11-23/G.783 – MSnP4fsh_C traffic matrix connections

Traffic matrix connections			Outputs											
			A				B							
			Ww	Pw	We	Pe	Ww	Ew	Pw	Nw	We	Ee	Pe	Ne
Inputs	A	Ww					X			X				
		Pw					X (span switch)	X	X	X	X (ring switch)			
		We									X			X
		Pe					X (ring switch)				X (span switch)	X	X	X
	B	Ww	X	X (span switch)		X (ring switch)								
		Ew		X										
		Pw		X										
		Nw	X	X										
		We		X (ring switch)	X	X (span switch)								
		Ee				X								
		Pe				X								
		Ne			X	X								

In the sink direction (Figure 11-33, from A to B), the signal output at the West [East] Working B MSnP4fsh connection point can be the signal received via either the associated West [East] Working A capacity, the West [East] Protection A capacity (span switch) or the East [West] Protection A capacity (ring switch); this is determined by the SF, SD conditions (relayed via CI_SSF, CI_SSD signals), the external commands and the information relayed via the APS signal.

In the source direction, the Working A outputs are connected either to the associated Working B inputs, or to the associated NUT traffic. The Protection A outputs are connected to a local unequipped VC generator, extra traffic input, NUT traffic input or one of the working inputs at B as shown in Figures 11-34 to 11-37.

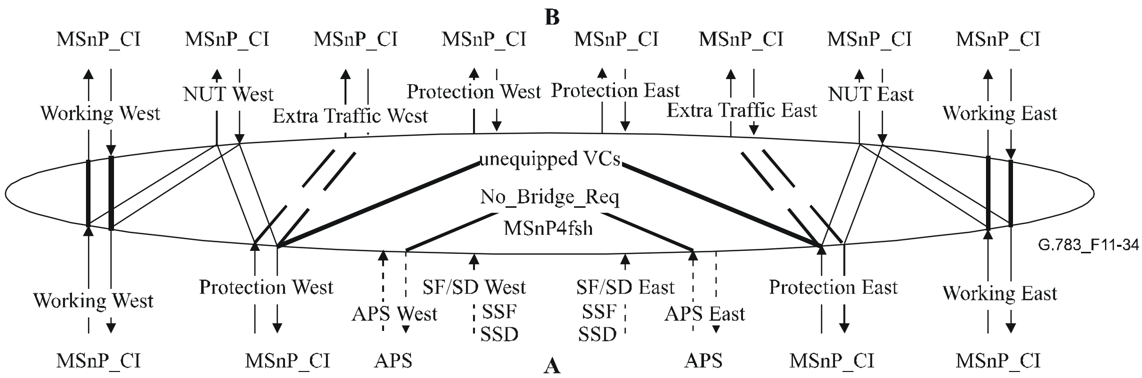


Figure 11-34/G.783 – Matrix connections in a network element within a 4-fibre ring without a fault; dotted lines represent the case of extra traffic support

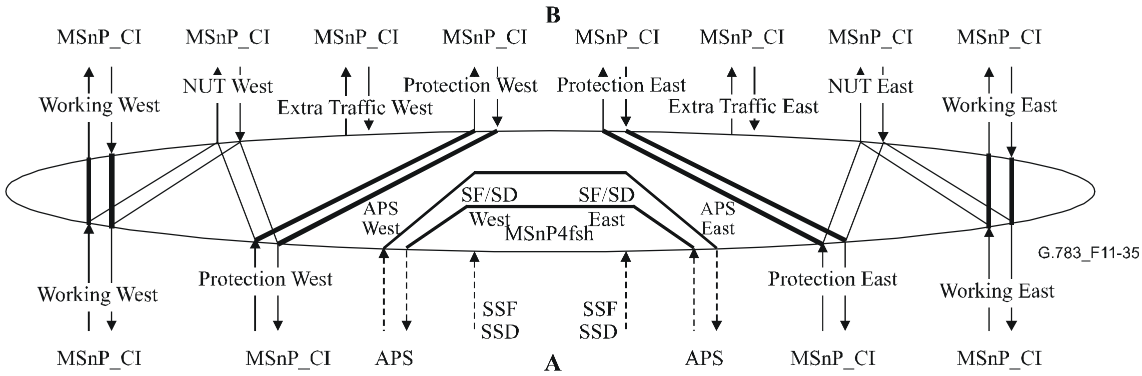


Figure 11-35/G.783 – Matrix connections in a network element not adjacent to a fault

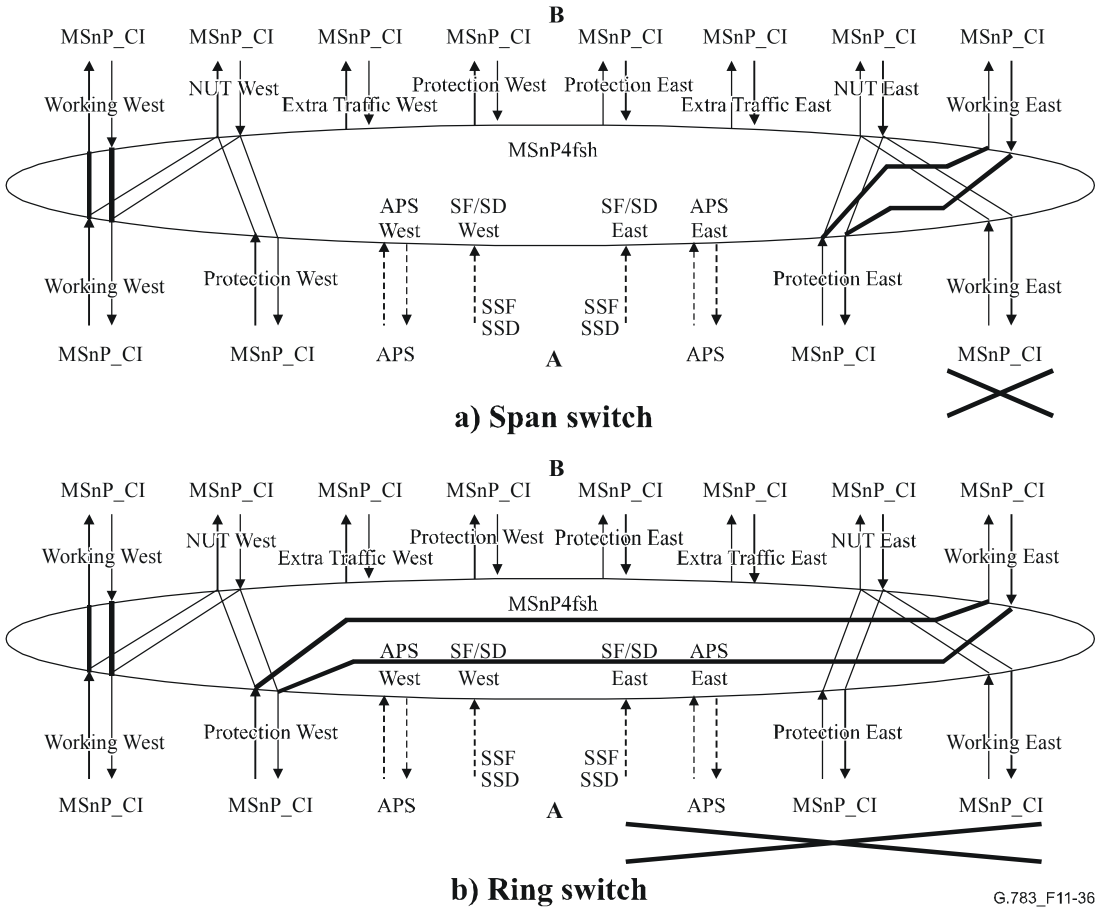


Figure 11-36/G.783 – Matrix connections in a network element adjacent to a fault on its east side

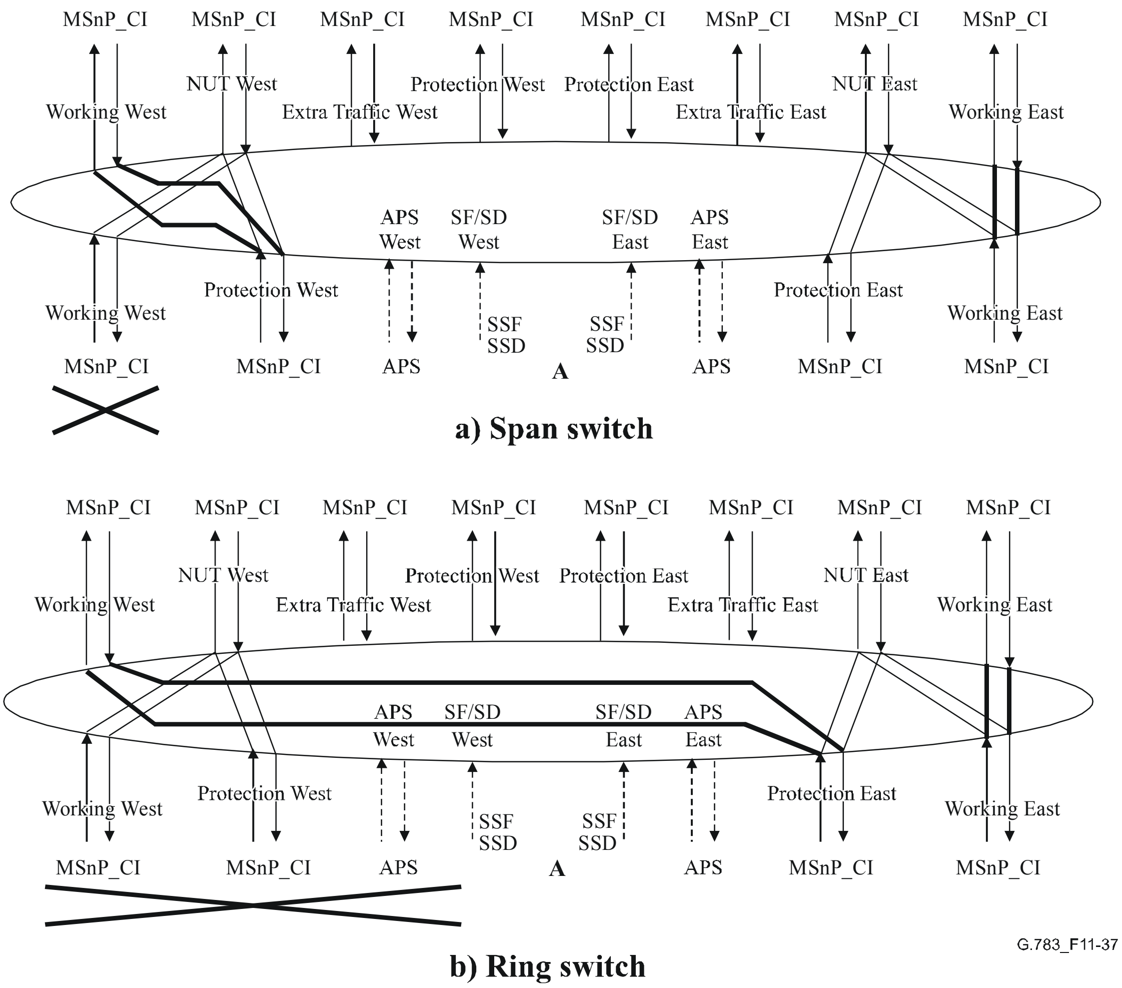


Figure 11-37/G.783 – Matrix connections in a network element adjacent to a fault on its west side

NOTE 3 – ITU-T Rec. G.841 states that protection AUs when not in use (for extra traffic or working traffic) may be sourced by VC unequipped signals. This shall be performed in this MSnP4fsh_C functions as ITU-T Rec. G.841 also shows that the Sn_C (S4-4c_C) functions have permanent matrix connections for the protection timeslot capacity. The protection is a MS layer protection scheme and should not impact client layers. In the functional model, the MSn layer knows the HOVC path multiplex structure, and is able to control HOVC unequipped signal insertion.

If NUT is supported, then on each span, selected channels on the working bandwidth and their corresponding protection channels may be provisioned as non-preemptible unprotected channels. The remaining working channels are still protected, for both span and ring switching, by their corresponding protection channels. The effect on a selected non-preemptible unprotected channel is as follows (refer to ITU-T Rec. G.841):

– ring switching is disabled on that channel everywhere on the ring (as in the 2-fibre case);
– span switching is disabled for that channel on the provisioned span.

The non-preemptible unprotected channels have no APS protection.

NOTE 4 – When an AU-4 is provisioned to support NUT, the protection matrix MSnP2fsh_C does not modify the connections for this AU-4 during protection operation.

MS protection operation: The 4-fibre MS shared protection ring trail protection process shall operate as specified in ITU-T Rec. G.841.

Defects

For further study.

Consequent actions

The function shall generate an AUG with VC-n [VC-4-4c] unequipped signal (plus valid AU-n [AU-4-4c] pointer) for each protection timeslot when the protection timeslot is not in use.

The function shall insert all-ONEs (AIS) (squelching) for an AUG [AU-4-4c] within protection timeslots that would otherwise be misconnected.

Defect correlations

For further study.

Performance monitoring

For further study.

11.4.3.2 STM-N Multiplex Section 4-Fibre Shared Protection Ring Trail Termination Functions

11.4.3.2.1 STM-N Multiplex Section 4-Fibre Shared Protection Ring Trail Termination Source MSnP4fsh_TT_So

Symbol

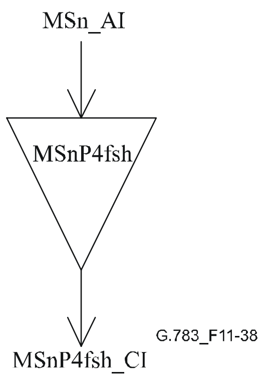


Figure 11-38/G.783 – MSnP4fsh_TT_So symbol

Interfaces

Table 11-24/G.783 – MSnP4fsh_TT_So input and output signals

Inputs	Outputs
MSnP4fsh_AI_D MSnP4fsh_AI_CK MSnP4fsh_AI_FS	MSnP4fsh_CI_D MSnP4fsh_CI_CK MSnP4fsh_CI_FS

Processes

No information processing is required in the MSnP4fsh_TT_So, the MSn_AI at its output being identical to the MSnP4fsh_CI at its input.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

11.4.3.2.2 STM-N Multiplex Section 4-Fibre Shared Protection Ring Trail Termination Sink MSnP4fsh_TT_Sk

Symbol

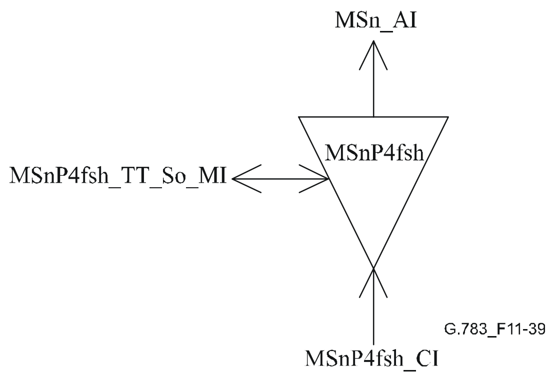


Figure 11-39/G.783 – MSnP4fsh_TT_Sk symbol

Interfaces

Table 11-25/G.783 – MSnP4fsh_TT_Sk input and output signals

Inputs	Outputs
MSnP4fsh_CI_D MSnP4fsh_CI_CK MSnP4fsh_CI_FS MSnP4fsh_CI_SSF MSnP4fsh_TT_Sk_MI_SSF_Reported	MSn_AI_D MSn_AI_CK MSn_AI_FS MSn_AI_TSF MSnP4fsh_TT_Sk_MI_cSSF

Processes

The MSnP4fsh_TT_Sk function reports, as part of the MSn layer, the state of the protected MSn trail. In case all connections are unavailable the MSnP4fsh_TT_Sk reports the signal fail condition of the protected trail. This is applicable only for the working capacity.

Defects

None.

Consequent actions

aTSF ← CI_SSF

Defect correlations

cSSF ← CI_SSF and SSF_Reported

Performance monitoring

None.

11.4.3.3 STM-N Multiplex Section 4-Fibre Shared Protection Ring Adaptation Functions

11.4.3.3.1 STM-N Multiplex Section to STM-N Multiplex Section 4-Fibre Shared Protection Ring Adaptation Source MSn/MSnP4fsh_A_So

Symbol

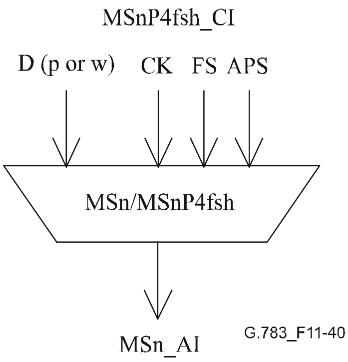


Figure 11-40/G.783 – MSn/MSnP4fsh_A_So symbol

Interfaces

Table 11-26/G.783 – MSn/MSnP4fsh_A_So input and output signals

Inputs	Outputs
MSnP4fsh_CI_Dw MSnP4fsh_CI_Dp MSnP4fsh_CI_CK MSnP4fsh_CI_FS MSnP4fsh_CI_APS (on fibres carrying protection channels)	MSn_AI_D MSn_AI_CK MSn_AI_FS

Processes

On fibres carrying protection channels: The function shall multiplex the CI_Dp signals into the MSn payload (n AUG timeslots). The function shall map the MSn 4-fibre shared protection ring APS signal into bytes K1 and K2.

On fibres carrying working channels: The function shall multiplex the CI_Dw signals into the MSn payload (n AUG timeslots).

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

11.4.3.3.2 STM-N Multiplex Section to STM-N Multiplex Section 4-Fibre Shared Protection Ring Adaptation Sink MSn/MSnP4fsh_A_Sk

Symbol

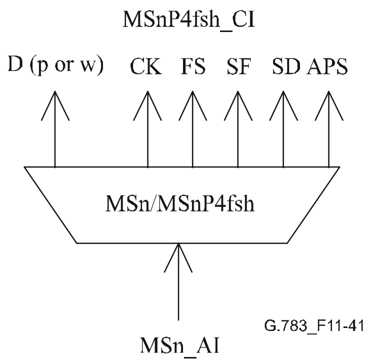


Figure 11-41/G.783 – MSn/MSnP4fsh_A_Sk symbol

Interfaces

Table 11-27/G.783 – MSn/MSnP4fsh_A_Sk input and output signals

Inputs	Outputs
MSn_AI_D MSn_AI_CK MSn_AI_FS MSn_AI_TSF MSn_AI_TSD	MSnP4fsh_CI_Dw or MSnP4fsh_CI_Dp MSnP4fsh_CI_CK MSnP4fsh_CI_FS MSnP4fsh_CI_SSF MSnP4fsh_CI_SSD MSnP4fsh_CI_APS (on fibres carrying protection channels)

Processes

On fibres carrying protection channels: The function shall extract the MSn payload (i.e., n AUG timeslots). The n protection AUG shall be output at MSnP4fsh_CI_Dp. The function shall extract the 16 APS bits K1[1-8] and K2[1-8] from the MSn_AI_D signal. A new value shall be accepted when the value is identical for three consecutive frames. This value shall be output via MSnP4fsh_CI_APS.

On fibres carrying working channels: The function shall extract the MSn payload (i.e., n AUG timeslots). The n working AUG shall be output at MSnP4fsh_CI_Dw.

Defects

None.

Consequent actions

aSSF ← AI_TSF

aSSD ← AI_TSD

Defect correlations

None.

Performance monitoring

None.

12 VC-n Path (Sn) Layer (n = 4-X, 4, 3-X, 3)

The VC-4 and VC-3 logical structure is defined in 7.1/G.707/Y.1322 [6]. The structures for virtual concatenation of VC-3s or VC-4s and contiguous concatenation of VC-4s is defined in clause 11/G.707/Y.1322.

Figure 12-1 illustrates the set of atomic functions for the VC-n path layers. At the access point (Sn_AP), the following payloads are supported:

– VC-3 payload (9×84 bytes per frame);

– VC-4 payload (9×260 bytes per frame);

– VC-3-X payload ($X \geq 1$, $X \times 9 \times 84$ bytes per frame);

– VC-4-X payload ($X \geq 1$, $X \times 9 \times 260$ bytes per frame).

The characteristic information supported at the connection point can be a VC-3, a VC-4, or a VC-4-Xc (X = 4, 16, 64, 256).

VC-3-X payloads may be carried using X VC-3s with virtual concatenation. The VC-3s collectively are referred to as a VC-3-Xv. After the S3-Xv adaptation source function, each VC-3 is carried independently until all X VC-3s arrive at the S3-Xv adaptation sink function.

VC-4-X payloads may be carried either using X VC-4s with virtual concatenation, or with a single VC-4-Xc for the cases of X = 4, 16, 64, 256. In the case of virtual concatenation, the VC-4s collectively are referred to as VC-4-Xv. After the VC-4-Xv adaptation source function, each VC-4 is carried independently until all X VC-4s arrive at the S4-Xv adaptation sink function.

Figure 12-1 shows that more than one adaptation function exists in the Sn layer that can be connected to one Sn-X access point. For such cases, a subset of these adaptation source functions is allowed to be activated together, but only one adaptation source function may have access to a specific timeslot. Access to the same timeslot by other adaptation source functions shall be denied. In contradiction with the source direction, adaptation sink functions may be activated all together. This may cause faults to be detected and reported. To prevent this an adaptation sink function can be deactivated.

NOTE 1 – If one adaptation function only is connected to the AP, it will be activated. If one or more other functions are connected to the same AP accessing the same timeslot, one out of the set of functions will be active.

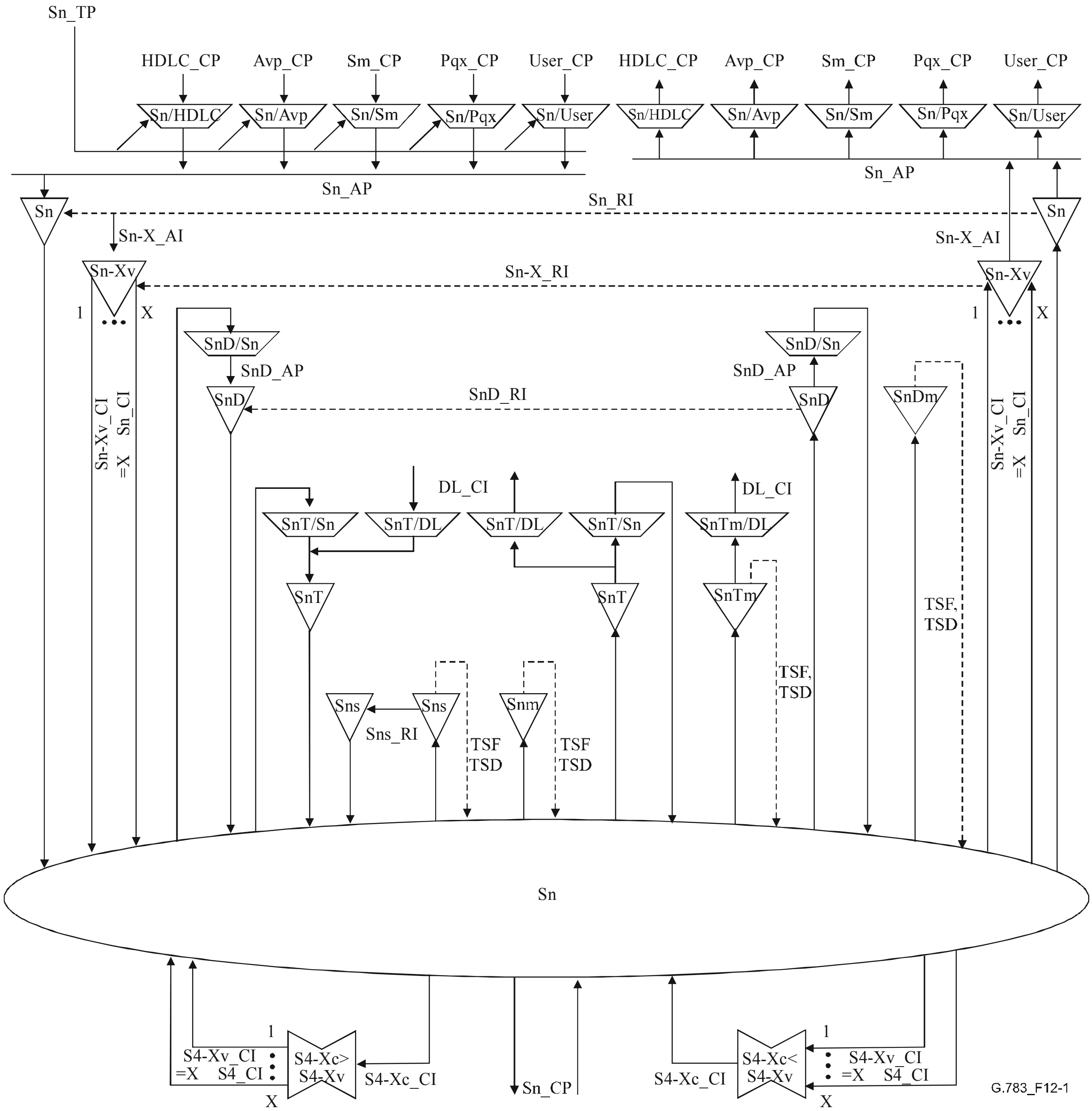
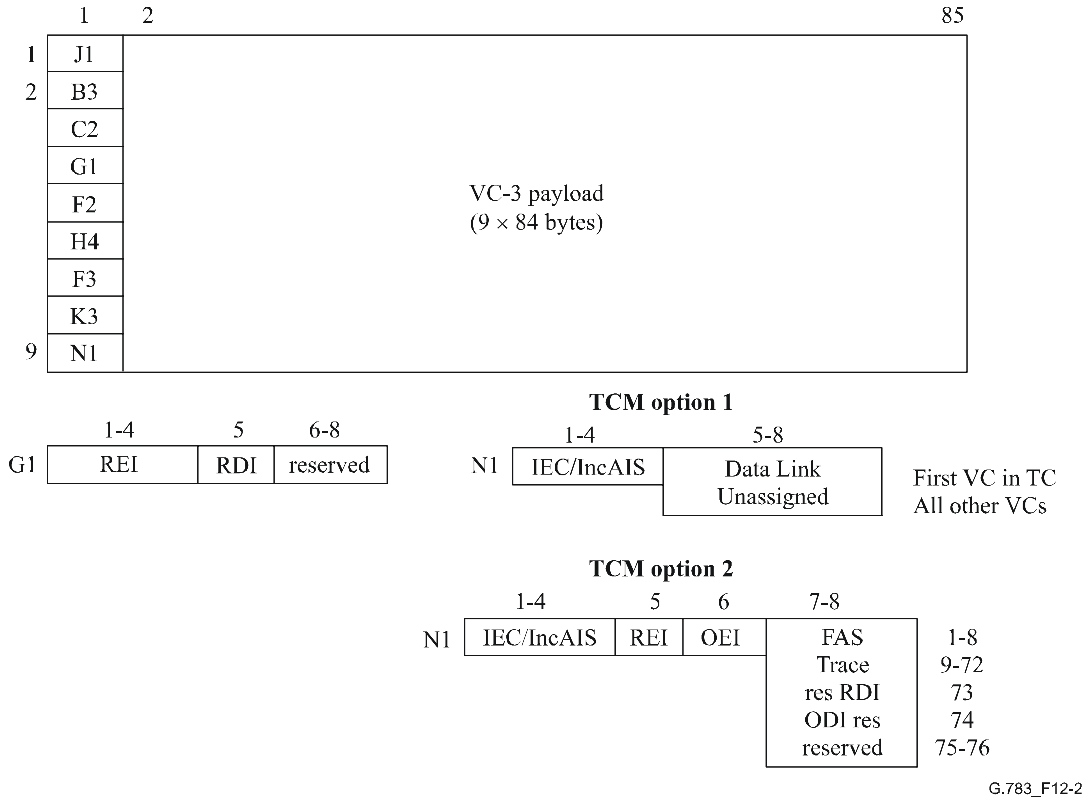


Figure 12-1/G.783 – VC-n path layer atomic functions

Sn Layer Characteristic Information

The Characteristic Information Sn_CI has co-directional timing and is octet structured with a 125 µs frame.

S3_CI is shown in Figure 12-2. Its format is characterized as the VC-3 trail termination overhead in the J1, B3, and G1 bytes as defined in ITU-T Rec. G.707/Y.1322 plus the S3 Adapted Information given in the next subclause. Alternatively, it may be an unequipped signal as defined in ITU-T Rec. G.707/Y.1322.

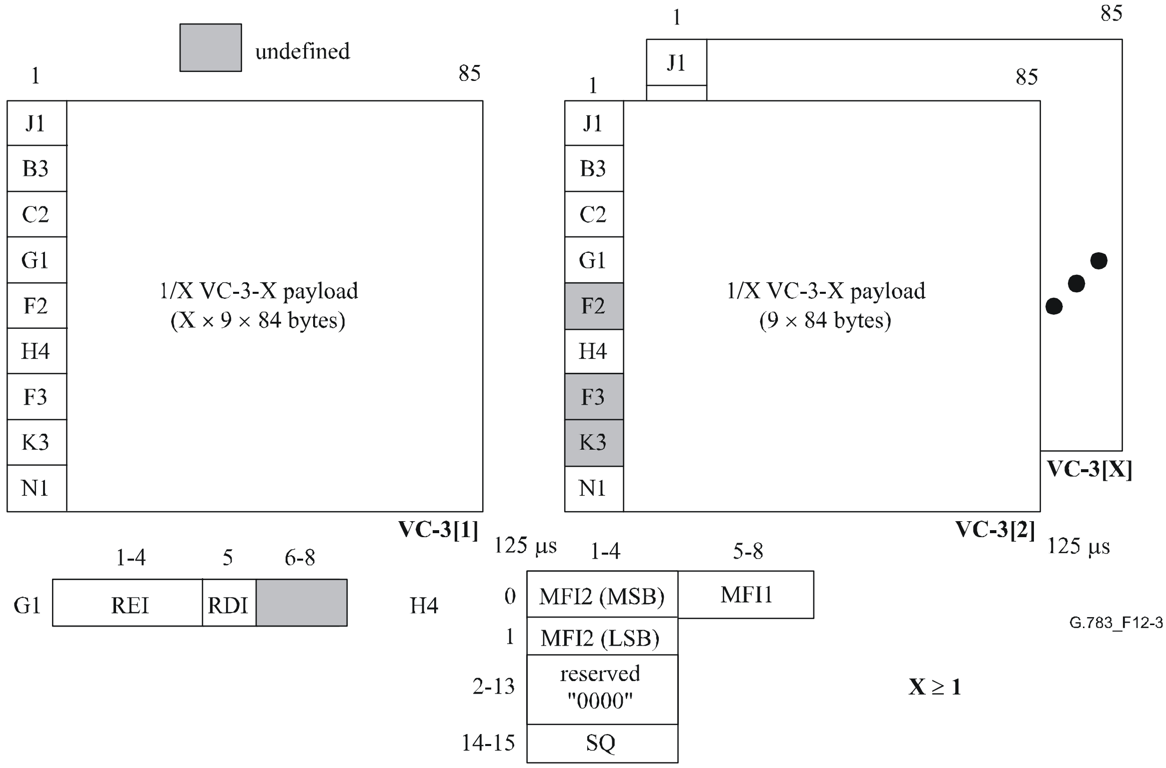


NOTE – Bits 6 to 7 of G1 are reserved for an optional use of enhanced RDI described in Appendix VI.

Figure 12-2/G.783 – S3_CI_D

A VC-3 concatenated trail can be transported via virtual concatenated VC-3 (VC-3-Xv) connections. For a VC-3-X trail supported by a virtual concatenated VC-3-Xv connection, all values for X ≥ 1 are allowed. The CI of a VC-3-Xv (S3-Xv_CI_D) consists of X times S3_CI (see Figure 12-3). The H4 byte is generated as defined in ITU-T Rec. G.707/Y.1322. The mapping of S3-X_AI to S3-Xv_CI is performed as shown in Figure 12-4.

NOTE 2 – F2, F3 and K3 of VC-3[2..X] are undefined.



NOTE – Bits 6 to 7 of G1 are reserved for an optional use of enhanced RDI described in Appendix VI.

Figure 12-3/G.783 – S3-Xv_CI_D

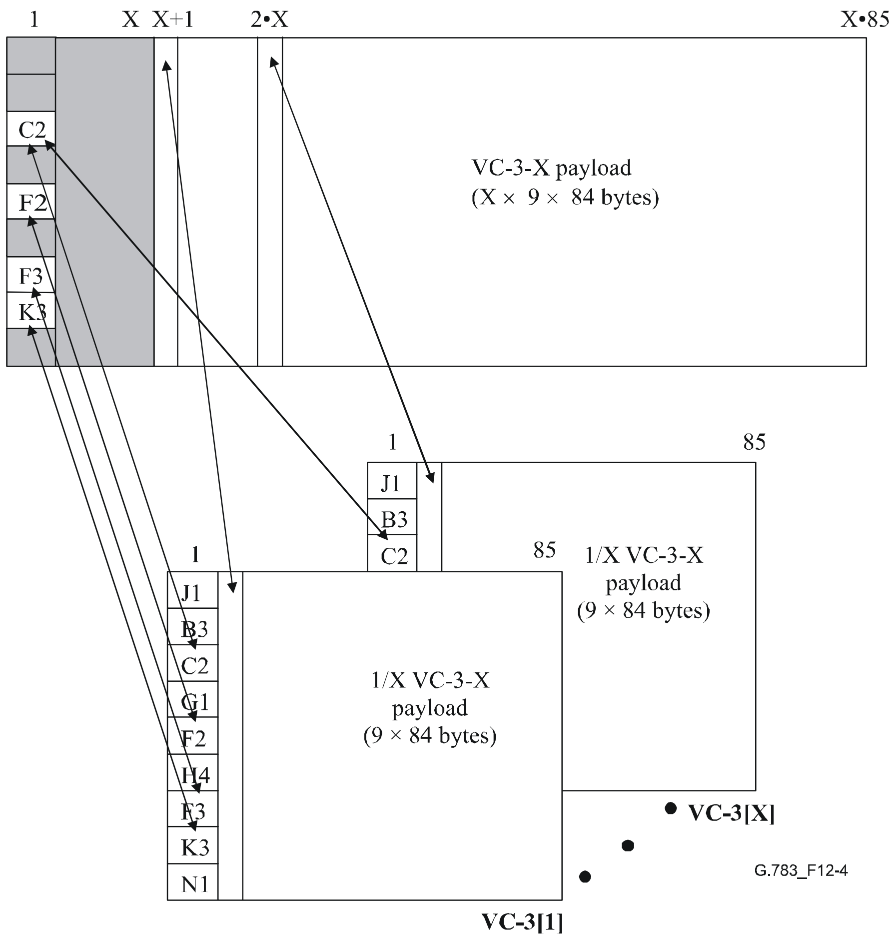
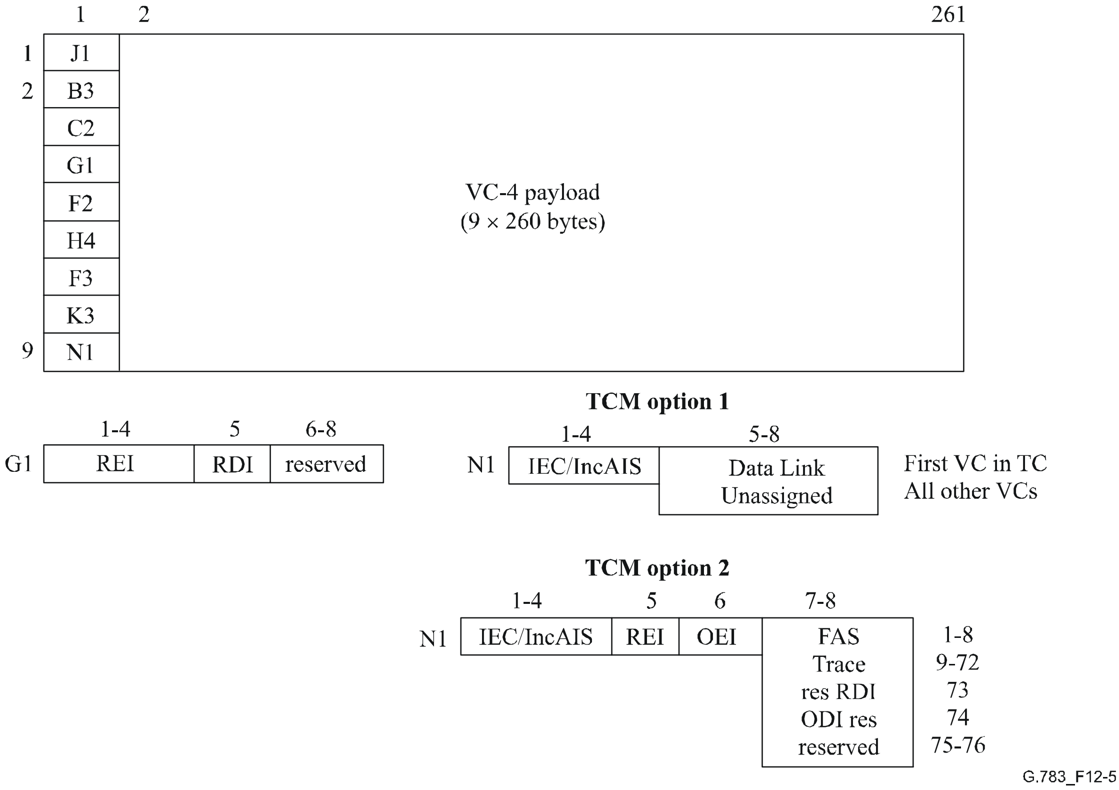


Figure 12-4/G.783 – S3-X_AI_D to S3-Xv_CI_D mapping

S4_CI is shown in Figure 12-5. Its format is characterized as the VC-4 trail termination overhead in the J1, B3, and G1 bytes as defined in ITU-T Rec. G.707/Y.1322 plus the S4 Adapted Information given in the next subclause. Alternatively, it may be an unequipped signal as defined in ITU-T Rec. G.707/Y.1322.



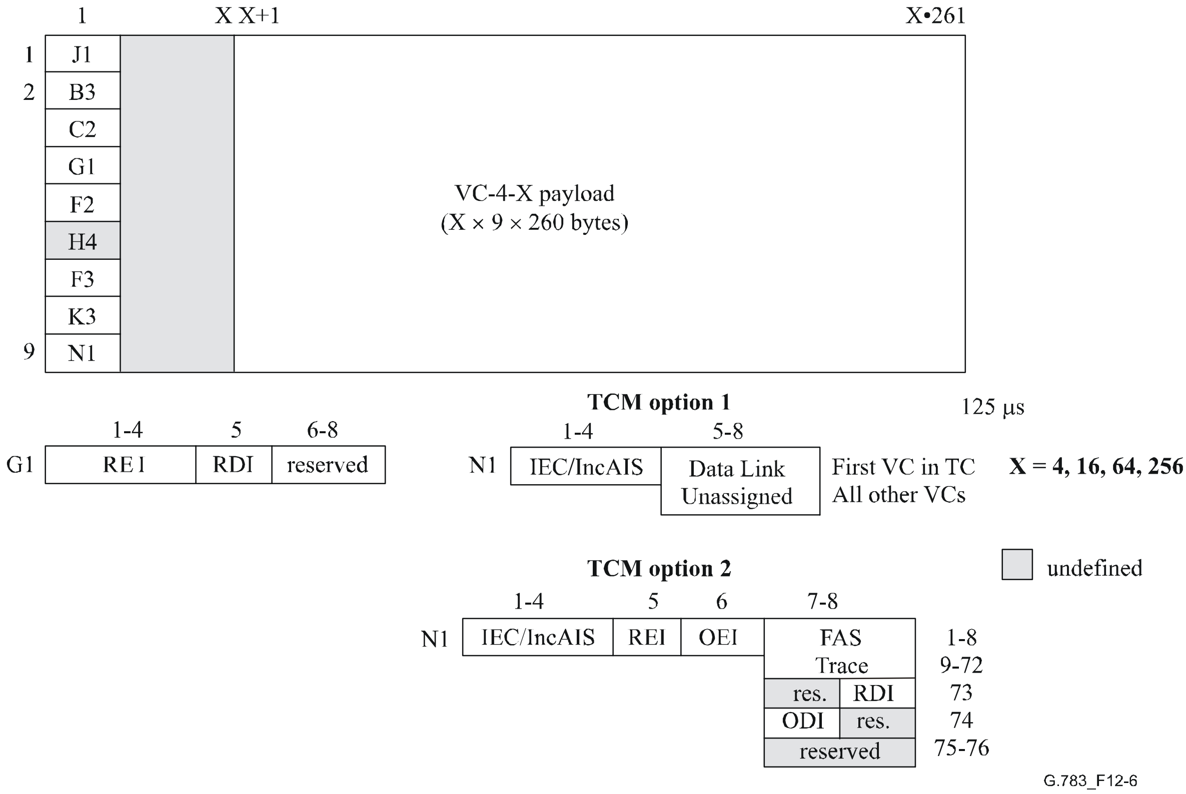
NOTE – Bits 6 to 7 of G1 are reserved for an optional use of enhanced RDI described in Appendix VI.

Figure 12-5/G.783 – S4_CI_D

A VC-4 concatenated trail can be transported via contiguous concatenated VC-4 (VC-4-Xc) or virtual concatenated VC-4 (VC-4-Xv) connections. If the concatenated VC-4-X trail is supported by a contiguous concatenated VC-4-Xc connection, the allowed values for X are 4, 16, 64 and 256. If the concatenated VC-4-X trail is supported by a virtual concatenated VC-4-Xv connection, all values for $X \geq 1$ are allowed.

The CI of a VC-4-Xc (S4-Xc_CI_D) signal is octet structured with a 125 μs frame (see Figure 12-6). Its format is characterized as S4-X_AI plus the VC-4 trail termination overhead in the J1, B3, and G1 locations as defined in ITU-T Rec. G.707/Y.1322.

NOTE 3 – H4 is not used in VC-4-Xc.

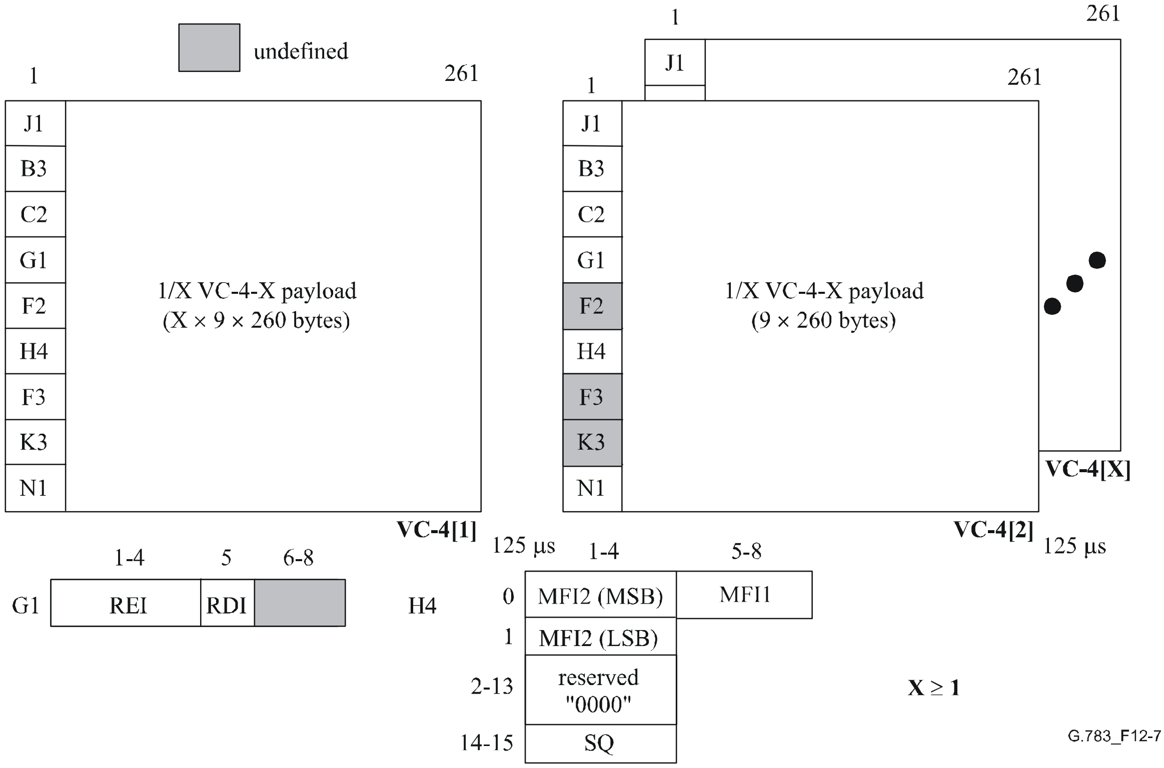


NOTE – Bits 6 to 7 of G1 are reserved for an optional use of enhanced RDI described in Appendix VI.

Figure 12-6/G.783 – S4-Xc_CI_D

The CI of a VC-4-Xv (S4-Xv_CI_D) consists of X times S4_CI (see Figure 12-7). The H4 byte is generated as defined in ITU-T Rec. G.707/Y.1322. The mapping of S4-X_AI to S4-Xv_CI is performed as shown in Figure 12-8.

NOTE 4 – F2, F3 and K3 of VC-4[2..X] are undefined.



NOTE – Bits 6 to 7 of G1 are reserved for an optional use of enhanced RDI described in Appendix VI.

Figure 12-7/G.783 – S4-Xv_CI_D

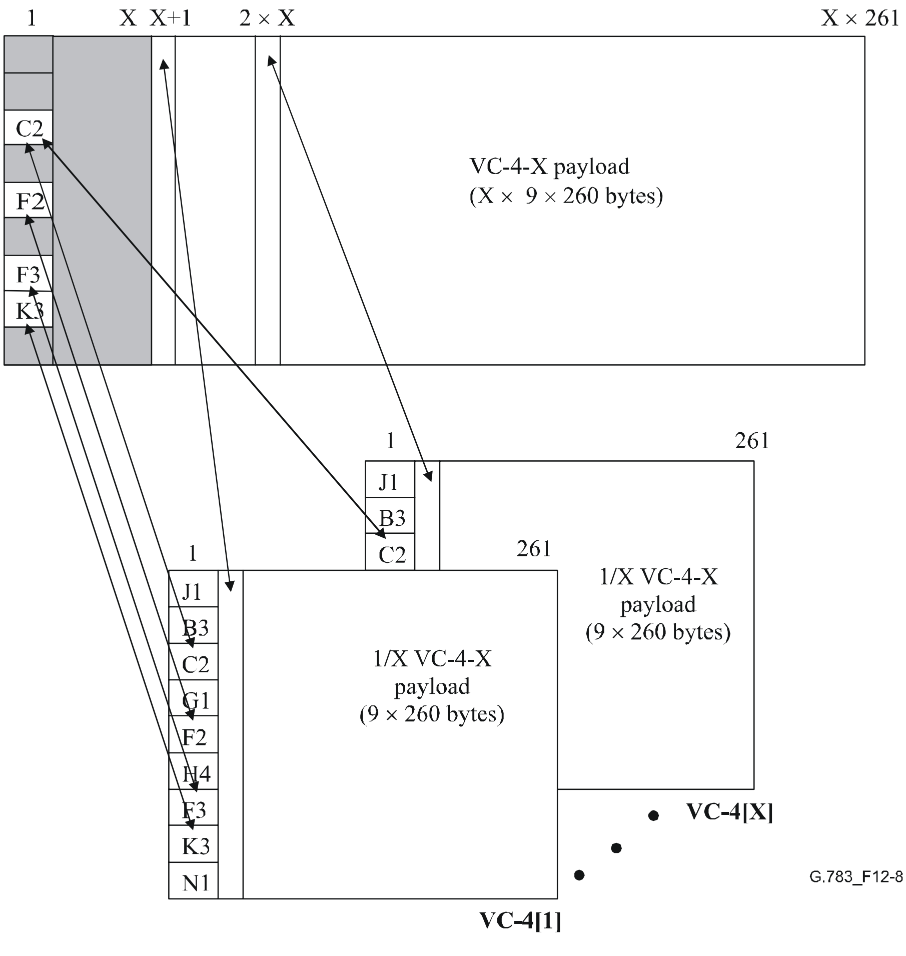
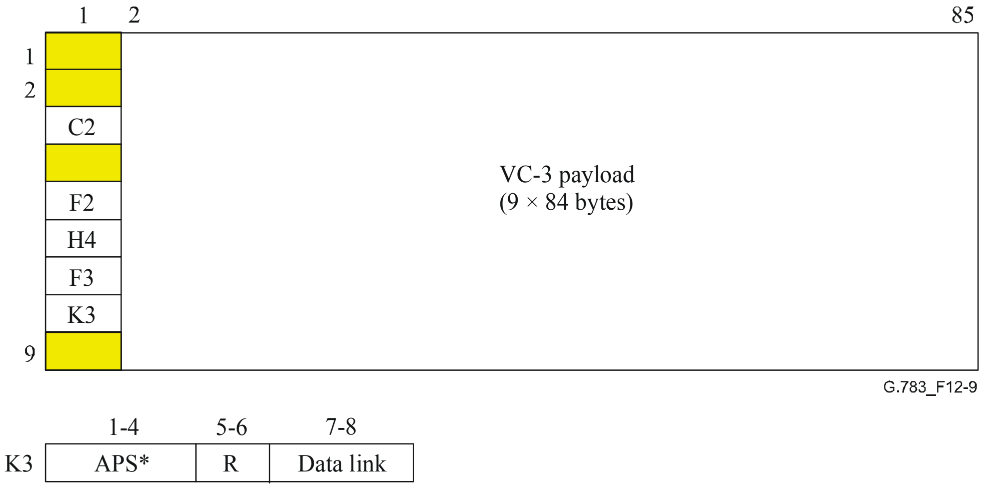


Figure 12-8/G.783 – S4-X_AI_D to S4-Xv_CI_D mapping

Sn Layer Adaptation Information

The Adaptation Information AI is octet structured with an 125 µs frame.

S3_AI is shown in Figure 12-9. It represents adapted client layer information consisting of client layer information, the signal label, and client-specific information combined with 1-byte user channels F2 and F3. For the case the signal has passed the trail protection sublayer (S3P), Sn_AI has defined APS bits (1 to 4) in byte K3.



NOTE – Bits 7 and 8 of K3 are allocated as path data link; their value will be undefined when the S3_CI has not been processed in a path data link sublayer atomic function.

Figure 12-9/G.783 – S3_AI_D

S3-X_AI is shown in Figure 12-10. It represents adapted client layer information comprising X × 756 bytes for client layer information, the signal label byte C2, and the 2-path user channel bytes F2/3 as defined in ITU-T Rec. G.707/Y.1322. For the case where the signal has passed the trail protection sublayer, S3-X_AI has defined APS bits (1 to 4) in byte K3.

NOTE 5 – The APS signal has not been defined; a multiframed APS signal might be required.

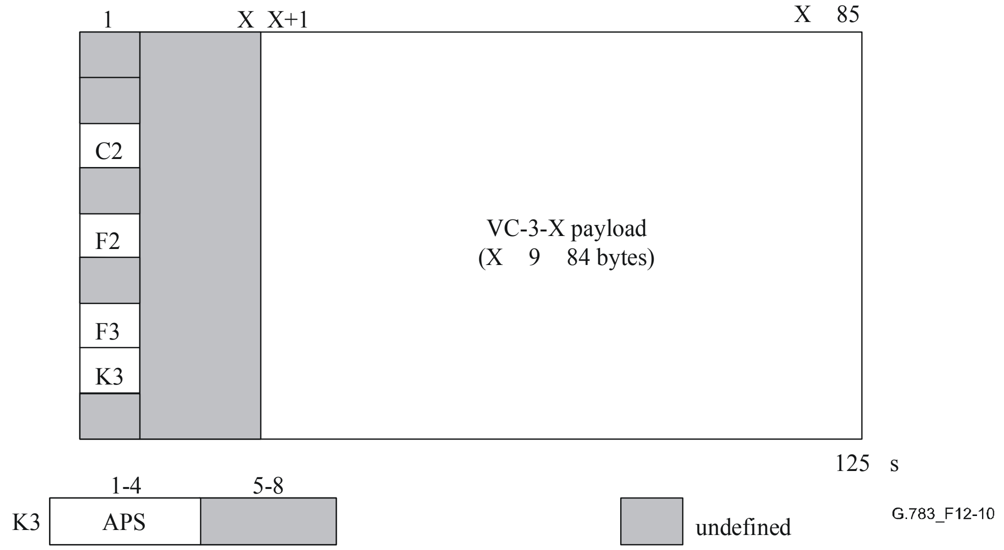
NOTE 6 – Bits 1 to 4 of byte K3 will be undefined when the signal S3-X_AI has not been processed in a trail protection connection function Sn-XP_C.

NOTE 7 – Bytes F2 and F3 will be undefined when the adaptation functions sourcing these bytes are not present in the network element.

A VC-3-X comprises one of the following payloads:

– an ATM X × 48 348 kbit/s cell stream signal;

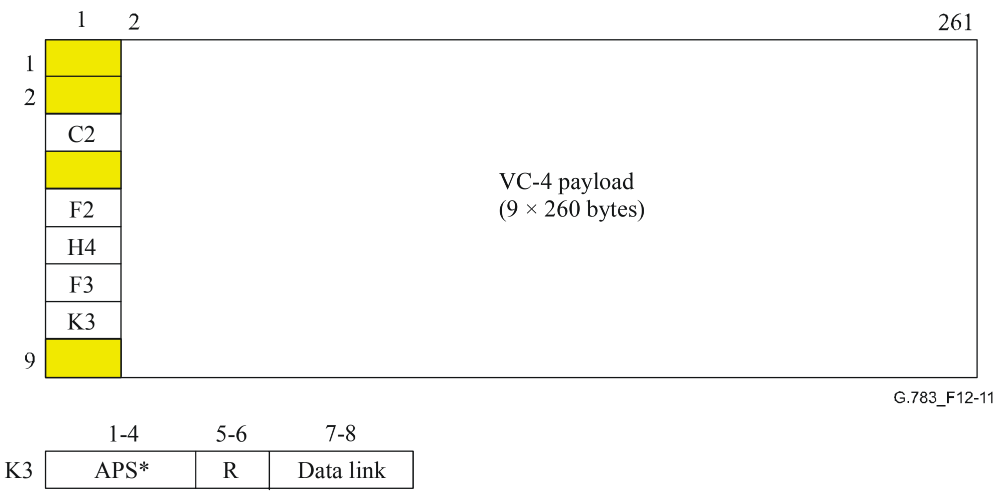
– an HDLC X × 48 348 kbit/s packet stream signal.



NOTE – Bits 7 and 8 of K3 are allocated as path data link; their value will be undefined when the CI has not been processed in a path data link sublayer atomic function.

Figure 12-10/G.783 – S3-X_AI_D

S4_AI is shown in Figure 12-11. It represents adapted client layer information consisting of client layer information, the signal label, and client-specific information combined with 1-byte user channels F2 and F3. For the case where the signal has passed the trail protection sublayer (S4P), Sn_AI has defined APS bits (1 to 4) in byte K3.



NOTE – Bits 7 and 8 of K3 are allocated as path data link; their value will be undefined when the S4_CI has not been processed in a path data link sublayer atomic function.

Figure 12-11/G.783 – S4_AI_D

S4-X_AI is shown in Figure 12-12. It represents adapted client layer information comprising X × 2340 bytes for client layer information, the signal label byte C2, and the 2-path user channel bytes F2/3 as defined in ITU-T Rec. G.707/Y.1322. For the case where the signal has passed the trail protection sublayer, S4-X_AI has defined APS bits (1 to 4) in byte K3.

NOTE 8 – The APS signal has not been defined; a multiframed APS signal might be required.

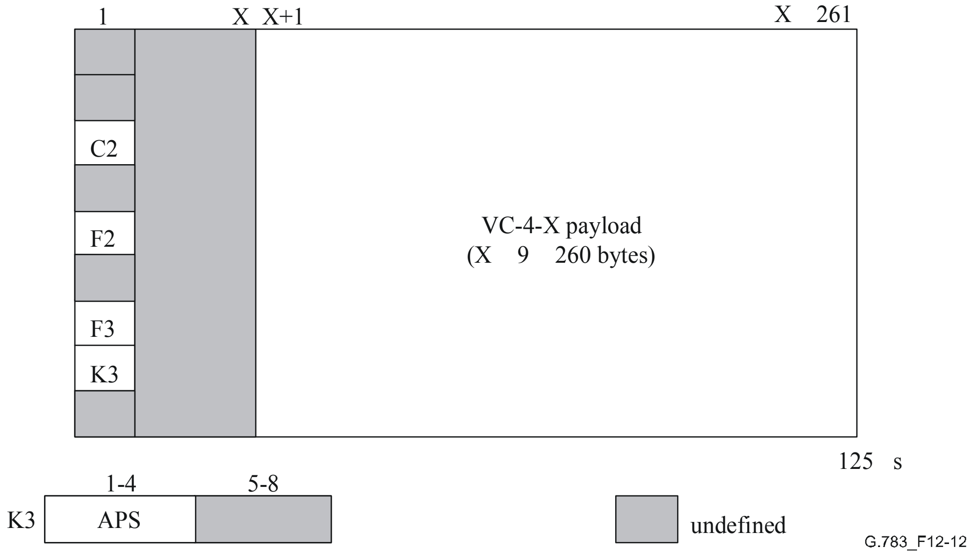
NOTE 9 – Bits 1 to 4 of byte K3 will be undefined when the signal S4-X_AI has not been processed in a trail protection connection function Sn-XP_C.

NOTE 10 – Bytes F2 and F3 will be undefined when the adaptation functions sourcing these bytes are not present in the network element.

A VC-4-X comprises one of the following payloads:

– an ATM X × 149 760 kbit/s cell stream signal;

– an HDLC X × 149 760 kbit/s packet stream signal.



NOTE – Bits 7 and 8 of K3 are allocated as path data link; their value will be undefined when the CI has not been processed in a path data link sublayer atomic function.

Figure 12-12/G.783 – S4-X_AI_D

Layer functions

Sn_C	VC-n layer connection function
Sn_TT	VC-n layer trail termination function
Snm_TT	VC-n non-intrusive monitor function
Sns_TT	VC-n supervisory-unequipped termination function
Sn/Sm_A	VC-n layer to VC-m layer adaptation functions
SnP_C	VC-n layer linear trail protection connection function
SnP_TT	VC-n layer linear trailprotection trail termination function
Sn/SnP_A	VC-n layer linear trailprotection adaptation function
Sn/User_A	VC-n layer to user data adaptation function
Sn/Pqx_A	VC-n layer to Pqx layer adaptation function
SnD_TT	VC-n tandem connection (option 2) termination function
SnD/Sn_A	VC-n tandem connection (option 2) to VC-n layer adaptation function
SnDm_TT	VC-n tandem connection (option 2) non-intrusive monitor function
SnT_TT	VC-n tandem connection (option 1) termination function
SnT/Sn_A	VC-n tandem connection (option 1) to VC-n layer adaptation function
SnTm_TT	VC-n tandem connection (option 1) non-intrusive monitor function
SnT/DL_A	VC-n tandem connection (option 1) to Data Link adaptation function

Sn-X_TT	VC-n-X layer trail termination function
Sn-Xv/Sn-X_A	VC-n-Xv to VC-n-X layer adaptation function
S4-Xc↔S4-Xv_I	VC-4-Xc to VC-4-Xv concatenation interworking function

12.1 Connection functions

12.1.1 VC-n Layer Connection Sn_C

Sn_C is the function which assigns VC-n (n = 3, 4, 4-Xc) at its input ports to VC-n at its output ports.

The Sn_C connection process is a unidirectional function as illustrated in Figure 12-13. The signal formats at the input and output ports of the function are similar, differing only in the logical sequence of the VC-ns. As the process does not affect the nature of the characteristic information of the signal, the reference point on either side of the Sn_C function is the same, as illustrated in Figure 12-13.

Incoming VC-ns at the Sn_CP are assigned to available outgoing VC-n capacity at the Sn_CP.

An unequipped VC-n shall be applied at any outgoing VC-n which is not connected to an incoming VC-n.

Symbol

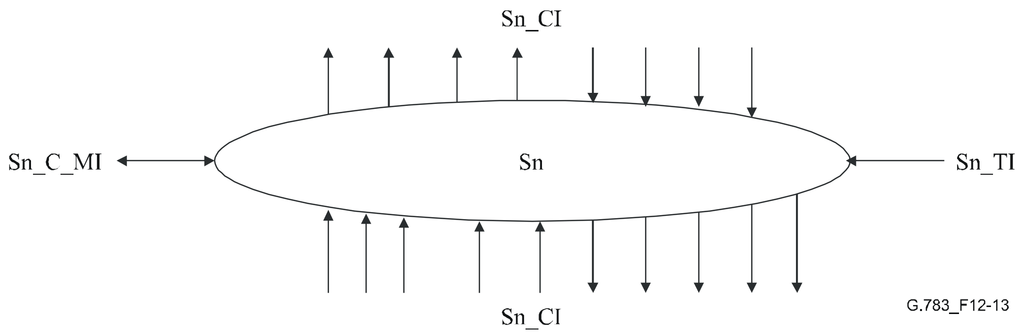


Figure 12-13/G.783 – Sn_C symbol

Interfaces

Table 12-1/G.783 – Sn_C input and output signals

Inputs	Outputs
Per Sn_CP, n × for the function: Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF Sn_AI_TSF Sn_AI_TSD 1 × per function: Sn_TI_Clock Sn_TI_FrameStart Per input and output connection point: Sn_C_MI_ConnectionPortIds Per matrix connection: Sn_C_MI_ConnectionType Sn_C_MI_Directionality Per SNC protection group: Sn_C_MI_PROTtype Sn_C_MI_OPERtype Sn_C_MI_WTRtime Sn_C_MI_Hotime Sn_C_MI_EXTCMD	Per Sn_CP, m × per function: Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF
NOTE – Protection status reporting signals are for further study.	

Processes

In the Sn_C function VC-n Layer Characteristic Information is routed between input (termination) connection points ((T)CPs) and output (T)CPs by means of matrix connections. (T)CPs may be allocated within a protection group.

NOTE 1 – Neither the number of input/output signals to the connection function, nor the connectivity is specified in this Recommendation. That is a property of individual network elements. Examples of Sn_C are given in Appendix I/G.806.

Figure 12-1 presents a subset of the atomic functions that can be connected to this VC-n connection function: VC-n trail termination functions, VC-m non-intrusive monitor trail termination sink function, VC-n unequipped-supervisory trail termination functions, VC-n tandem connection trail termination and adaptation functions. In addition, adaptation functions in the VC-n server (e.g., MS1 or MS4) layers will be connected to this VC-n connection function.

Routing: The function shall be able to connect a specific input with a specific output by means of establishing a matrix connection between the specified input and output. It shall be able to remove an established matrix connection.

Each (matrix) connection in the Sn_C function should be characterized by the:

Type of connection:	unprotected, 1 + 1 protected (SNC/I, SNC/N or SNC/S protection)
Traffic direction:	unidirectional, bidirectional
Input and output connection points:	set of connection point

NOTE 2 – Broadcast connections are handled as separate connections to the same input CP.

NOTE 3 – For the case where a network element supports 1 + 1 protected matrix connections in its Sn_C function, this function may contain at any moment in time either all unprotected matrix connections, or all 1 + 1 protected matrix connections, or a mixture of unprotected and 1 + 1 protected matrix connections. The actual set of matrix connections and associated connection types and directions is an operational parameter controlled by network management.

Provided no protection switching action is activated/required, the following changes to (the configuration of) a connection shall be possible without disturbing the CI passing the connection:

– addition and removal of protection;
– addition and removal of connections to/from a broadcast connection;
– change between operation types;
– change of WTR time;
– change of Hold-off time.

Unequipped VC generation: The function shall generate an unequipped VC-n signal, as defined in ITU-T Rec. G.707/Y.1322.

Defects

None.

Consequent actions

If an output of this function is not connected to one of its inputs, the function shall connect the unequipped VC-n (with valid frame start (FS) and SSF = false) to the output.

Defect correlations

None.

Performance monitoring

None.

12.1.1.1 VC-n SubNetwork Connection Protection Process

NOTE 1 – This process is active in the Sn_C function as many times as there are 1 + 1 protected matrix connections.

VC-n subnetwork connection protection mechanism is described in ITU-T Rec. G.841.

Figure 12-14 gives the atomic functions involved in SNC protection. Bottom to the left is the two (working and protection) adaptation function (MSn/Sn_A) pairs. Above them is the non-intrusive monitoring functions (Snm_TT_Sk), in case of SNC/I they are not present. To the right is either the trail termination functions (Sn_TT) or the adaptation functions (MSn/Sn_A) depending on whether the Sn trail is terminated at the same point the SNC protection is terminated or at a later point.

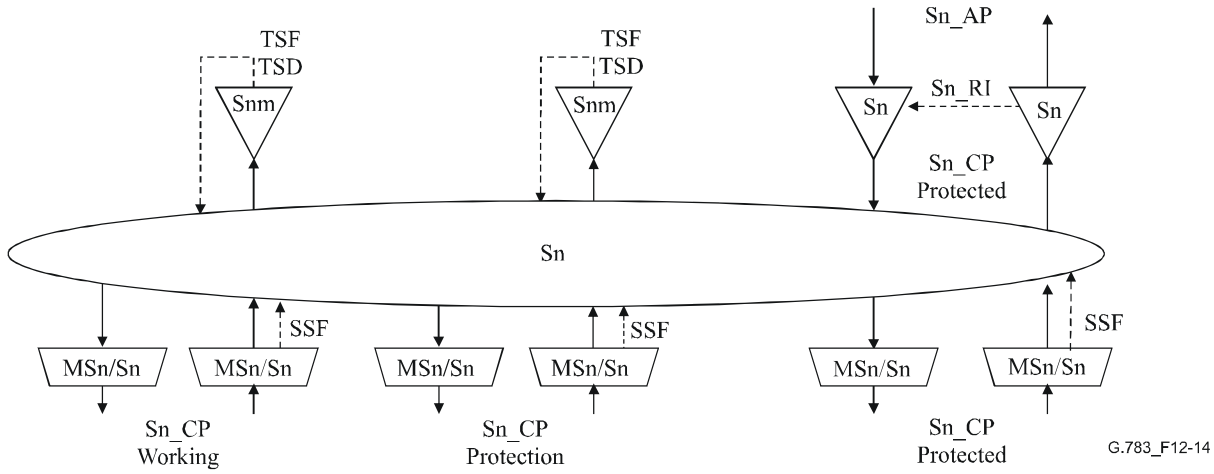


Figure 12-14/G.783 – VC-n SNC/N protection atomic functions

The Sn_C function may provide protection for the trail against channel-associated defects within a (sub)network connection.

The Sn_C functions at both ends operate the same way, by monitoring subnetwork connection for defects, evaluating the system status taking into consideration the priorities of defect conditions and of external switch requests, and switching the appropriate channel to the protection (sub)network connection.

The signal flow associated with the Sn_C SNC protection process is described with reference to Figures 12-15 and 12-16. The Sn_C protection process receives control parameters and external switch requests at the Sn_C_MP reference point from the synchronous equipment management function and outputs status indicators at the Sn_C_MP to the synchronous equipment management function, as a result of switch commands described in ITU-T Rec. G.841.

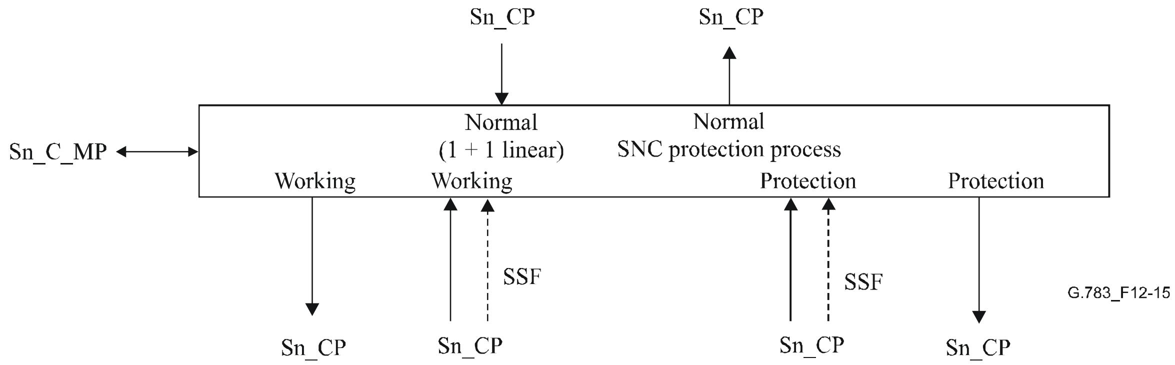


Figure 12-15/G.783 – VC-n inherent monitored subnetwork connection (SNC/I) protection process

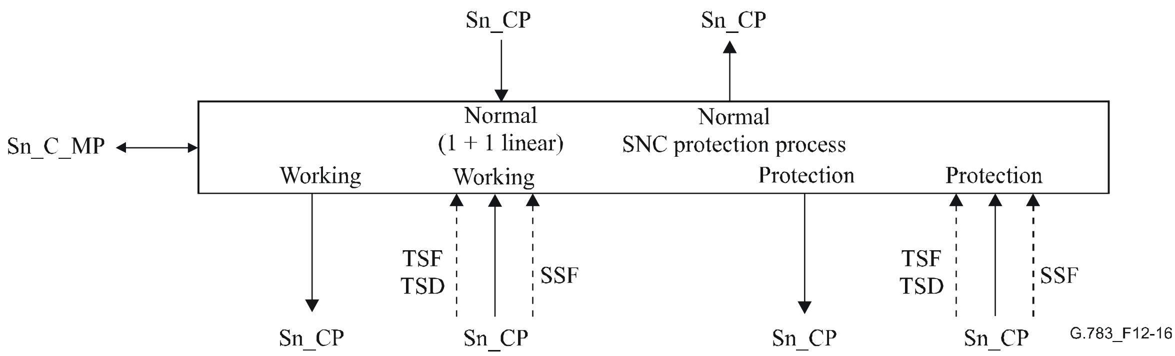


Figure 12-16/G.783 – VC-n non-intrusive monitored subnetwork connection (SNC/N) protection process

Source direction

Data at the Sn_CP is a trail signal.

For 1 + 1 architecture, the signal received at the Sn_CP from the MSn/Sn_A (or Sn_TT) function is bridged permanently at the Sn_CP to both working and protection MSn/Sn_A functions.

NOTE 2 – The atomic function connected at the Sn_CP to the Sn_C is either a MSn/Sn_A or a Sn_TT. When the trail signal is terminated in this network element, it will be connected at the Sn_CP to a Sn_TT; otherwise it will be connected at the Sn_CP to a MSn/Sn_A (for further transport).

Sink direction

Framed trail signals (data) are presented at the Sn_CP along with incoming timing references. The defect condition(s) SSF (and TSF and TSD) are also received at the Sn_CP from all MSn/Sn_A (or Snm_TT_Sk) functions.

For the SNC/I protection (Figures 12-14 and 12-15), the trail signals pass the MSn/Sn_A functions. The SSF signals from the MSn/Sn_A_Sk are used by the Sn_C SNC protection process.

For SNC/N protection (Figures 12-14 and 12-16), the trail signals are broadcasted to a Snm_TT_Sk function for non-intrusive monitoring of the trail. The resultant TSF, TSD signals are used by the Sn_C SNC protection process instead of the SSF signal from the MSn/Sn_A.

Under normal conditions, Sn_C passes the data and timing from the working MSn/Sn_A functions to the MSn/Sn_A (or Sn_TT) function at the Sn_CP. The data and timing from the protection (sub)network connection is terminated.

If a switch is to be performed, then the data and timing received from the protection MSn/Sn_A at the Sn_CP is switched to the MSn/Sn_A (or Sn_TT) function at the SnP_C, and the signal received from the working MSn/Sn_A at the Sn_CP is not forwarded.

Switch initiation criteria

Automatic protection switching is based on the defect conditions of the working and protection (sub)network connections. These condition(s) are for SNC/I server signal fail (SSF) and for SNC/N trail signal fail (TSF) and trail signal degrade (TSD). Detection of these conditions is described in 11.3.1.2 for MSn/Sn_A_Sk and 12.2.2 for Snm_TT_Sk.

The protection switch can also be initiated by switch commands received via the synchronous equipment management function. See the switch initiation criteria described in ITU-T Rec. G.841.

Switching time

Refer to ITU-T Rec. G.841.

Switch restoration

In the revertive mode of operation, the working channel shall be restored, i.e., the signal on the protection (sub)network connection shall be switched back to the working (sub)network connection, when the working (sub)network connection has recovered from the fault.

To prevent frequent operation of the protection switch due to an intermittent fault, a failed (sub)network connection must become fault-free. After the failed (sub)network connection 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 SSF, TSF or TSD condition shall override the WTR.

12.2 Termination functions

12.2.1 VC-n Layer Trail Termination Sn_TT

The Sn_TT_So function creates a VC-n (n = 3, 4, 4-Xc) at the Sn_CP by generating and adding POH to a container C-n from the Sn_AP. 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 ITU-T Rec. G.707/Y.1322.

Data at the Sn_AP takes the form of a container C-n (n = 3, 4, 4-Xc) which is synchronized to the timing reference Sn_TP.

Synchronously adapted information in the form of synchronous containers (data) and the associated container frame offset information (frame offset) are received at the Sn_AP.

12.2.1.1 VC-n Layer Trail Termination Source Sn_TT_So

This function adds error monitoring and status overhead bytes to the Sn_AP.

Data at the Sn_AP is a VC-n (n = 3, 4, 4-Xc), having a payload as described in ITU-T Rec. G.707/Y.1322, but with indeterminate VC-3/4/4-Xc POH bytes: J1, B3, G1. These POH bytes are set as part of the Sn_TT function and the complete VC-n is forwarded to the Sn_CP.

Symbol

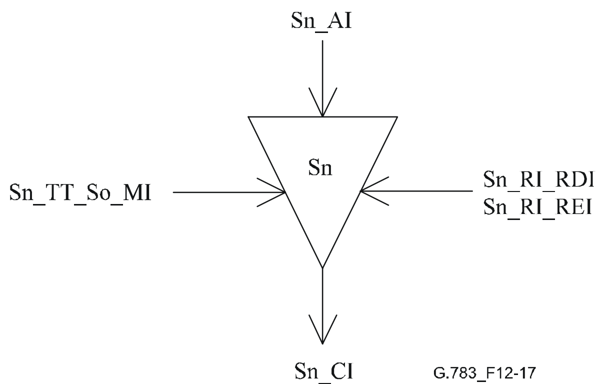


Figure 12-17/G.783 – Sn_TT_So symbol

Interfaces

Table 12-2/G.783 – Sn_TT_So input and output signals

Inputs	Outputs
Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart Sn_RI_RDI Sn_RI_REI Sn_TT_So_MI_TxTI	Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart

Processes

J1: The trail trace identifier should be generated. Its value is derived from reference point Sn_TT_So_MP. The path trace format is described in 6.2.2.2/G.806.

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

G1[1-4]: The number of errors indicated in RI_REI is encoded in the REI (bits 1 to 4 of the G1 byte). Upon the detection of a number of errors at the termination sink function the trail termination source function shall have inserted that value in the REI bits within 1 ms.

G1[5]: Upon the declaration/clearing of aRDI at the termination sink function, the trail termination source function shall have inserted/removed the RDI indication within 1 ms.

G1[6-7]: Bits 6 and 7 of byte G1 are reserved for the optional use of enhanced-RDI (E-RDI) described in Appendix VI. If this option is not used, bits 6 and 7 shall be set to 00 or 11.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

12.2.1.2 VC-n Layer Trail Termination Sink Sn_TT_Sk

This function monitors the VC-n (n = (3, 4, 4-Xc)) for errors, and recovers the trail termination status. It extracts the payload-independent overhead bytes/bits (J1, G1, B3) from the VC-n layer Characteristic Information.

Symbol

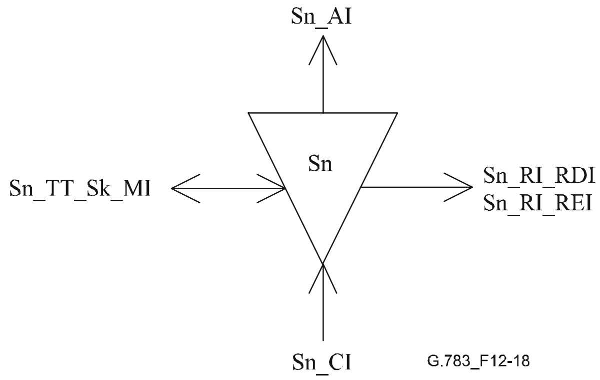


Figure 12-18/G.783 – Sn_TT_Sk symbol

Interfaces

Table 12-3/G.783 – Sn_TT_Sk input and output signals

Inputs	Outputs
Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF Sn_TT_Sk_MI_TPmode Sn_TT_Sk_MI_ExTI Sn_TT_Sk_MI_RDI_Reported Sn_TT_Sk_MI_SSF_Reported Sn_TT_Sk_MI_DEGTHR Sn_TT_Sk_MI_DEGM Sn_TT_Sk_MI_EXC_X Sn_TT_Sk_MI_DEG_X Sn_TT_Sk_MI_1second Sn_TT_Sk_MI_TIMdis Sn_TT_Sk_MI_TIMAISdis	Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart Sn_AI_TSF Sn_AI_TSD Sn_RI_RDI Sn_RI_REI Sn_TT_Sk_MI_cTIM Sn_TT_Sk_MI_cUNEQ Sn_TT_Sk_MI_cEXC Sn_TT_Sk_MI_cDEG Sn_TT_Sk_MI_cRDI Sn_TT_Sk_MI_cSSF Sn_TT_Sk_MI_AcTI Sn_TT_Sk_MI_pN_EBC Sn_TT_Sk_MI_pF_EBC Sn_TT_Sk_MI_pN_DS Sn_TT_Sk_MI_pF_DS

Processes

J1: The trail trace identifier is recovered from VC-n POH at the Sn_CP and processed as specified in 6.2.2.2/G.806. The accepted value of J1 is also available at the Sn_TT_Sk_MP. For further description of trace identifier mismatch processing, see 6.2.2.2/G.806.

C2: The unequipped defect is processed as described in 6.2.1.3/G.806.

B3: The error monitoring byte B3 at the Sn_CP shall be recovered. 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. The process for detecting excessive errors and signal degrade is described in 6.2.3.1/G.806.

G1[1-4]: The REI shall be recovered and the derived performance primitives should be reported at the Sn_TT_Sk_MP.

G1[5]: The RDI defect is processed as described in 6.2.6.3/G.806.

G1[6-7]: Bits 6 and 7 of G1 are reserved for the optional use of enhanced-RDI (E-RDI) described in Appendix VI. If this option is not used, the content of bits 6 and 7 of byte G1 shall be ignored.

N1: The network operator byte N1 is defined for TC monitoring purposes. It shall be ignored by this function.

K3[5-8]: These bits are undefined and shall be ignored by this function.

Defects

The function shall detect for dUNEQ, dTIM, dEXC, dDEG and dRDI defects according to the specification in 6.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aAIS ← dUNEQ or (dTIM and not TIMAISdis)

aRDI ← CI_SSF or dUNEQ or dTIM

aREI ← "number of error detection code violations"

aTSF ← CI_SSF or dUNEQ or (dTIM and not TIMAISdis)

aTSFprot ← aTSF or dEXC

aTSD ← dDEG

On declaration of aAIS, the function shall output an all-ONEs (AIS) signal – complying to the frequency limits for this signal within two frames (250 µs). Upon termination of the above failure conditions, the all-ONEs shall be removed within two frames (250 µs).

Defect correlations

The function shall perform the following defect correlations to determine the most probable fault cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cSSF ← CI_SSF and SSF_Reported and MON

cUNEQ ← dUNEQ and MON

cTIM ← dTIM and (not dUNEQ) and MON

cEXC ← dEXC and (not dTIM or TIMAISdis) and MON

cDEG ← dDEG and (not dTIM or TIMAISdis) and MON

cRDI ← dRDI and (not dUNEQ) and (not dTIM or TIMAISdis) and MON and RDI_Reported

Performance monitoring

The function shall perform the following performance monitoring primitives processing (see 6.5/G.806). The performance monitoring primitives shall be reported to the SEMF.

pN_DS ← CI_SSF or dUNEQ or dTIM or dEQ

pF_DS ← dRDI

pN_EBC ← $\sum$ nN_B

pF_EBC ← $\sum$ nF_B

12.2.2 VC-n Layer non-intrusive monitor

Two versions of the non-intrusive monitor are defined.

Version 1 is only applicable for the supervision of equipped VCs. It cannot be used for the supervision of supervisory-unequipped VCs as the unequipped defect will constantly be active and as a consequence activates TSF and suppresses other defects.

Version 2 is applicable for the supervision of equipped and supervisory-unequipped VCs, as the unequipped defect is correlated with an accepted trace identifier of all-0s.

12.2.2.1 VC-n Layer non-intrusive monitor, version 1 Snm1_TT_Sk

Version 1 of the Path overhead monitoring function is only applicable for the supervision of equipped VCs.

This function monitors the VC-n (n = (3, 4, 4-Xc)) for errors, and recovers the trail termination status. It extracts the payload-independent overhead bytes/bits (J1, G1, B3) from the VC-n layer Characteristic Information.

Symbol

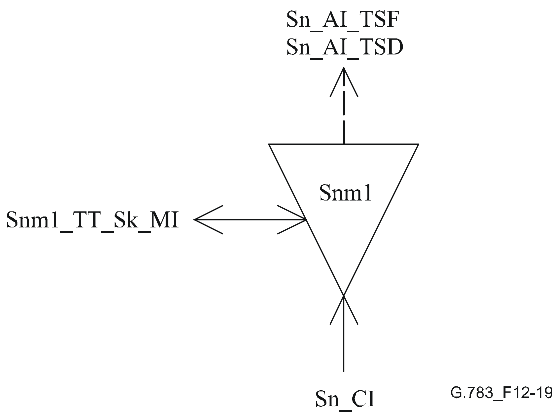


Figure 12-19/G.783 – Snm1_TT_Sk symbol

Interfaces

Table 12-4/G.783 – Snm1_TT_Sk input and output signals

Inputs	Outputs
Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF Snm1_TT_Sk_MI_TPmode Snm1_TT_Sk_MI_ExTI Snm1_TT_Sk_MI_RDI_Reported Snm1_TT_Sk_MI_SSF_Reported Snm1_TT_Sk_MI_DEGTHR Snm1_TT_Sk_MI_DEGM Snm1_TT_Sk_MI_EXC_X Snm1_TT_Sk_MI_DEG_X Snm1_TT_Sk_MI_1second Snm1_TT_Sk_MI_TIMdis	Sn_AI_TSF Sn_AI_TSD Snm1_TT_Sk_MI_cTIM Snm1_TT_Sk_MI_cUNEQ Snm1_TT_Sk_MI_cDEG Snm1_TT_Sk_MI_cEXC Snm1_TT_Sk_MI_cRDI Snm1_TT_Sk_MI_cSSF Snm1_TT_Sk_MI_AcTI Snm1_TT_Sk_MI_pN_EBC Snm1_TT_Sk_MI_pF_EBC Snm1_TT_Sk_MI_pN_DS Snm1_TT_Sk_MI_pF_DS

Processes

J1: The trail trace identifier is recovered from VC-n POH at the Sn_CP. The accepted value of J1 is also available at the Snm1_TT_Sk_MP. For a description of trace identifier mismatch processing, see 6.2.2.2/G.806.

C2: The signal label bits at the Sn_CP shall be recovered. For further description of unequipped defect processing, see 6.2.1.3/G.806. The function shall detect for an AIS VC (VC-AIS) condition by monitoring the VC PSL for code "1111 1111". For further description of VC AIS defect processing, see 6.2.6.2/G.806.

B3: Byte B3 is recovered from the VC-n POH the Sn_CP. 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. The process for detecting excessive errors and signal degrade is described in 6.2.3.1/G.806.

G1[1-4]: The REI shall be recovered and the derived performance primitives should be reported at the Snm1_TT_Sk_MP.

G1[5]: The RDI defect is processed as described in 6.2.6.3/G.806.

G1[6-7]: These bits are reserved for optional use of enhanced RDI described in Appendix VI. If this option is not used, these bits are ignored.

Defects

The function shall detect for dUNEQ, dTIM, dEXC, dDEG, dAIS and dRDI defects according to the specification in 6.4/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aTSF ← CI_SSF or dAIS or dUNEQ or (dTIM and not TIMAISdis)

aTSFprot ← dEXC or aTSF

aTSD ← dDEG

Defect correlations

The function shall perform the following defect correlations to determine the most probable fault cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cSSF ← (CI_SSF or dAIS) and MON and SSF_Reported

cUNEQ ← dUNEQ and MON

cTIM ← dTIM and (not dUNEQ) and MON

cEXC ← dEXC and (not dTIM or TIMAISdis) and MON

cDEG ← dDEG and (not dTIM or TIMAISdis) and MON

cRDI ← dRDI and (not dUNEQ) and (not dTIM or TIMAISdis) and MON and RDI_Reported

Performance monitoring

The function shall perform the following performance monitoring primitives processing (see 6.5/G.806). The performance monitoring primitives shall be reported to the SEMF.

pN_DS ← CI_SSF or dAIS or dUNEQ or dTIM or dEQ

pF_DS ← dRDI

pN_EBC ← ∑ nN_B

pF_EBC ← ∑ nF_B

12.2.2.2 VC-n Layer non-intrusive monitor, version 2 Snm2_TT_Sk

Version 2 of the Path overhead monitor functions is applicable for supervision of equipped and supervisory unequipped VCs.

This function monitors the VC-n (n = (3, 4, 4-Xc)) for errors, and recovers the trail termination status. It extracts the payload-independent overhead bytes/bits (J1, G1, B3) from the VC-n layer Characteristic Information.

Symbol

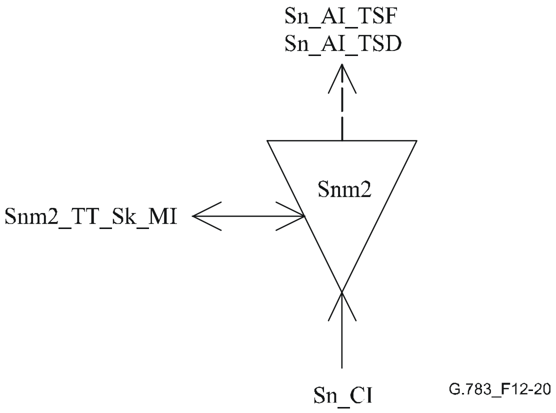


Figure 12-20/G.783 – Snm2_TT_Sk symbol

Interfaces

Table 12-5/G.783 – Snm2_TT_Sk input and output signals

Inputs	Outputs
Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF Snm2_TT_Sk_MI_TPmode Snm2_TT_Sk_MI_ExTI Snm2_TT_Sk_MI_RDI_Reported Snm2_TT_Sk_MI_DEGTHR Snm2_TT_Sk_MI_DEGM Snm2_TT_Sk_MI_EXC_X Snm2_TT_Sk_MI_DEG_X Snm2_TT_Sk_MI_1second Snm2_TT_Sk_MI_TIMdis Snm2_TT_Sk_MI_SSF_Reported	Sn_AI_TSF Sn_AI_TSD Snm2_TT_Sk_MI_cTIM Snm2_TT_Sk_MI_cUNEQ Snm2_TT_Sk_MI_cDEG Snm1_TT_Sk_MI_cEXC Snm2_TT_Sk_MI_cRDI Snm2_TT_Sk_MI_cSSF Snm2_TT_Sk_MI_AcTI Snm2_TT_Sk_MI_pN_EBC Snm2_TT_Sk_MI_pF_EBC Snm2_TT_Sk_MI_pN_DS Snm2_TT_Sk_MI_pF_DS

Processes

J1: The trail trace identifier is recovered from VC-n POH at the Sn_CP. The accepted value of J1 is also available at the Snm2_TT_Sk_MP. For a description of trace identifier mismatch processing, see 6.2.2.2/G.806.

C2: The signal label bits at the Sn_CP shall be recovered. For further description of unequipped defect processing, see 6.2.1.3/G.806. The function shall detect for an AIS VC (VC-AIS) condition by monitoring the VC PSL for code "1111 1111". For further description of VC AIS defect processing, see 6.2.6.2/G.806.

B3: Byte B3 is recovered from the VC-n POH the Sn_CP. 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. The process for detecting excessive errors and signal degrade is described in 6.2.3.1/G.806.

G1[1-4]: The REI shall be recovered and the derived performance primitives should be reported at the Snm2_TT_Sk_MP.

G1[5]: The RDI defect is processed as described in 6.2.6.3/G.806.

G1[6-7]: These bits are reserved for the optional use of enhanced RDI (E-RDI) described in Appendix VI. If this option is not used, these bits are ignored.

Defects

The function shall detect for dUNEQ, dTIM, dEXC, dDEG, dAIS and dRDI defects according to the specification in 6.4/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aTSF	←	CI_SSF or dAIS or (dUNEQ and (AcTI = all "0"s)) or (dTIM and not TIMAISdis)
aTSFprot	←	dEXC or aTSF
aTSD	←	dDEG

Defect correlations

The function shall perform the following defect correlations to determine the most probable fault cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cUNEQ	←	dUNEQ and (AcTI = all "0"s) and MON
cTIM	←	dTIM and not (dUNEQ and (AcTI = all "0"s)) and MON
cEXC	←	dEXC and (not dTIM or TIMAISdis) and MON
cDEG	←	dDEG and (not dTIM or TIMAISdis) and MON
cRDI	←	dRDI and not (dUNEQ and (AcTI = all "0"s)) and (not dTIM or TIMAISdis) and MON and RDI_Reported
cSSF	←	(CI_SSF or dAIS) and MON and SSF_Reported

Performance monitoring

The function shall perform the following performance monitoring primitives processing (see 6.5/G.806). The performance monitoring primitives shall be reported to the SEMF.

pN_DS	←	CI_SSF or dAIS or (dUNEQ and (AcTI = all "0"s)) or dTIM or dEQ
pF_DS	←	dRDI
pN_EBC	←	$\sum$ nN_B
pF_EBC	←	$\sum$ nF_B

12.2.3 VC-n Layer Supervisory-Unequipped Termination Sns_TT

The Sns_TT function creates a VC-n at the Sn_CP by generating and adding POH to an undefined container C-n. 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 ITU-T Rec. G.707/Y.1322.

NOTE – The Sns_TT (n = (3, 4, 4-Xc)) function generates and monitors supervisory-unequipped signals.

12.2.3.1 VC-n Layer Supervisory-Unequipped Termination Source Sns_TT_So

This function generates error monitoring and status overhead bytes to an undefined VC-n (n = (3, 4, 4-Xc)).

Symbol

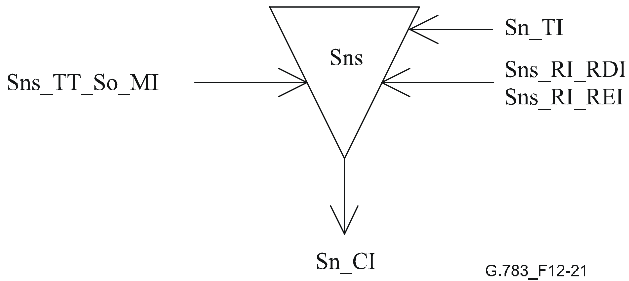


Figure 12-21/G.783 – Sns_TT_So symbol

Interfaces

Table 12-6/G.783 – Sns_TT_So input and output signals

Inputs	Outputs
Sn_RI_RDI Sn_RI_REI Sn_TI_Clock Sn_TI_FrameStart Sns_TT_So_MI_TxTI	Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart

Processes

An undefined VC-n (n = (3, 4, 4-Xc)) should be generated.

C2: Signal label 0000 0000 (unequipped) should be inserted in the VC-n.

J1: The trail trace identifier should be generated. Its value is derived from reference point Sn_TT_So_MP. The path trace format is described in 6.2.2.2/G.806.

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

G1[1-4]: The number of errors indicated in RI_REI is encoded in the REI (bits 1 to 4 of the G1 byte). Upon the detection of a number of errors at the termination sink function, the trail termination source function shall have inserted that value in the REI bits within 1 ms.

G1[5]: Upon the declaration/clearing of aRDI at the termination sink function, the trail termination source function shall have inserted/removed the RDI indication within 1 ms.

G1[6-7]: These bits are reserved for the optional use of enhanced RDI (E-RDI) described in Appendix VI. If this option is not used, these bits shall be set to 00 or 11.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

12.2.3.2 VC-n Layer Supervisory-Unequipped Termination Sink Sns_TT_Sk

Symbol

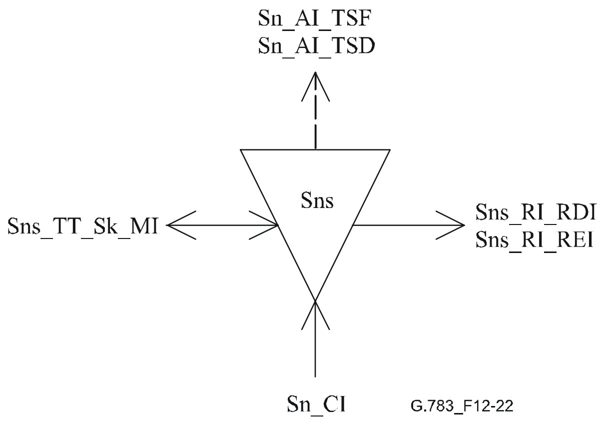


Figure 12-22/G.783 – Sns_TT_Sk symbol

Interfaces

Table 12-7/G.783 – Sns_TT_Sk input and output signals

Inputs	Outputs
Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF Sns_TT_Sk_MI_TPmode Sns_TT_Sk_MI_ExTI Sns_TT_Sk_MI_RDI_Reported Sns_TT_Sk_MI_SSF_Reported Sns_TT_Sk_MI_DEGTHR Sns_TT_Sk_MI_DEGM Sns_TT_Sk_MI_EXC_X Sns_TT_Sk_MI_DEG_X Sns_TT_Sk_MI_1second Sns_TT_Sk_MI_TIMdis	Sn_AI_TSF Sn_AI_TSD Sn_RI_RDI Sn_RI_REI Sns_TT_Sk_MI_cTIM Sns_TT_Sk_MI_cUNEQ Sns_TT_Sk_MI_cDEG Sns_TT_Sk_MI_cEXC Sns_TT_Sk_MI_cRDI Sns_TT_Sk_MI_cSSF Sns_TT_Sk_MI_AcTI Sns_TT_Sk_MI_pN_EBC Sns_TT_Sk_MI_pF_EBC Sns_TT_Sk_MI_pN_DS Sns_TT_Sk_MI_pF_DS

Processes

J1: The trail trace identifier is recovered from VC-n POH at the Sn_CP and processed as specified in 6.2.2.2/G.806. The accepted value of J1 is also available at the Sn_TT_Sk_MP. For further description of trace identifier mismatch processing, see 6.2.2.2/G.806.

C2: The signal label at the Sn_CP shall be recovered. Note that the Sns_TT sink direction always expects an unequipped signal label. For further description of unequipped defect processing, see 6.2.1.3/G.806.

B3: The error monitoring byte B3 at the Sn_CP shall be recovered. 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. The process for detecting excessive errors and signal degrade is described in 6.2.3.1/G.806.

G1[1-4]: The REI shall be recovered and the derived performance primitives should be reported at the Sns_TT_Sk_MP.

G1[5]: The RDI defect is processed as described in 6.2.6.3/G.806.

G1[6-7]: These bits are reserved for the optional use of enhanced RDI (E-RDI) described in Appendix VI. If this option is not used, these bits shall be ignored.

Defects

The function shall detect for dUNEQ, dTIM, dEXC, dDEG and dRDI defects according to the specification in 6.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aRDI ← SSF or dTIM

aREI ← "number of error detection code violations"

aTSF ← CI_SSF or (dTIM and not TIMAISdis)

aTSFprot ← aTSF or dEXC

Defect correlations

The function shall perform the following defect correlations to determine the most probable fault cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cSSF ← CI_SSF and SSF_Reported and MON

cUNEQ ← dTIM and (AcTI = all ZEROS) and dUNEQ and MON

cTIM ← dTIM and (not (dUNEQ and AcTI = all ZEROS)) and MON

cEXC ← dEXC and (not dTIM or TIMAISdis) and MON

cDEG ← dDEG and (not dTIM or TIMAISdis) and MON

cRDI ← dRDI and (not dTIM or TIMAISdis) and MON and RDI_Reported

Performance monitoring

The function shall perform the following performance primitives processing (see 6.5/G.806). The performance monitoring primitives shall be reported to the SEMF.

pN_DS ← CI_SSF or dTIM or dEQ

pF_DS ← dRDI

pN_EBC ← ∑ nN_B

pF_EBC ← ∑ nF_B

12.3 Adaptation functions

12.3.1 VC-n Layer to VC-m Layer Adaptation Sn/Sm_A

The Sn/Sm_A provides the primary functionality within the Sn/Sm_A, (m = 11, 12, 2 or 3; n = 3 or 4). It defines the TU pointer processing, and may be divided into three functions:

– pointer generation;
– pointer interpretation;
– frequency justification.

The S4/S11*_A provides the interworking functionality for the transport of lower order VC-11s into VC-4 via TU-12. It defines the TU pointer processing, and may be divided into four functions:

– adding and removal of stuffing bytes;
– pointer generation;
– pointer interpretation;
– frequency justification.

The format for TU pointers, their roles for processing, and mappings of VCs are described in ITU-T Rec. G.707/Y.1322.

The Sn/Sm_A function also acts as a source and sink for bytes H4, and C2.

12.3.1.1 VC-n Layer to VC-m Layer Adaptation Source Sn/Sm_A_So

Symbol

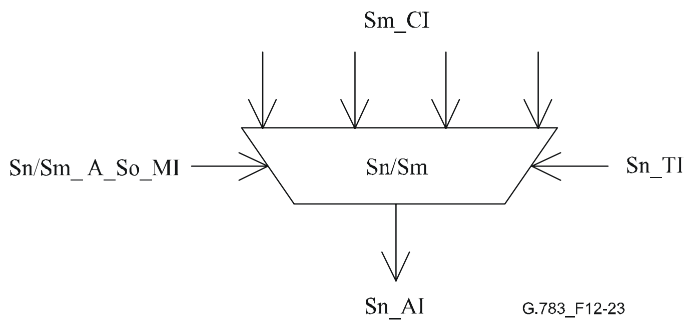


Figure 12-23/G.783 – Sn/Sm_A_So symbol

Interfaces

Table 12-8/G.783 – Sn/Sm_A_So input and output signals

Inputs	Outputs
Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart Sm_CI_MultiFrameSync Sn_TI_Clock Sn_TI_FrameStart Sn/Sm_A_So_MI_Active	Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart

Processes

The Sn/Sm_A 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).

In the case of the S4/S11*_A_So function, 36 bytes of fixed stuff are added to the VC-11 container according to 10.1.6/G.707/Y.1322.

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 ITU-T Rec. G.707/Y.1322. LOVC data at the Sm_CP is synchronized to timing from the Sm_TP reference point.

The PP function provides accommodation for wander and plesiochronous offset in the received signal with respect to the synchronous equipment timing reference. The PP function can be modelled 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 Sn_TP. 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. 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. 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 the read opportunity is cancelled. Pointer processing in the MSn/Sn_A function is described in 11.3.1.

H4: A multiframe indicator is generated as described in ITU-T Rec. G.707/Y.1322 and placed in the H4 byte position.

C2: Signal label information derived directly from the Adaptation function type is placed in the C2 byte position.

Defects

None.

Consequent actions

The function shall perform the following consequent actions:

aAIS ← CI_SSF

When an all-ONEs (AIS) signal is applied at the Sm_CP, an all-ONEs (TU-AIS) signal shall be applied at the Sn_AP within 2 (multi)frames. Upon termination of the all-ONEs signal at the Sm_CP, the all-ONEs (TU-AIS) signal shall be terminated within 2 (multi)frames.

Defect correlations

None.

Performance monitoring

None.

12.3.1.2 VC-n Layer to VC-m Layer Adaptation Sink Sn/Sm_A_Sk

Symbol

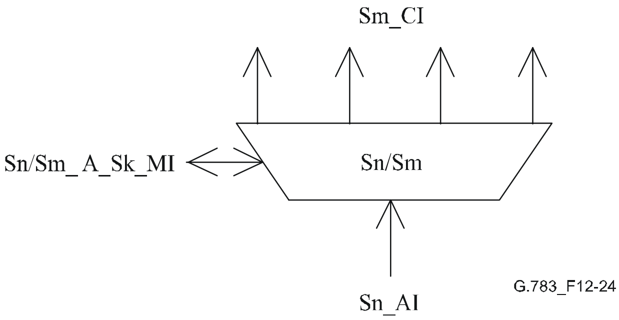


Figure 12-24/G.783 – Sn/Sm_A_Sk symbol

Interfaces

Table 12-9/G.783 – Sn/Sm_A_Sk input and output signals

Inputs	Outputs
Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart Sn_AI_TSF Sn/Sm_A_Sk_MI_Active	Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart Sm_CI_MFS Sm_CI_SSF Sn/Sm_A_Sk_MI_AcSL Sn/Sm_A_Sk_MI_cPLM Sn/Sm_A_Sk_MI_cLOM

Processes

The S4/Sm_A_Sk function disassembles VC-4 into VCs of lower order m (m = 11, 12, 2, 3), performing multiframe alignment if necessary. S3/Sm_A_Sk disassembles VC-3 into VCs of lower order m (m = 11, 12, 2), performing multiframe alignment if necessary.

In the case of the S4/S11*_A_Sk function, the function strips off the 36 fixed stuff bytes from the VC-12 container according to 10.1.6/G.707/Y.1322 to recover the VC-11. It should be noted that this action may cause a discrepancy between PM reports at an S12m_TT_Sk and a S11_TT_Sk for a VC-11 trail.

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 ITU-T Rec. G.707/Y.1322. 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.

The function shall perform TU pointer interpretation as specified in Annex A to recover the LOVC frame phase within the HOVC. Two defect conditions can be detected by the pointer interpreter:

– loss of pointer (LOP);

– TU-AIS.

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

C2: Byte C2 is recovered from VC-n port at the Sn_AP. If an dPLM is detected (see 6.2.4.2/G.806), then it shall be reported via reference point Sn/Sm_A_Sk_MP. The accepted value of C2 is also available at the Sn/Sm_A_Sk_MP.

NOTE – Acceptance criteria and defect detection specification for signal label is for further study.

H4: In the case of payloads requiring multiframe alignment, a multiframe indicator is derived from the H4 byte and multiframe alignment is performed as defined in 8.2.2. The multiframe indicator is further used to derive the LOM defect (see 6.2.5.2).

Defects

dAIS – See Annex A.

dLOP – See Annex A.

dLOM – See 6.2.5.2.

dPLM – See 6.2.4.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

for VC-3:

aAIS ← dPLM or dAIS or dLOP

aSSF ← dPLM or dAIS or dLOP

for VC-11/VC-12/VC-2:

aAIS ← dPLM or dLOM or dAIS or dLOP

aSSF ← dPLM or dLOM or dAIS or dLOP

Upon the declaration of aAIS, a logical all-ONEs (AIS) signal shall be applied at the Sm_CP within 2 (multi)frames. Upon termination of these aAIS, the all-ONEs signal shall be removed within 2 (multi)frames.

Defect correlations

The function shall perform the following defect correlations to determine the most probable fault cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cPLM ← dPLM and (not AI_TSF)

for VC-3:

cAIS ← dAIS and (not AI_TSF) and (not dPLM) and AIS_Reported

cLOP ← dLOP and (not dPLM)

for VC-11/VC-12/VC-2:

cLOM ← dLOM and (not AI_TSF) and (not dPLM)

cAIS ← dAIS and (not AI_TSF) and (not dPLM) and (not dLOM) and AIS_Reported

cLOP ← dLOP and (not dPLM) and (not dLOM)

Performance monitoring

None.

12.3.2 VC-n Layer to Pqx Layer Adaptation Sn/Pqx_A

Sn/Pqx_A (n = (3 or 4), q = (31, 32 or 4)) operates at the access port to a synchronous network or subnetwork and adapts user data for transport in the synchronous domain. Sn/Pq_A function acts also as a source and sink for the POH payload-dependent information. The Sn/Pqx_A function directly maps G.703 (PDH) signals into a container of level n.

Adaptation functions are defined for each of the levels in the existing plesiochronous hierarchies. Each adaptation function defines the manner in which a user signal can be mapped into one of a range of synchronous containers C-m of appropriate size. The container sizes have been chosen for ease of mapping various plesiochronous signals into containers of level n; see Table 12-1. Detailed descriptions for mapping user data into containers are given in ITU-T Rec. G.707/Y.1322.

Table 12-10/G.783 – Container sizes

Atomic function	Server layer	Client layer	Signal label	Container size
S3/P31x_A	S3	P31x	0000 0100	C-3
S3/P32x_A	S3	P32x	0000 0100	C-3
S4/P4x_A	S4	P4x	0001 0010	C-4

12.3.2.1 VC-n Layer to Pqx Layer Adaptation Source Sn/Pqx_A_So

Symbol

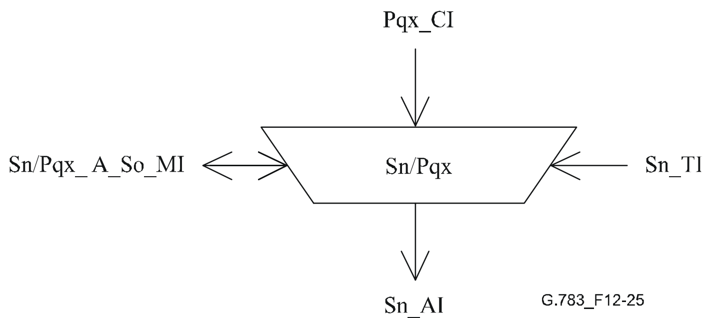


Figure 12-25/G.783 – Sn/Pqx_A_So symbol

Interfaces

Table 12-11/G.783 – Sn/Pqx_A_So input and output signals

Inputs	Outputs
Pqx_CI_Data Pqx_CI_Clock Sn_TI_Clock Sn_TI_FrameStart Sn/Pqx_A_So_MI_Active	Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart

Processes

Data at the Pqx_CP is the user information stream. Timing of the data is also delivered as timing at the CP. Data is adapted according to one of the adaptation functions referred to above. This involves synchronization and mapping of the information stream into a container as described in ITU-T Rec. G.707/Y.1322 and the adding of payload-dependent functions.

The container is passed to the Sn_AP as data together with frame offset which represents the offset of the container frame with respect to reference point Sn_TP. This frame offset is constrained by the requirements of the client layer; e.g., for SDH equipment, the timing of the client layer is defined in ITU-T Rec. G.813.

C2: The signal label shall be inserted according to the type of mapping used by the adaptation function; see Table 12-10.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

12.3.2.2 VC-n Layer to Pqx Layer Adaptation Sink Sn/Pqx_A_Sk

Symbol

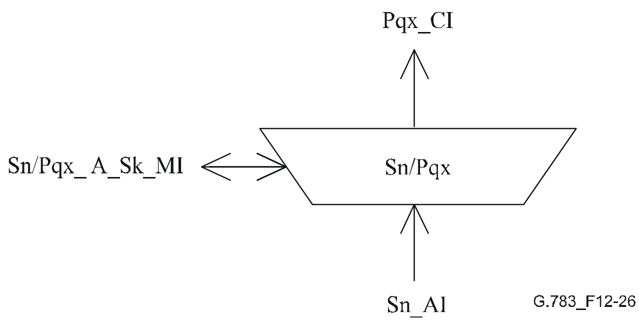


Figure 12-26/G.783 – Sn/Pqx_A_Sk symbol

Interfaces

Table 12-12/G.783 – Sn/Pqx_A_Sk input and output signals

Inputs	Outputs
Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart Sn_AI_TSF Sn/Pqx_A_Sk_MI_Active	Pqx_CI_Data Pqx_CI_Clock Sn/Pqx_A_Sk_MI_cPLM Sn/Pqx_A_Sk_MI_AcSL

Processes

The information stream data at the Sn_AP 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 Pqx_CP as data and timing. This involves de-mapping and desynchronizing as described in ITU-T Rec. G.707/Y.1322 and payload-dependent information.

C2: Signal label, byte C2 is recovered. For further description of signal label processing, see 6.2.4.2/G.806.

Defects

The function shall detect for dPLM defects according to the specification in 6.2.4.2/G.806.

Consequent actions

The function shall perform the following consequent actions:

aAIS ← AI_TSF or dPLM

aSSF ← AI_TSF or dPLM

When AIS is applied at the Sn_AP, or an dPLM defect is detected (mismatch between expected value of signal label and received value of signal label), the adaptation function shall generate an all-ONEs signal (AIS) in accordance with the relevant G.700-series Recommendations.

NOTE – In the case of 45 Mbit/s interface, the AIS signal is defined in ITU-T Rec. M.20.

Defect correlations

The function shall perform the following defect correlation to determine the most probable fault cause. This fault cause shall be reported to the SEMF.

cPLM ← dPLM and (not AI_TSF)

Performance monitoring

None.

12.3.3 VC-n Layer to User channel Adaptation Sn/User_A

12.3.3.1 VC-n Layer to User channel Adaptation Source Sn/User_A_So

Symbol

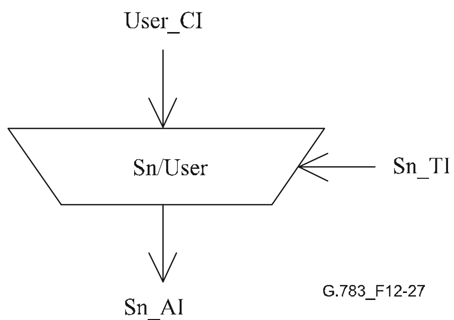


Figure 12-27/G.783 – Sn/User_A_So symbol

Interfaces

Table 12-13/G.783 – Sn/User_A_So function inputs and outputs

Inputs	Outputs
User_CI_Data User_CI_Clock Sn_TI_CK	Sn_AI_Data

Processes

The user data is placed in the F2/F3 byte position of the POH. These bytes are allocated for user communication purposes and shall be used as 64 kbit/s clear channels.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

12.3.3.2 VC-n Layer to User channel Adaptation Sink Sn/User_A_Sk

Symbol

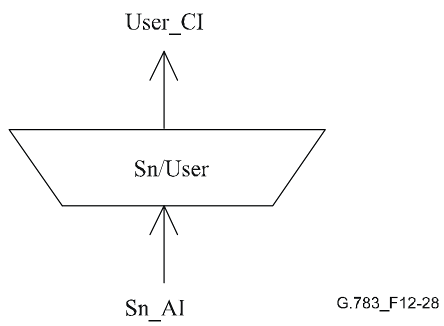


Figure 12-28/G.783 – Sn/User_A_Sk symbol

Interfaces

Table 12-14/G.783 – Sn/User_A_Sk function inputs and outputs

Inputs	Outputs
Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart Sn_AI_TSF	User_CI_Data User_CI_Clock User_CI_SSF

Processes

The user data is recovered from the F2/F3 byte positions of the POH.

Defects

None.

Consequent actions

aSSF ← AI_TSF

aAIS ← AI_TSF

On declaration of aAIS, the function shall output an all-ONEs (AIS) signal – complying to the frequency limits for this signal (a bit rate in range 64 kbit/s ± 100 ppm) within two frames (250 μs). Upon termination of the above failure conditions, the all-ONES shall be removed within two frames (250 μs).

Defect correlations

None.

Performance monitoring

None.

12.3.4 VC-n Layer to ATM VP Adaptation Sn/Avp_A

12.3.4.1 VC-n Layer to ATM VP Adaptation source Sn/Avp_A_So

This function is described in ITU-T Rec. I.732.

12.3.4.2 VC-n Layer to ATM VP Adaptation sink Sn/Avp_A_Sk

This function is described in ITU-T Rec. I.732.

12.3.5 VC-n Layer to HDLC Adaptation Sn/HDLC_A

12.3.5.1 VC-n Layer to HDLC Adaptation source Sn/HDLC_A_So

To be determined.

12.3.5.2 VC-n Layer to HDLC Adpatation sink Sn/HDLC_A_Sk

To be determined.

12.4 Sublayer functions

12.4.1 VC-n Layer Trail Protection Functions

VC trail protection mechanism is described in ITU-T Rec. G.841.

The SnP_C function provides protection for the trail against channel-associated defects within a trail from trail termination source to trail termination sink. In Figures 12-29 and 12-30, the trail protection sublayer is given. It should be noted that the Sn/User_A function may be absent or connected before or after the protection functions SnP_C. When connected before SnP_C (see Figure 12-29), the transport of the user channel is not protected. When connected after SnP_C (see Figure 12-30), the transport of the user channel is protected. The protection is performed in the sublayer connection function (SnP_C).

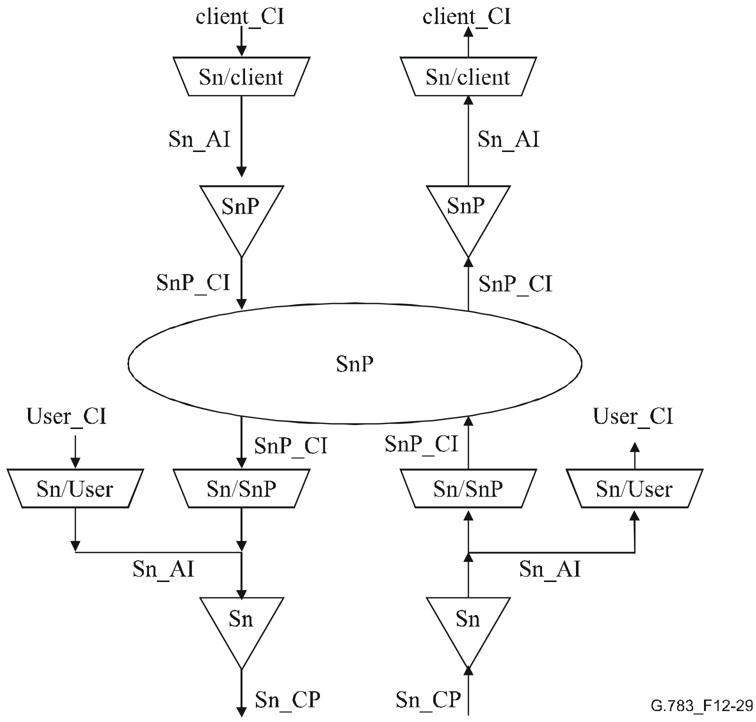


Figure 12-29/G.783 – VC-n layer trail protection sublayer functions (unprotected user channel)

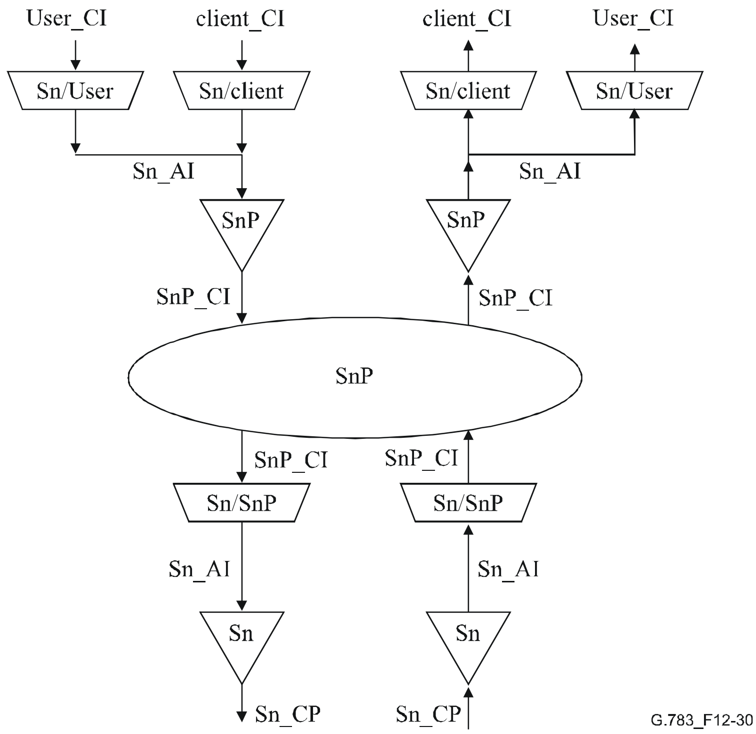


Figure 12-30/G.783 – VC-n layer trail protection sublayer functions (protected user channel)

The SnP_C functions at both ends operate the same way, by monitoring VC-n (n = (3, 3-X, 4, or 4-X)) signals for defects, evaluating the system status taking into consideration the priorities of defect conditions and of external and remote switch requests, and selecting the signal from the appropriate path. The two SnP_C functions may communicate with each other via a bit-oriented protocol defined for the SnP_C characteristic information byte K3 in the POH of the protection path). This protocol is described in ITU-T Rec. G.841.

The VC-n protection function is explained in Figure 12-31. The working and protection paths are shown in Figures 12-32 to 12-35.

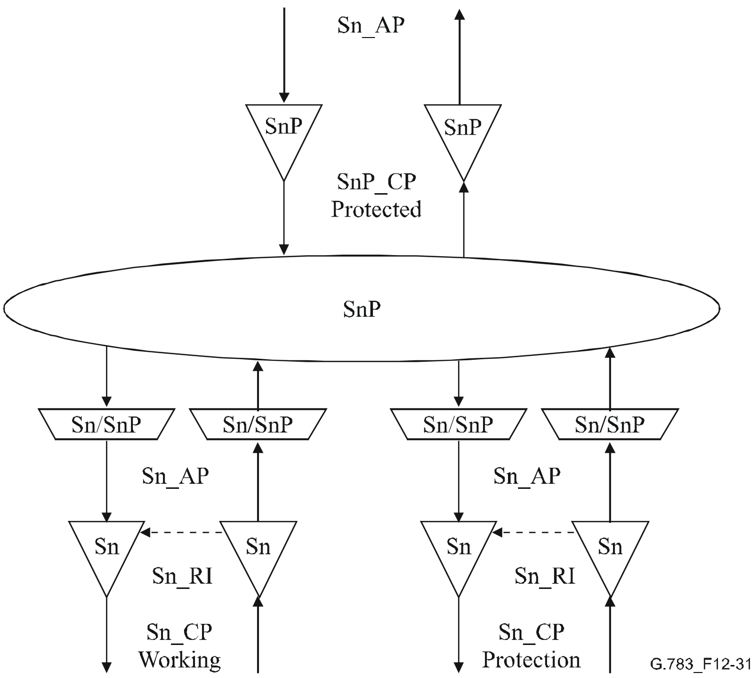
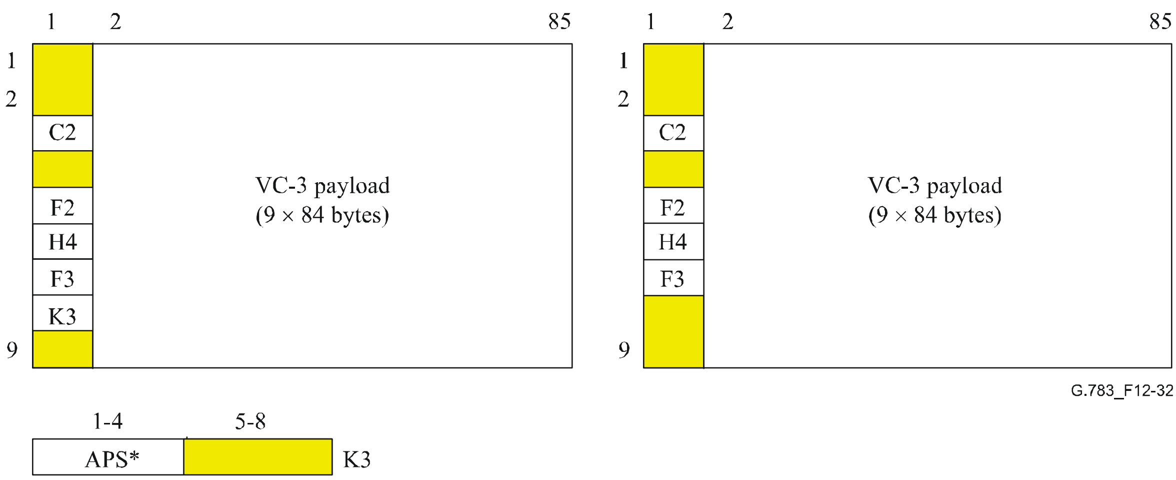
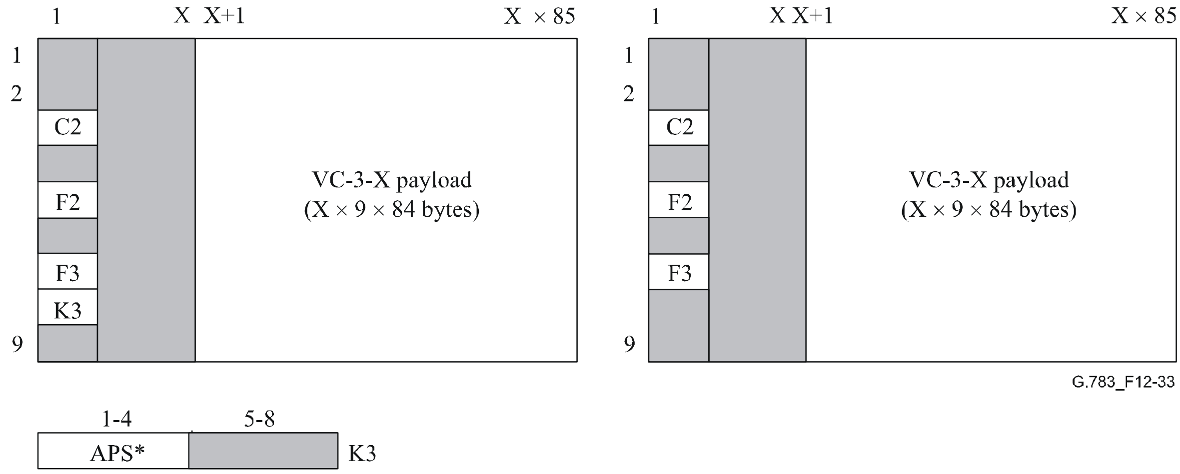


Figure 12-31/G.783 – VC-n linear trail protection atomic functions



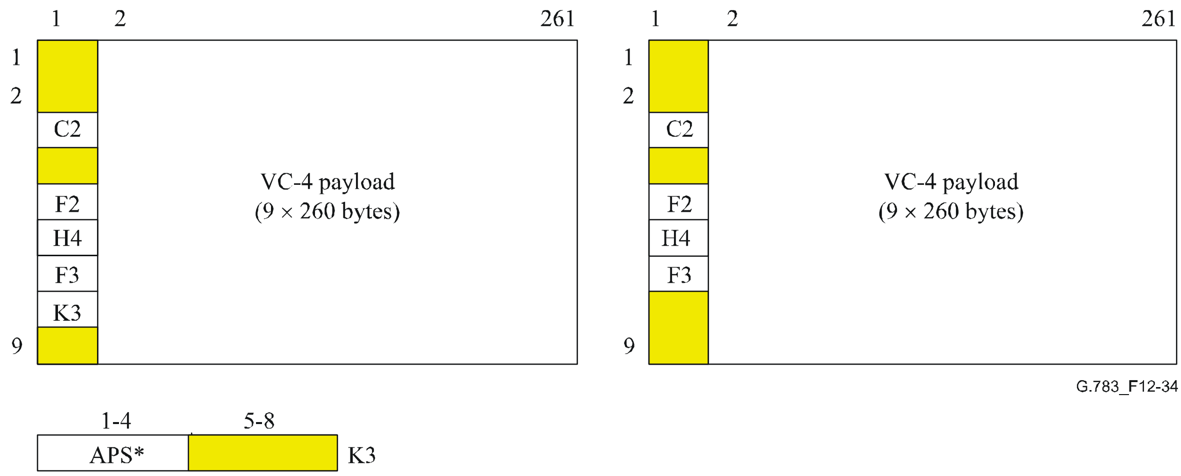
NOTE – The presence/absence of F2/F3 in S3P_CI_D depends on the location of the S3/User_A function.

Figure 12-32/G.783 – S3P_AI_D (left) and S3P_CI_D (right)



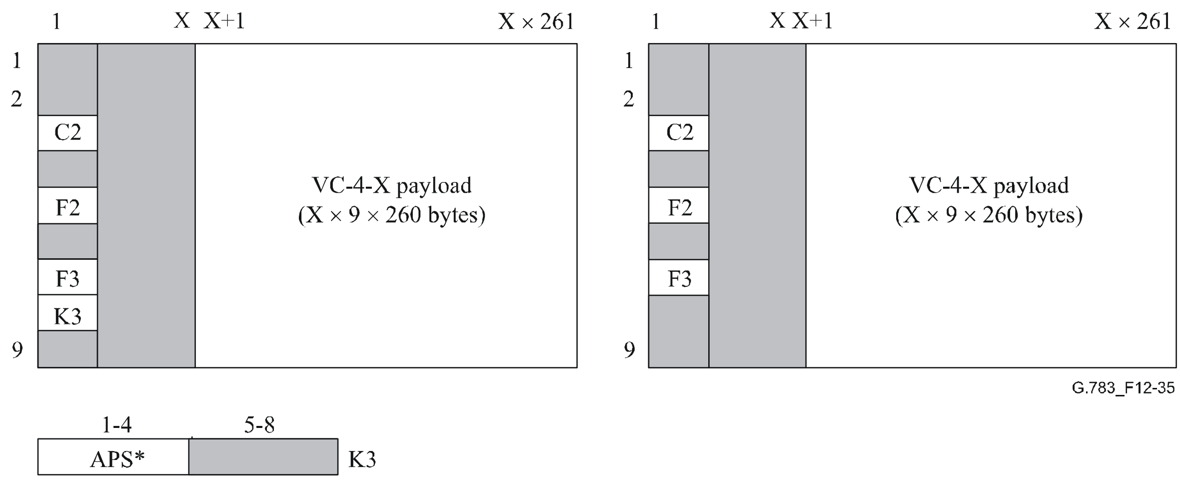
NOTE – The presence/absence of F2/F3 in S3-XP_CI_D depends on the location of the S3-X/User_A function.

Figure 12-33/G.783 – S3-XP_AI_D (left) and S3-XP_CI_D (right)



NOTE – The presence/absence of F2/F3 in S4P_CI_D depends on the location of the S4/User_A function.

Figure 12-34/G.783 – S4P_AI_D (left) and S4P_CI_D (right)



NOTE – The presence/absence of F2/F3 in S4-XP_CI_D depends on the location of the S4-X/User_A function.

Figure 12-35/G.783 – S4-XP_AI_D (left) and S4-XP_CI_D (right)

12.4.1.1 VC-n Layer Trail Protection Connection Function SnP_C

The SnP_C function receives control parameters and external switch requests at the SnP_C_MP reference point from the synchronous equipment management function and outputs status indicators at the SnP_C_MP to the synchronous equipment management function, as a result of switch commands described in ITU-T Rec. G.841.

Symbol

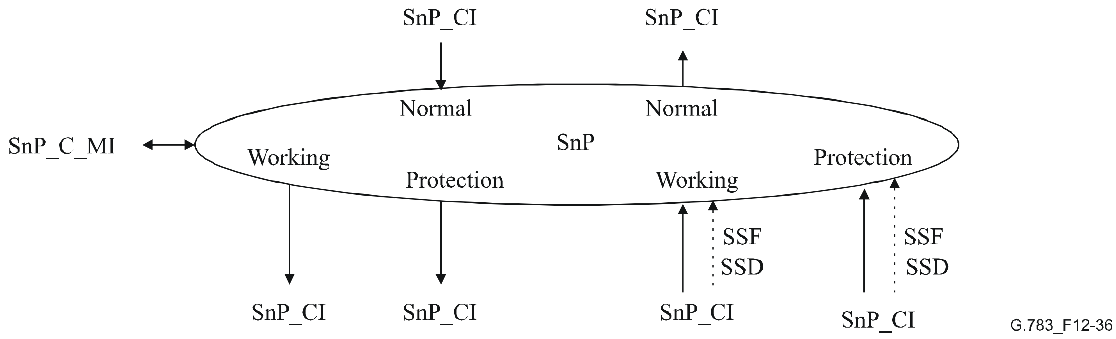


Figure 12-36/G.783 – SnP_C symbol

Interfaces

Table 12-15/G.783 – SnP_C input and output signals

Inputs	Outputs
For connection points W and P: Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart Sn_AI_SSF Sn_AI_SSD For connection point N: Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart For connection point P: Sn_AI_APS SnP_C_MI_OPERType SnP_C_MI_WTRTime SnP_C_MI_HOTime SnP_C_MI_EXTCMD	For connection points W and P: Sn_AI_Data Sn_AI_Clock Sn_AI_FrameSstart For connection point N: Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart Sn_AI_SSF For connection point P: Sn_AI_APS
NOTE – Protection status reporting signals are for further study.	

Processes

Source direction

Data at the SnP_CP is a trail signal, timed from the Sn_TP reference point, with indeterminate Sn layer POH bytes.

For 1 + 1 architecture, the signal received at the Sn_CP from the protection trail termination function SnP_TT_So is bridged permanently at the Sn_AP to both working and protection Sn_TT functions.

The APS information generated according to the rules in ITU-T Rec. G.841 is presented at the SnP_CP to the protection trail. This APS information may also be presented to the working trails Protection trail termination (SnP_TT_So) functions.

Sink direction

Framed trail signals (data) SnP_CI whose trail POH bytes have already been recovered by the Sn_TT_Sk are presented at the SnP_CP along with incoming timing references. The defect conditions SSF and SSD are also received at the SnP_CP from all Sn_TT_Sk functions.

The recovered APS information from the protection trail's adaptation function (Sn/SnP_A_Sk) is presented at the SnP_CP. Working trail's adaptation functions may also present this APS information to the SnP_C. The SnP_C must be able to ignore this information from the working adaptation functions.

Under normal conditions, SnP_C passes the data, timing, and signal fail from the working Sn/SnP_A_Sk functions to the corresponding SnP_TT_Sk at the SnP_CP. The data, timing, and signal fail from the protection path is not forwarded.

Under a fault condition on the working path, SnP_C passes the data, timing, and signal fail from the protection Sn/SnP_A_Sk function to the corresponding SnP_TT_Sk at the SnP_CP. The signal received from the working Sn/SnP_A_Sk is not forwarded.

Switch initiation criteria

Automatic protection switching is based on the TSF and TSD conditions of the working and protection paths. Detection of these conditions is described in 12.2.1.2.

The protection switch can also be initiated by switch commands received via the synchronous equipment management function. See ITU-T Rec. G.841.

Switching time

Refer to ITU-T Rec. G.841.

Switch restoration

Switch restoration is a function related to revertive operation, when the working path has recovered from defect. It is not applicable to VC trail protection which supports non-revertive operation only. See the description of revertive 1 + 1 unidirectional protection switching in ITU-T Rec. G.841.

Defects

None.

Consequent actions

None.

Defect correlation

None.

Performance monitoring

None.

12.4.1.2 VC-n Layer Trail Protection Trail Termination SnP_TT

12.4.1.2.1 VC-n Layer Trail Protection Trail Termination Source SnP_TT_So

Symbol

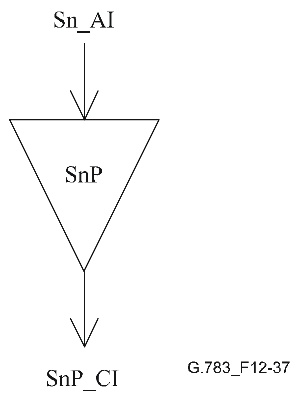


Figure 12-37/G.783 – SnP_TT_So symbol

Interfaces

Table 12-16/G.783 – SnP_TT_So input and output signals

Inputs	Outputs
Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart	SnP_CI_Data SnP_CI_Clock SnP_CI_FrameStart

Processes

No information processing is required in the SnP_TT_So since the Sn_AI at its output is identical to the SnP_CI.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

12.4.1.2.2 VC-n Layer Trail Protection Trail Termination Sink SnP_TT_Sk

Symbol

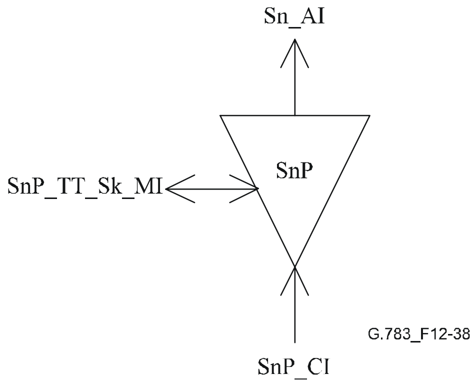


Figure 12-38/G.783 – SnP_TT_Sk symbol

Interfaces

Table 12-17/G.783 – SnP_TT_Sk input and output signals

Inputs	Outputs
SnP_CI_Data SnP_CI_Clock SnP_CI_FrameStart SnP_CI_SSF SnP_TT_Sk_MI_SSF_Reported	SnP_AI_Data SnP_AI_Clock SnP_AI_FrameStart SnP_AI_TSF SnP_TT_Sk_MI_cSSF

Processes

The SnP_TT_Sk function reports, as part of the Sn layer, the state of the protected Sn trail. In case all trails are unavailable, the SnP_TT_Sk reports the signal fail condition of the protected trail.

Defects

None.

Consequent actions

aTSF ← CI_SSF

Defect correlations

cSSF ← CI_SSF and SSF_Reported

Performance monitoring

None.

12.4.1.3 VC-n trail to VC-n Trail Protection Layer Adaptation Sn/SnP_A

12.4.1.3.1 VC-n trail to VC-n Trail Protection Layer Adaptation Source Sn/SnP_A_So

Symbol

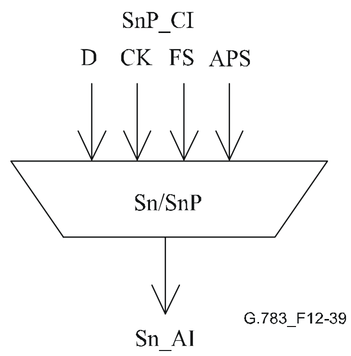


Figure 12-39/G.783 – Sn/SnP_A_So symbol

Interfaces

Table 12-18/G.783 – Sn/SnP_A_So input and output signals

Inputs	Outputs
Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart Sn_AI_APS	Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart

Processes

The function shall multiplex the Sn APS signal and Sn data signal onto the Sn_AP.

K3[1-4]: The insertion of the APS signal is for further study. This process is required only for the protection trail.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

12.4.1.3.2 VC-n trail to VC-n Trail Protection Layer Adaptation Sink Sn/SnP_A_Sk

Symbol

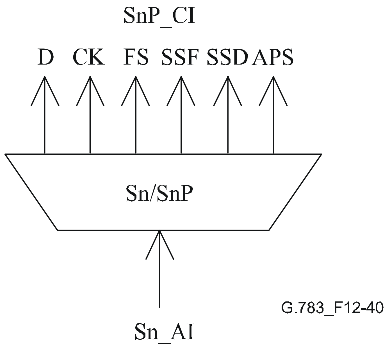


Figure 12-40/G.783 – Sn/SnP_A_Sk symbol

Interfaces

Table 12-19/G.783 – Sn/SnP_A_Sk input and output signals

Inputs	Outputs
Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart Sn_AI_TSF Sn_AI_TSD	Sn_AI_Data Sn_AI_Clock Sn_AI_FrameStart Sn_AI_SSF Sn_AI_SSD Sn_AI_APS (for Protection signal only)

Processes

The function shall extract and output the SnP_CI_D signal from the SnP_AI_D signal.

K3[1-4]: The extraction and persistency processing of the APS signal is for further study. This process is required only for the protection trail.

Defects

None.

Consequent actions

aSSF ← AI_TSF

aSSD ← AI_TSD

Defect correlations

None.

Performance monitoring

None.

12.4.2 Option 2 Tandem Connection sublayer Functions

Two options for higher order tandem connection monitoring are currently defined in ITU-T Rec. G.707/Y.1322, where they are referred to as "option 1" and "option 2". The functions defined in this clause support option 2.

NOTE – Service could be affected when activating TCM on an existing connection.

12.4.2.1 VC-n Tandem Connection Trail Termination SnD_TT

This function acts as a source and sink for the VC-n tandem connection overhead (TCOH) described in Annex D/G.707/Y.1322 (TC monitoring protocol option 2).

12.4.2.1.1 VC-n Tandem Connection Trail Termination Source SnD_TT_So

Symbol

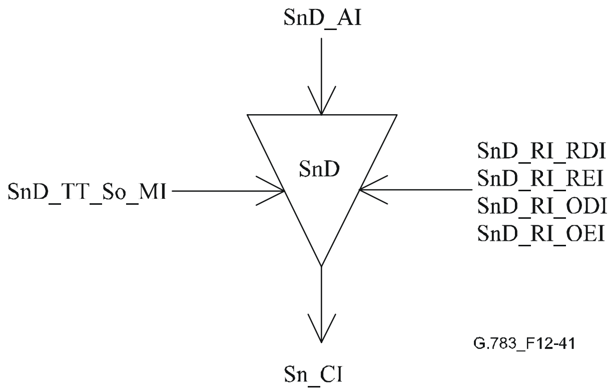


Figure 12-41/G.783 – SnD_TT_So symbol

Interfaces

Table 12-20/G.783 – SnD_TT_So input and output signals

Inputs	Outputs
SnD_AI_Data SnD_AI_Clock SnD_AI_FrameStart SnD_AI_SF SnD_RI_RDI SnD_RI_REI SnD_RI_ODI SnD_RI_OEI SnD_TT_So_MI_TxTI	Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart

Processes

N1[1-4]: See 8.3.2.

N1[8][73]: The function shall insert the TC RDI code. Upon the declaration/clearing of aRDI at the termination sink function, the trail termination source function shall have inserted/removed the RDI code within 20 ms.

NOTE – N1[x][y] refer to bit x (x = 7, 8) of byte N1 in frame y (y = 1..76) of the 76-frame multiframe.

N1[5]: The function shall insert the RI_REI value in the REI bit. Upon the detection of a number of errors at the termination sink function, the trail termination source function shall have inserted that value in the REI bit within 20 ms.

N1[7][74]: The function shall insert the ODI code. Upon the declaration/clearing of aODI at the termination sink function, the trail termination source function shall have inserted/removed the ODI code within 20 ms.

N1[6]: The function shall insert the RI_OEI value in the OEI bit. Upon the detection of a number of errors at the termination sink function, the trail termination source function shall have inserted that value in the OEI bit within 20 ms.

N1[7-8]: The function shall insert in the multiframed N1[7-8] channel:

– the Frame Alignment Signal (FAS) "1111 1111 1111 1110" in FAS bits in frames 1 to 8;

– the TC trace identifier, received via reference point SnD_TT_So_MP (MI_TxTI), in the TC trace ID bits in frames 9 to 72;

– the RDI (N1[8][73]) and ODI (N1[7][74]) signals; and

– all-0s in the six reserved bits in frames 73 to 76.

B3: The function shall correct the VC-n BIP-8 (in B3) according to the rule found in D.4/G.707/Y.1322, and as specified in 8.4/G.806.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

12.4.2.1.2 VC-n Tandem Connection Trail Termination Sink SnD_TT_Sk

Symbol

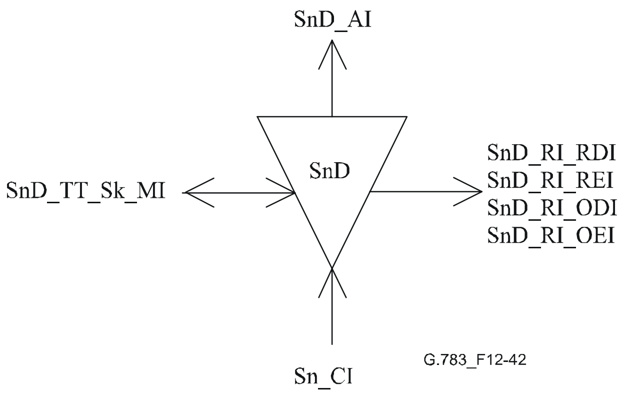


Figure 12-42/G.783 – SnD_TT_Sk symbol

Interfaces

Table 12-21/G.783 – SnD_TT_Sk input and output signals

Inputs	Outputs
Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF SnD_TT_Sk_MI_ExTI SnD_TT_Sk_MI_RDI_Reported SnD_TT_Sk_MI_ODI_Reported SnD_TT_Sk_MI_SSF_Reported SnD_TT_Sk_MI_AIS_Reported SnD_TT_Sk_MI_TIMdis SnD_TT_Sk_MI_DEGM SnD_TT_Sk_MI_DEGTHR SnD_TT_Sk_MI_1second SnD_TT_Sk_MI_TPmode	SnD_AI_Data SnD_AI_Clock SnD_AI_FrameStart SnD_AI_TSF SnD_AI_TSD SnD_AI_OSF SnD_RI_RDI SnD_RI_REI SnD_RI_ODI SnD_RI_OEI SnD_TT_Sk_MI_cLTC SnD_TT_Sk_MI_cTIM SnD_TT_Sk_MI_cUNEQ SnD_TT_Sk_MI_cDEG SnD_TT_Sk_MI_cRDI SnD_TT_Sk_MI_cODI SnD_TT_Sk_MI_cSSF SnD_TT_Sk_MI_cIncAIS SnD_TT_Sk_MI_AcTI SnD_TT_Sk_MI_pN_EBC SnD_TT_Sk_MI_pF_EBC SnD_TT_Sk_MI_pN_DS SnD_TT_Sk_MI_pF_DS SnD_TT_Sk_MI_pON_EBC SnD_TT_Sk_MI_pOF_EBC SnD_TT_Sk_MI_pON_DS SnD_TT_Sk_MI_pOF_DS

Processes

TC EDC violations: See 8.3.1.

N1[1-4]: The function shall extract the Incoming Error Code (IEC). It shall accept the received code without further processing.

N1[7-8][9-72]: The Received Trail Trace Identifier shall be recovered from the tandem connection trail trace identifier overhead. The accepted value of TC trace identifier is also available at the SnD_TT_Sk_MP.

N1[1-4]: The function shall extract the Incoming AIS code.

N1[5], N1[8][73]: The information carried in the REI, RDI bits in byte N1 shall be extracted to enable single-ended maintenance of a bidirectional tandem connection Trail. The REI shall be used to monitor the error performance of the other direction of transmission, and the RDI shall be used to provide information as to the status of the remote receiver. A "1" indicates a Remote Defect Indication state, while a "0" indicates the normal, working state.

N1[6], N1[7][74]: The information carried in the OEI, ODI bits in byte N1 shall be extracted to enable single-ended (intermediate) maintenance of the VC-n egressing the tandem connection Trail. The OEI shall be used to monitor the error performance of the other direction of transmission, and the ODI shall be used to provide information as to the status of the remote receiver. A "1" indicates an Outgoing Defect Indication state, while a "0" indicates the normal, working state.

N1[7-8]: Multiframe alignment: See 8.2.4.

N1: The function shall terminate N1 channel by inserting an all-ZEROs pattern.

B3: The function shall compensate the VC-n BIP-8 in byte B3 according to the algorithm defined in the source direction.

Defects

The function shall detect for dUNEQ, dLTC, dTIM, dDEG, dRDI, dODI, dIncAIS defects according to the specification in 6.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aAIS	←	dUNEQ or dTIM or dLTC
aTSF	←	CI_SSF or dUNEQ or dTIM or dLTC
aTSD	←	dDEG
aRDI	←	CI_SSF or dUNEQ or dTIM or dLTC
aREI	←	N_B (errored TC-n block)
aODI	←	CI_SSF or dUNEQ or dTIM or dIncAIS or dLTC
aOEI	←	ON_B (errored outgoing VC-n block)
aOSF	←	CI_SSF or dUNEQ or dTIM or dLTC or IncAIS

The function shall insert the all-ONEs (AIS) signal within 250 µs after AIS request generation, and cease the insertion within 250 µs after the AIS request is cleared.

Defect correlations

The function shall perform the following defect correlations to determine the most probable cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cSSF	←	CI_SSF and SSF_Reported and MON
cIncAIS	←	dIncAIS and (not CI_SSF) and (not dLTC) and (not dTIM) and AIS_Reported and MON
cUNEQ	←	dUNEQ and MON
cLTC	←	(not dUNEQ) and dLTC and MON and (not CI_SSF)
cTIM	←	(not dUNEQ) and (not dLTC) and dTIM and MON
cDEG	←	(not dTIM) and (not dLTC) and dDEG and MON
cRDI	←	(not dUNEQ) and (not dTIM) and (not dLTC) and dRDI and RDI_Reported and MON
cODI	←	(not dUNEQ) and (not dTIM) and (not dLTC) and dODI and ODI_Reported and MON

Performance monitoring

The function shall perform the following performance monitoring primitives processing (see 6.5/G.806). The performance monitoring primitives shall be reported to the SEMF.

pN_DS	←	aTSF or dEQ
pF_DS	←	dRDI

pN_EBC ← ∑ nN_B

pF_EBC ← ∑ nF_B

pON_DS ← aODI or dEQ

pOF_DS ← dODI

pON_EBC ← ∑ nON_B

pOF_EBC ← ∑ nOF_B

12.4.2.2 VC-n Tandem Connection Non-Intrusive Monitor SnDm_TT_Sk

This function can be used to perform the following:

1) single-ended maintenance of the TC by monitoring at an intermediate node, using remote information (RDI, REI);
2) aid in fault localization within TC trail by monitoring near-end defects;
3) monitoring of VC performance at TC egressing point (except for connectivity defects before the TC) using remote outgoing information (ODI, OEI);
4) performing non-intrusive monitor function within SNC/S protection.

This function acts as a non-intrusive monitor for the VC-n tandem connection overhead (TCOH) described in Annex D/G.707/Y.1322 (TC monitoring protocol option 2).

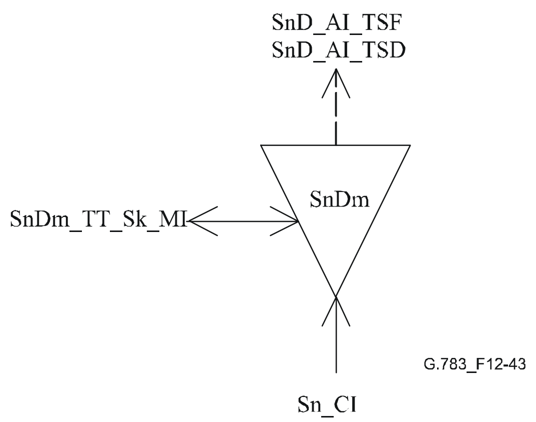


Figure 12-43/G.783 – SnDm_TT_Sk symbol

Interfaces

Table 12-22/G.783 – SnDm_TT_Sk input and output signals

Inputs	Outputs
Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF SnDm_TT_Sk_MI_ExTI SnDm_TT_Sk_MI_RDI_Reported SnDm_TT_Sk_MI_ODI_Reported SnDm_TT_Sk_MI_SSF_Reported SnDm_TT_Sk_MI_AIS_Reported SnDm_TT_Sk_MI_TIMdis SnDm_TT_Sk_MI_DEGM SnDm_TT_Sk_MI_DEGTHR SnDm_TT_Sk_MI_1second SnDm_TT_SK_MI_TPmode	SnD_AI_TSF SnD_AI_TSD SnDm_TT_Sk_MI_cLTC SnDm_TT_Sk_MI_cTIM SnDm_TT_Sk_MI_cUNEQ SnDm_TT_Sk_MI_cDEG SnDm_TT_Sk_MI_cRDI SnDm_TT_Sk_MI_cODI SnDm_TT_Sk_MI_cIncAIS SnDm_TT_Sk_MI_cSSF SnDm_TT_Sk_MI_AcTI SnDm_TT_Sk_MI_pN_EBC SnDm_TT_Sk_MI_pF_EBC SnDm_TT_Sk_MI_pN_DS SnDm_TT_Sk_MI_pF_DS SnDm_TT_Sk_MI_pON_EBC SnDm_TT_Sk_MI_pON_DS SnDm_TT_Sk_MI_pOF_EBC SnDm_TT_Sk_MI_pOF_DS

Processes

TC EDC violations: See 8.3.1.

N1[1-4]: The function shall extract the Incoming Error Code (IEC). It shall accept the received code without further processing.

N1[7-8][9-72]: The Received Trail Trace Identifier shall be recovered from the tandem connection trail trace identifier overhead. The accepted value of TC trace identifier is also available at the SnDm_TT_Sk_MP.

N1[1-4]: The function shall extract the Incoming AIS code.

N1[5], N1[8][73]: The information carried in the REI, RDI bits in byte N1 shall be extracted to enable single-ended maintenance of a bidirectional tandem connection Trail. The REI shall be used to monitor the error performance of the other direction of transmission, and the RDI shall be used to provide information as to the status of the remote receiver. A "1" indicates a Remote Defect Indication state, while a "0" indicates the normal, working state.

N1[6], N1[7][74]: The information carried in the OEI, ODI bits in byte N1 shall be extracted to enable single-ended (intermediate) maintenance of the VC egressing the tandem connection Trail. The OEI (nOF_B) shall be used to monitor the error performance of the other direction transmission, and the ODI shall be used to provide information as to the status of the remote receiver. A "1" indicates an Outgoing Defect Indication state, while a "0" indicates the normal, working state.

N1[7-8]: Multiframe alignment: See 8.2.4.

Defects

The function shall detect for dUNEQ, dLTC, dTIM, dDEG, dRDI, dODI, dIncAIS defects according to the specification in 6.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aTSF	←	CI_SSF or dUNEQ or dTIM or dLTC
aTSD	←	dDEG

Defect correlations

The function shall perform the following defect correlations to determine the most probable cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cSSF	←	CI_SSF and SSF_Reported and MON
cUNEQ	←	dUNEQ and MON
cLTC	←	(not dUNEQ) and dLTC and MON and (not CI_SSF)
cIncAIS	←	dIncAIS and (not CI_SSF) and (not dLTC) and (not dTIM) and AIS_Reported and MON
cTIM	←	(not dUNEQ) and (not dLTC) and dTIM and MON
cDEG	←	(not dTIM) and (not dLTC) and dDEG and MON
cRDI	←	(not dUNEQ) and (not dTIM) and (not dLTC) and dRDI and RDI_Reported and MON
cODI	←	(not dUNEQ) and (not dTIM) and (not dLTC) and dODI and ODI_Reported and MON

Performance monitoring

The function shall perform the following performance monitoring primitives processing (see 6.5/G.806). The performance monitoring primitives shall be reported to the SEMF.

pN_DS	←	aTSF or dEQ
pF_DS	←	dRDI
pN_EBC	←	Σ nN_B
pF_EBC	←	Σ nF_B
pON_DS	←	CI_SSF or dUNEQ or dTIM or dIncAIS or dLTC or dEQ
pON_EBC	←	Σ nON_B
pOF_DS	←	dODI
pOF_EBC	←	Σ nOF_B

12.4.2.3 VC-n Tandem Connection to VC-n Adaptation SnD/Sn_A

This function acts as source and sink for the adaptation of Sn layer to SnD sublayer. This function is applicable for networks that support the VC-n tandem connection monitoring protocol option 2 described in Annex D/G.707/Y.1322.

12.4.2.3.1 VC-n Tandem Connection to VC-n Adaptation Source SnD/Sn_A_So

Symbol

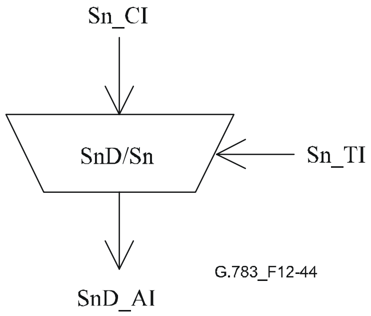


Figure 12-44/G.783 – SnD/Sn_A_So symbol

Interfaces

Table 12-23/G.783 – SnD/Sn_A_So input and output signals

Inputs	Outputs
Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF Sn_TI_CK	SnD_AI_Data SnD_AI_Clock SnD_AI_FrameStart SnD_AI_SF

Processes

NOTE 1 – The function has no means to verify the existence of a tandem connection within the incoming signal. Nested tandem connections are not supported.

The function shall replace the incoming Frame Start signal by a local generated one (i.e., enter "holdover") if an all-ONEs (AIS) VC is received (i.e., this function replace an all-ONEs incoming VC by a VC-AIS signal).

NOTE 2 – This replacement of the (invalid) incoming frame start signal results in the generation of a valid pointer in the MSn/Sn_A function.

Defects

None.

Consequent actions

This function shall perform the following consequent actions:

aSSF ← CI_SSF

Defect correlations

None.

Performance monitoring

None.

12.4.2.3.2 VC-n Tandem Connection to VC-n Adaptation Sink SnD/Sn_A_Sk

Symbol

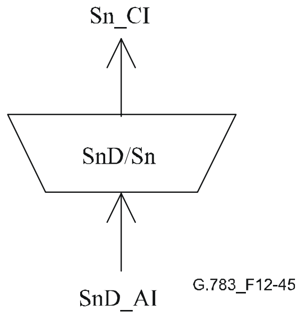


Figure 12-45/G.783 – SnD/Sn_A_Sk symbol

Interfaces

Table 12-24/G.783 – SnD/Sn_A_Sk input and output signals

Inputs	Outputs
SnD_AI_Data SnD_AI_Clock SnD_AI_FrameStart SnD_AI_OSF	Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF

Processes

The function shall restore the invalid frame start condition if that existed at the ingress of the tandem connection.

NOTE 1 – In addition, the invalid frame start condition is activated on a tandem connection connectivity defect condition that causes all-ONEs (AIS) insertion in the SnD_TT.

Defects

None.

Consequent actions

This function shall perform the following consequent actions:

aAIS ← AI_OSF

aSSF ← AI_OSF

NOTE 2 – CI_SSF = true will result in AU-AIS generation by MSn/Sn_A function.

The function shall insert the all-ONEs (AIS) signal within 250 µs after the AIS request has cleared.

Defect correlations

None.

Performance monitoring

None.

12.4.3 Option 1 Tandem Connection sublayer functions

Two options for higher order tandem connection monitoring are currently defined in ITU-T Rec. G.707/Y.1322, where they are referred to as "option 1" and "option 2". The functions defined in this clause support option 1 for a single higher order VC-n.

12.4.3.1 VC-n Tandem Connection Trail Termination SnT_TT

This function acts as source and sink for the VC-n tandem connection overhead (TCOH) described in Annex C/G.707/Y.1322 (TC monitoring protocol option 1).

12.4.3.1.1 VC-n Tandem Connection Trail Termination Source SnT_TT_So

Symbol

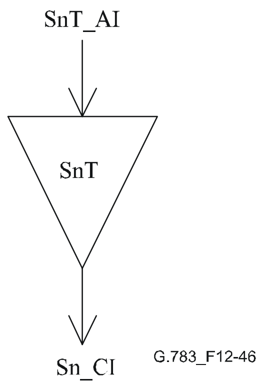


Figure 12-46/G.783 – SnT_TT_So symbol

Interfaces

Table 12-25/G.783 – SnT_TT_So input and output signals

Inputs	Outputs
SnT_AI_Data SnT_AI_Clock SnT_AI_FrameStart SnT_AI_SF	Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart

Processes

N1[1-4]: See 8.3.2.

B3: The function shall correct the VC-n BIP-8 (in B3) according to the rule found in C.5/G.707/Y.1322 and as specified in 8.4/G.806.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

12.4.3.1.2 VC-n Tandem Connection Trail Termination Sink SnT_TT_Sk

Symbol

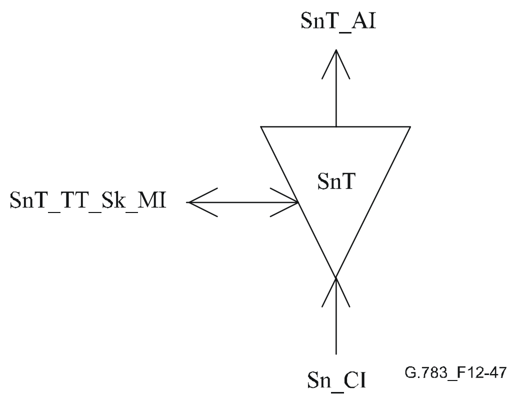


Figure 12-47/G.783 – SnT_TT_Sk symbol

Interfaces

Table 12-26/G.783 – SnT_TT_Sk input and output signals

Inputs	Outputs
Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF SnT_TT_Sk_MI_DEGM SnT_TT_Sk_MI_DEGTHR SnT_TT_Sk_MI_1second SnT_TT_Sk_MI_TPmode SnT_TT_Sk_MI_AIS_Reported	SnT_AI_Data SnT_AI_Clock SnT_AI_FrameStart SnT_AI_TSF SnT_AI_TSD SnT_AI_OSF SnT_TT_Sk_MI_cUNEQ SnT_TT_Sk_MI_cDEG SnT_TT_Sk_MI_cIncAIS SnT_TT_Sk_MI_pN_EBC SnT_TT_Sk_MI_pN_DS

Processes

TC EDC violations: See 8.3.1.

N1[1-4]: The function shall extract the Incoming Error Code (IEC). It shall accept the received code without further processing.

N1[1-4]: The function shall extract the Incoming AIS code.

N1[1-4]: The function shall terminate N1[1-4] by inserting an all-ZEROs pattern.

Defects

The function shall detect for dUNEQ, dDEG, dIncAIS defects according to the specification in 6.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aTSF ← CI_SSF

aTSD ← dDEG

aOSF ← CI_SSF or dIncAIS

The function shall insert the all-ONEs (AIS) signal within 250 μs after AIS request generation, and cease the insertion within 250 μs after the AIS request is cleared.

Defect correlations

The function shall perform the following defect correlations to determine the most probable cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cIncAIS ← dIncAIS and (not CI_SSF) and AIS_Reported and MON

cUNEQ ← dUNEQ and MON

cDEG ← dDEG and MON

Performance monitoring

The function shall perform the following performance monitoring primitives processing (see 6.5/G.806). The performance monitoring primitives shall be reported to the SEMF.

pN_DS ← aTSF or dEQ

pN_EBC ← $\sum$ nN_B

12.4.3.2 VC-n Tandem Connection non-intrusive monitor SnTm_TT_Sk

This function acts as a non-intrusive monitor for the VC-n tandem connection overhead (TCOH) described in Annex C/G.707/Y.1322 (TC monitoring protocol option 1).

This function can be used to aid in fault localization within a TC trail by monitoring near-end defects.

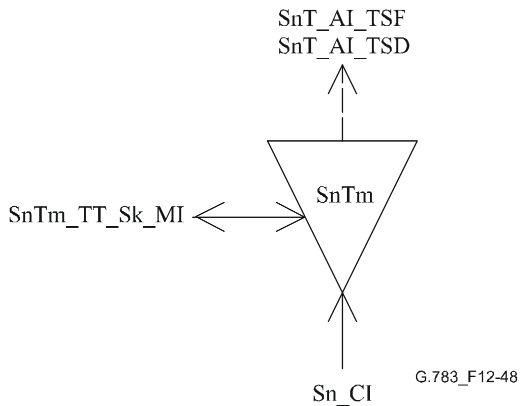


Figure 12-48/G.783 – SnTm_TT_Sk symbol

Interfaces

Table 12-27/G.783 – SnTm_TT_Sk input and output signals

Inputs	Outputs
Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF SnTm_TT_Sk_MI_DEGM SnTm_TT_Sk_MI_DEGTHR SnTm_TT_Sk_MI_1second SnTm_TT_SK_MI_TPmode SnTm_TT_Sk_MI_AIS_Reported	SnT_AI_TSF SnT_AI_TSD SnTm_TT_Sk_MI_cUNEQ SnTm_TT_Sk_MI_cDEG SnTm_TT_Sk_MI_cIncAIS SnTm_TT_Sk_MI_pN_EBC SnTm_TT_Sk_MI_pN_DS

Processes

TC EDC violations: See 8.3.1.

N1[1-4]: The function shall extract the Incoming Error Code (IEC). It shall accept the received code without further processing.

N1[1-4]: The function shall extract the Incoming AIS code.

Defects

The function shall detect for dUNEQ, dDEG, dIncAIS defects according to the specification in 6.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aTSF ← CI_SSF

aTSD ← dDEG

Defect correlations

The function shall perform the following defect correlations to determine the most probable cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cUNEQ ← dUNEQ and MON

cIncAIS ← dIncAIS and (not CI_SSF) and AIS_Reported and MON

cDEG ← dDEG and MON

Performance monitoring

The function shall perform the following performance monitoring primitives processing (see 6.5/G.806). The performance monitoring primitives shall be reported to the SEMF.

pN_DS ← aTSF or dEQ

pN_EBC ← ∑ nN_B

12.4.3.3 VC-n Tandem Connection to VC-n Adaptation SnT/Sn_A

This function acts as source and sink for the adaptation of Sn layer to SnT sublayer. This function is applicable for networks that support the VC-n tandem connection monitoring protocol option 1 described in Annex C/G.707/Y.1322.

12.4.3.3.1 VC-n Tandem Connection to VC-n Adaptation Source SnT/Sn_A_So

Symbol

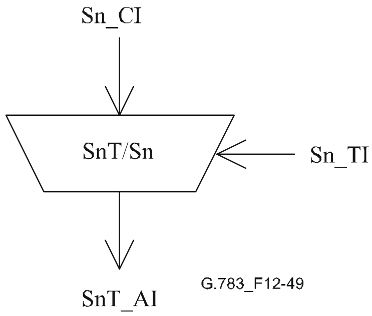


Figure 12-49/G.783 – SnT/Sn_A_So symbol

Interfaces

Table 12-28/G.783 – SnT/Sn_A_So input and output signals

Inputs	Outputs
Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF Sn_TI_CK	SnT_AI_Data SnT_AI_Clock SnT_AI_FrameStart SnT_AI_SSF

Processes

NOTE 1 – The function has no means to verify the existence of a tandem connection within the incoming signal. Nested tandem connections are not supported.

The function shall replace the incoming Frame Start signal by a local generated one (i.e., enter "holdover") if an all-ONEs (AIS) VC is received (i.e., this function replace an all-ONEs incoming VC by a VC-AIS signal).

NOTE 2 – This replacement of the (invalid) incoming frame start signal results in the generation of a valid pointer in the MSn/Sn_A function.

Defects

None.

Consequent actions

This function shall perform the following consequent actions:

aSSF ← CI_SSF

Defect correlations

None.

Performance monitoring

None.

12.4.3.3.2 VC-n Tandem Connection to VC-n Adaptation Sink SnT/Sn_A_Sk

Symbol

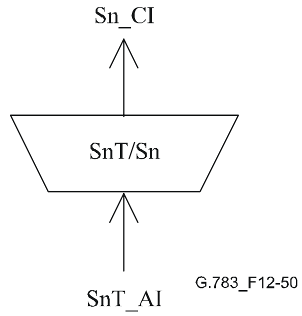


Figure 12-50/G.783 – SnT/Sn_A_Sk symbol

Interfaces

Table 12-29/G.783 – SnT/Sn_A_Sk input and output signals

Inputs	Outputs
SnT_AI_Data SnT_AI_Clock SnT_AI_FrameStart SnT_AI_OSF	Sn_CI_Data Sn_CI_Clock Sn_CI_FrameStart Sn_CI_SSF

Processes

The function shall restore the invalid frame start condition if that existed at the ingress of the tandem connection.

NOTE 1 – In addition, the invalid frame start condition is activated on a tandem connection connectivity defect condition that causes all-ONEs (AIS) insertion in the SnT_TT.

N1[5-8]: The function shall terminate N1[5-8] by inserting an all-ZEROs pattern.

B3: The function shall correct the VC-n BIP-8 in byte B3 according to the algorithm specified in 8.4/G.806.

Defects

None.

Consequent actions

This function shall perform the following consequent actions:

aAIS ← AI_OSF

aSSF ← AI_OSF

NOTE 2 – CI_SSF = true will result in AU-AIS generation by MSn/Sn_A function.

The function shall insert the all-ONEs (AIS) signal within 250 µs after AIS request generation, and cease the insertion within 250 µs after the AIS request is cleared.

Defect correlations

None.

Performance monitoring

None.

12.4.3.4 VC-n Tandem Connection to Datalink Adaptation SnT/DL_A

The SnT/DL_A adaptation function is applicable for networks that support the VC-n tandem connection monitoring option 1 data link (DL) as described in Annex C/G.707/Y.1322. The SnT/DL_A adaptation function places bits 5-8 of byte N1 of the TCOH into the SnT_AI in the source direction and recovers the information from SnT_AI in the sink direction.

12.4.3.4.1 VC-n Tandem Connection to Datalink Adaptation Source SnT/DL_A_So

Symbol

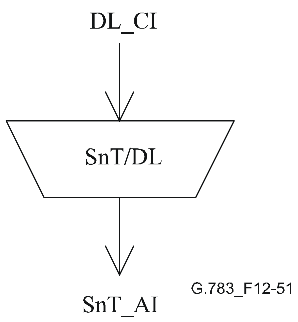


Figure 12-51/G.783 – SnT/DL_A_So symbol

Interfaces

Table 12-30/G.783 – SnT/DL_A_So function inputs and outputs

Inputs	Outputs
DL_CI_Data SnT_AI_FrameStart SnT_AI_Clock	SnT_AI_Data DL_CI_Clock

Processes

The Data Link (DL) bits are derived from the DL message communications function and placed in bits 5-8 of N1. The bits shall be used as described in Annex C/G.707/Y.1322. The data link is a message-based channel to support tandem connection maintenance.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

12.4.3.4.2 VC-n Tandem Connection to Datalink Adaptation Sink SnT/DL_A_Sk

Symbol

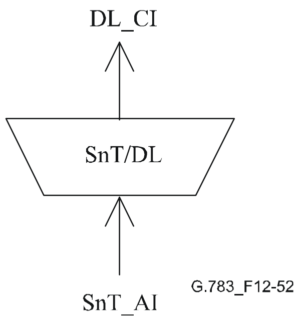


Figure 12-52/G.783 – SnT/DL_A_Sk symbol

Interfaces

Table 12-31/G.783 – SnT/DL_A_Sk function inputs and outputs

Inputs	Outputs
SnT_AI_Data SnT_AI_Clock SnT_AI_FrameStart SnT_AI_TSF	DL_CI_Data DL_CI_Clock DL_CI_SSF

Processes

The DL bits N1[5-8] are recovered from the TCOH and passed to the DL communications function.

Defects

None.

Consequent actions

aSSF $\leftarrow$ AI_TSF

Defect correlations

None.

Performance monitoring

None.

12.4.3.5 VC-n Tandem Connection to Datalink Adaptation for non-intrusive monitoring SnTm/DL_A_Sk

This function acts as a non-intrusive monitor for the VC-n tandem connection overhead data link (DL) described in Annex C/G.707/Y.1322 (option 1).

Symbol

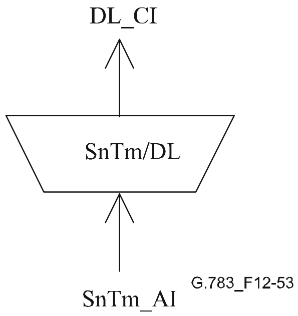


Figure 12-53/G.783 – SnTm/DL_A_Sk symbol

Interfaces

Table 12-32/G.783 – SnTm/DL_A_Sk function inputs and outputs

Inputs	Outputs
SnTm_AI_Data SnTm_AI_Clock SnTm_AI_FrameStart SnTm_AI_TSF	DL_CI_Data DL_CI_Clock DL_CI_SSF

Processes

The data link (DL) information from the bits 5-8 of N1 byte are recovered from the SnTm_AI and are passed to the DL communications function.

Defects

None.

Consequent actions

aSSF ← AI_TSF

Defect correlations

None.

Performance monitoring

None.

12.5 Virtual concatenation functions

12.5.1 Virtual concatenated VC-n path layer functions Sn-Xv (n = 3, 4; X ≥ 1)

12.5.1.1 VC-n-Xv Layer Trail Termination Function Sn-Xv_TT

The Sn-Xv_TT function is further decomposed as defined in ITU-T Rec. G.803 [11] and shown in Figure 12-54.

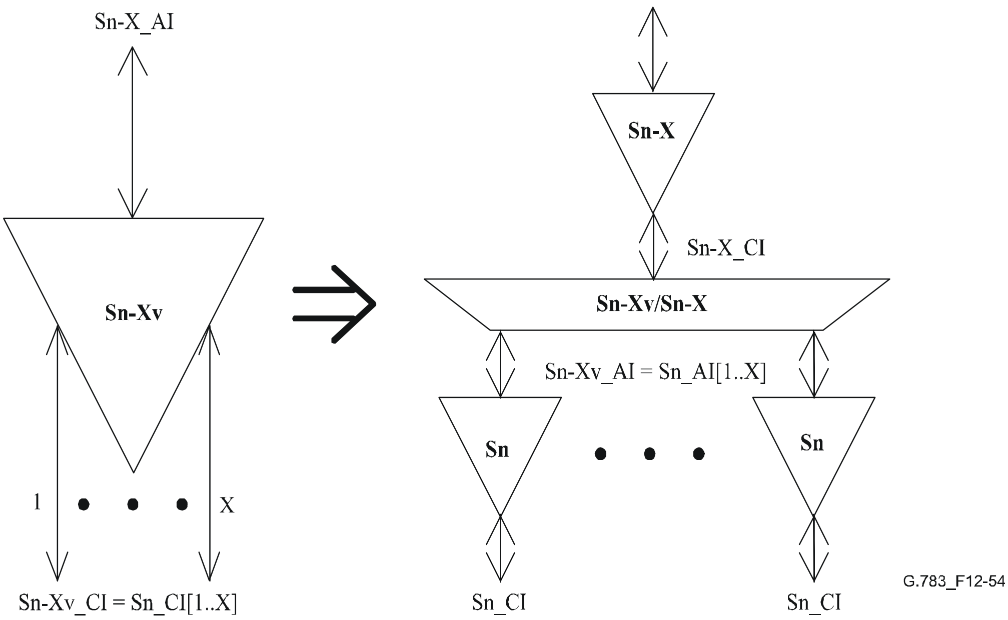


Figure 12-54/G.783 – Decomposition of Sn-Xv_TT function

The Sn_TT functions are the normal VC-n trail termination functions as defined in 12.2.1.

12.5.1.1.1 VC-n-Xv/VC-n-X Adaptation Source Function Sn-Xv/Sn-X_A_So

Symbol

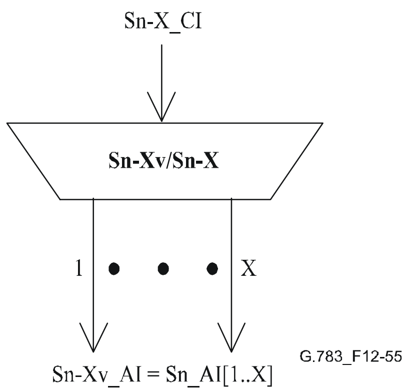


Figure 12-55/G.783 – Sn-Xv/Sn-X_A_So symbol

Interfaces

Table 12-33/G.783 – Sn-Xv/Sn-X_A_So input and output signals

Inputs	Outputs
Sn-X_CI_D Sn-X_CI_CK Sn-X_CI_FS	Sn-Xv_AI_D = Sn_AI[1..X]_D Sn-Xv_AI_CK = Sn_AI[1..X]_CK Sn-Xv_AI_FS = Sn_AI[1..X]_FS

Processes

This function shall perform the distribution of the incoming Sn-X_CI to X VC-n to form the Sn-Xv_AI (= Sn_AI[1..X]). Any values of X ≥ 2 are allowed.

Distribution processes

The Sn-X_CI shall be distributed to X × VC-n as shown in Figure 12-4 for S3-X_CI and in Figure 12-8 for S4-X_CI.

Payload

Starting from column X + 1 the payload shall be distributed to the X VC-n as defined in Table 12-34.

Table 12-34/G.783 – Sn-X → Sn-Xv Payload mapping

Sn-X_CI column	Sn_AI number	Sn_AI column
X + 1	1	2
...	...	...
2 × X	X	2
2 × X + 1	1	3
...	...	...
261/85 × X	X	261/85

C2: The incoming C2 byte shall be inserted to VC-n[1..X].

F2: The incoming F2 byte shall be inserted to VC-n[1]. F2 of VC-n[2..X] shall be set to 00h.

F3: The incoming F3 byte shall be inserted to VC-n[1]. F3 of VC-n[2..X] shall be set to 00h.

K3: The incoming K3 byte shall be inserted to VC-n[1]. K3 of VC-n[2..X] shall be set to 00h.

Multiframe process (H4[5-8], H4[1-4][0-1]): See 8.2.5.1.

Sequence process (H4[1-4][14-15])

An individual sequence number SQ shall be inserted in each VC-n as defined in ITU-T Rec. G.707/Y.1322. The sequence number for VC-n[y] is y – 1.

H4[1-4][2-13]: The bits are reserved for future use and shall be set to "0000".

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

12.5.1.1.2 VC-n-Xv/VC-n-X Adaptation Sink Function Sn-Xv/Sn-X_A_Sk

Symbol

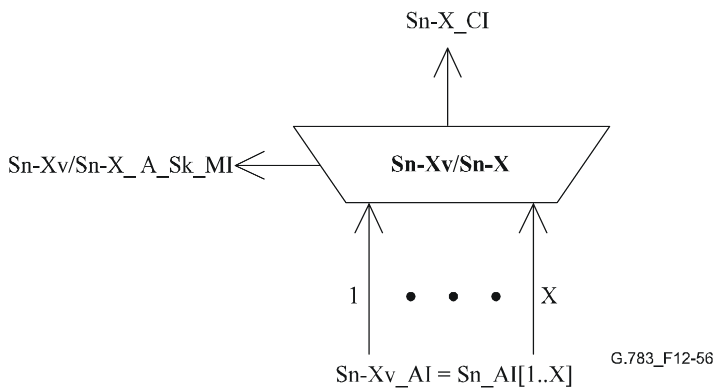


Figure 12-56/G.783 – Sn-Xv/Sn-X_A_Sk symbol

Interfaces

Table 12-35/G.783 – Sn-Xv/Sn-X_A_Sk input and output signals

Inputs	Outputs
Sn-Xv_AI_D = Sn_AI[1..X]_D Sn-Xv_AI_CK = Sn_AI[1..X]_CK Sn-Xv_AI_FS = Sn_AI[1..X]_FS Sn-Xv_AI_TSF = Sn_AI[1..X]_TSF	Sn-X_CI_D Sn-X_CI_CK Sn-X_CI_FS Sn-X_CI_SSF Sn-Xv/Sn-X_A_Sk_MI_cLOM[1..X] Sn-Xv/Sn-X_A_Sk_MI_cSQM[1..X] Sn-Xv/Sn-X_A_Sk_MI_cLOA Sn-Xv/Sn-X_A_Sk_MI_AcSQ[1..X]

Processes

This function shall perform the alignment of the individual VC-ns.

Multiframe process (H4[5-8], H4[1-4][0-1]): See 8.2.5.1.

Sequence process (H4[1-4][14-15])

The received sequence number (SQ) shall be recovered from the H4 byte, bits 1-4 in multiframe 14 and 15. It shall be made available as AcSQ[y] for network management purposes. A new sequence number is accepted if the received sequence has the same value in m consecutive multiframes of the first stage, with $3 \leq m \leq 10$.

Alignment processes

The function shall align the individual VC-ns to a common multiframe start if AI_TSF, dLOM or dSQM is not active for any individual VC-n. The alignment process shall cover at least a differential delay of 125 µs. On successful alignment, the VC-n-X is recovered from the X VC-ns. The overhead column is recovered from VC-n number 1. Table 12-36 provides the mapping of payload columns from the individual VC-ns into the VC-n-X.

Table 12-36/G.783 – Sn-Xv to Sn-X payload mapping

Sn_AI number	Sn_AI column	Sn-X_CI column
1	2	X + 1
	3	2 × X + 1
	...	...
	261 or 85	260 or 84 × X + 1
2	2	X + 2
	...	...
	261 or 85	260 or 84 × X + 2
…	…	…
X	261 or 85	2

Defects

Loss of Multiframe defect (dLOM): see 6.2.5.4.

Loss of Sequence defect (dSQM): dSQM shall be detected if the accepted sequence number (AcSQ) does not match the expected Sequence number (ExSQ). dSQM shall be cleared if AcSQ matches ExSQ. The ExSQ of VC-n[y] is y – 1.

Loss of Alignment (dLOA): dLOA shall be detected if the alignment process cannot perform the alignment of the individual VC-4s to a common multiframe start (e.g., dLOA is activated if the differential delay exceeds the size of the alignment buffer). The details are for further study.

Consequent actions

aAIS ← dLOM[1..X] or dSQM[1..X] or dLOA

aSSF ← AI_TSF[1..X] or dLOM[1..X] or dSQM[1..X] or dLOA

On declaration of aAIS, the function shall output all-ONEs signal within 250 µs; on clearing of aAIS, the function shall output normal data within 250 µs.

Defect correlations

cLOM[n] ← dLOM[n] and (not AI_TSF[n])

cSQM[n] ← dSQM[n] and (not dLOM[n]) and (not AI_TSF[n])

cLOA ← dLOA and (not dSQM[1..X]) and (not dLOM[1..X]) and (not AI_TSF[1..X])

Performance monitoring

None.

12.5.1.1.3 VC-n-X Trail Termination Source Function Sn-X_TT_So

Symbol

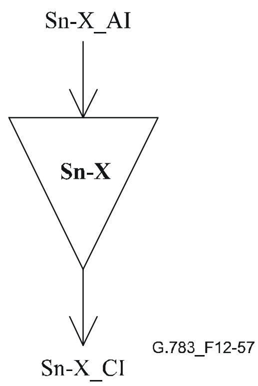


Figure 12-57/G.783 – Sn-X_TT_So symbol

Interfaces

Table 12-37/G.783 – Sn-X_TT_So input and output signals

Inputs	Outputs
Sn-X_AI_D Sn-X_AI_CK Sn-X_AI_FS	Sn-X_CI_D Sn-X_CI_CK Sn-X_CI_FS

Processes

None.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

12.5.1.1.4 VC-n-X Layer Trail Termination Sink Function Sn-X_TT_Sk

Symbol

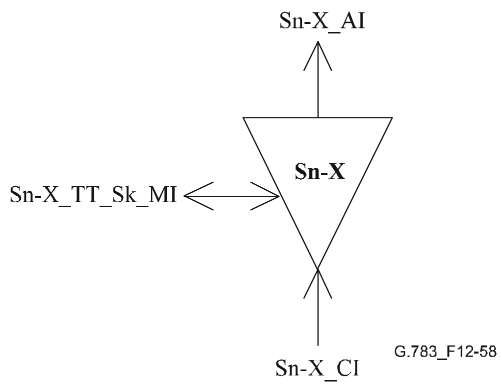


Figure 12-58/G.783 – Sn-X_TT_Sk symbol

Interfaces

Table 12-38/G.783 – Sn-X_TT_Sk input and output signals

Inputs	Outputs
Sn-X_CI_D Sn-X_CI_CK Sn-X_CI_FS Sn-X_CI_SSF	Sn-X_AI_D Sn-X_AI_CK Sn-X_AI_FS Sn-X_AI_TSF
Sn-X_TT_Sk_MI_SSF_Reported	Sn-X_TT_Sk_MI_cSSF

Processes

None.

Defects

None.

Consequent actions

aTSF ← CI_SSF

Defect correlations

cSSF ← CI_SSF and SSF_Reported

Performance monitoring

None.

12.5.2 Interworking functions

12.5.2.1 VC-4-Xc to VC-4-Xv Interworking Function S4-Xc>S4-Xv_I

Symbol

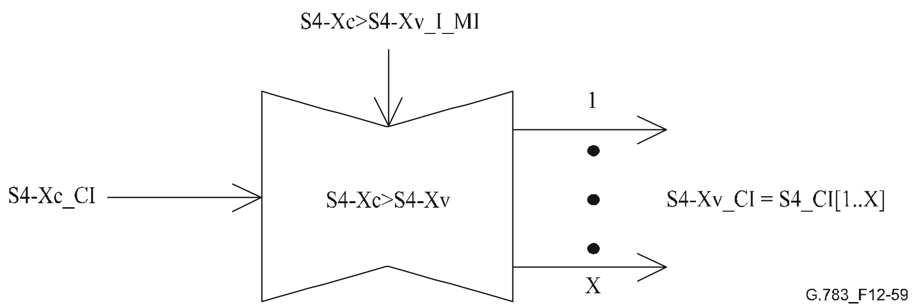


Figure 12-59/G.783 – S4-Xc>S4-Xv_I symbol

Interfaces

Table 12-39/G.783 – S4-Xc>S4-Xv_I input and output signals

Inputs	Outputs
S4-Xc_CI_D S4-Xc_CI_CK S4-Xc_CI_FS S4-Xc_CI_SSF S4-Xc>S4-Xv_I_MI_TxTI[2..X] S4-Xc>S4-Xv_I_MI_TIEn	S4-Xv_CI_D = S4_CI[1..X]_D S4-Xv_CI_CK = S4_CI[1..X]_CK S4-Xv_CI_FS = S4_CI[1..X]_FS S4-Xv_CI_SSF = S4_CI[1..X]_SSF

Processes

This function shall convert the incoming S4-Xc_CI to the outgoing S4-Xv_CI (= S4_CI[1..X]). Values of X = 4, 16, 64 are allowed. Higher values of X are for further study.

Payload

The VC-4-Xc payload area (C-4-Xc) shall be inserted in the VC-4-Xv payload as defined in Table 12-40.

Table 12-40/G.783 – Payload mapping S4-Xc_CI → S4-Xv_CI

S4-Xc_CI column	S4_CI number	S4_CI column
X + 1	1	2
...	...	...
2 × X	X	2
2 × X + 1	1	3
...	...	...
261 × X	X	261

J1: The byte of the VC-4-Xc shall be inserted to the first VC-4 of the VC-4-Xv. For all other VC-4s of the VC-4-Xv an individual J1 trace TxTI[n] shall be inserted if trace insertion is enabled (TIEn = true). If trace insertion is not enabled (TIEn = false) the byte of the VC-4-Xc shall be inserted.

B3: The BIP-8 shall be calculated for VC-4-Xc frame n – 1. It shall be compared with the related B3 of frame n to determine the number of bit errors. The BIP-8 shall be calculated for each individual VC-4 frame n – 1 of the VC-4-Xv. For the first VC-4 of the VC-4-Xv, as many bits of the BIP-8 shall be inverted as bit errors are detected in the VC-4-Xc before insertion into the related B3 of frame n. This can be accomplished by an exclusive OR process as shown in Figure 12-60. The BIP-8 of all other VC-4s shall be inserted into their related B3 of frame n without any modification.

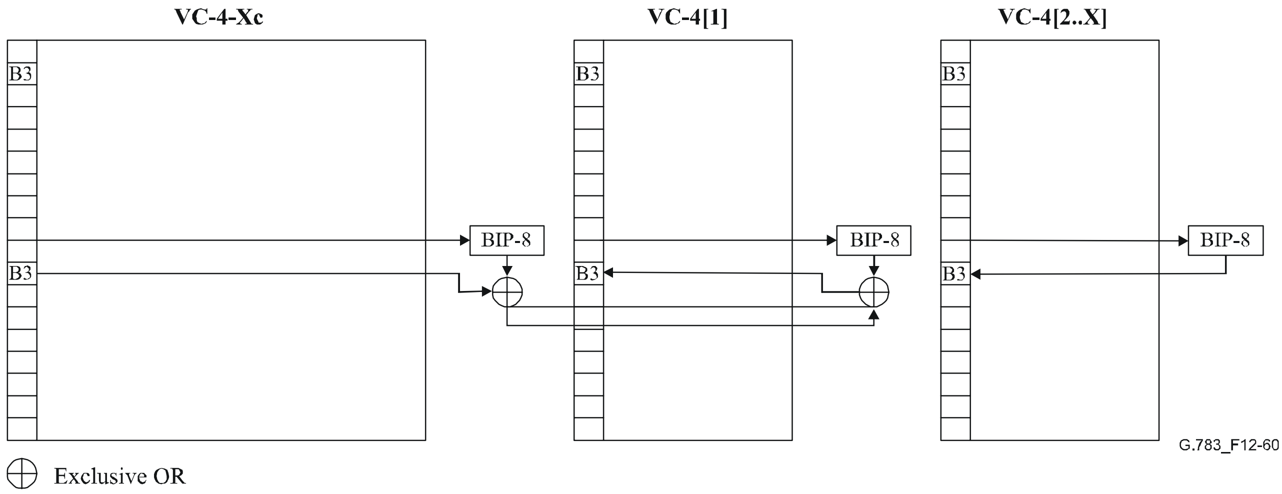


Figure 12-60/G.783 – B3 processing

C2: The byte of the VC-4-Xc shall be inserted to all individual VC-4s of the VC-4-Xv signal.

G1[1-4]: Bits 1 to 4 (REI) of the VC-4-Xc shall be inserted to bits 1 to 4 of the first VC-4 of the VC-4-Xv. Bits 1 to 4 of all other VC-4s of the VC-4-Xv shall be set to 0.

G1[5]: Bit 5 (RDI) of the VC-4-Xc shall be inserted to bit 5 of all VC-4s of the VC-4-Xv.

G1[6-7]: The optional use of enhanced-RDI is described in Appendix VI.

G1[8]: Bits 8 of the VC-4-Xc shall be inserted to bit 8 of all VC-4s of the VC-4-Xv.

F2: The F2 byte of the VC-4-Xc shall be inserted to the first VC-4 of the VC-4-Xv signal. The F2 bytes of all other VC-4s of the VC-4-Xv shall be set to 00h.

F3: The F3 byte of the VC-4-Xc shall be inserted to the first VC-4 of the VC-4-Xv signal. The F3 bytes of all other VC-4s of the VC-4-Xv shall be set to 00h.

K3: The K3 byte of the VC-4-Xc shall be inserted to the first VC-4 of the VC-4-Xv signal. The K3 bytes of all other VC-4s of the VC-4-Xv shall be set to 00h.

N1[1-4]: If bits 1 to 4 (IEC) of the VC-4-Xc contain the code "1110" (Incoming AIS), bits 1 to 4 of all VC-4s of the VC-4-Xv shall be set to "1110". If bits 1 to 4 (IEC) of the VC-4-Xc contain the code "0000" (part of TC Unequipped), bits 1 to 4 of all VC-4s of the VC-4-Xv shall be set to "0000". Otherwise, bits 1 to 4 of the VC-4-Xc shall be inserted to bits 1 to 4 of the first VC-4 of the VC-4-Xv and bits 1 to 4 of all other VC-4s of the VC-4-Xv shall be set to an IEC of 0 ("1001").

Multiframe process (H4[5-8], H4[1-4][0-1]): See 8.2.5.1.

Sequence process (H4[1-4][14-15])

An individual sequence number SQ shall be inserted in each VC-4 as defined in ITU-T Rec. G.707/Y.1322. The sequence number for VC-4[y] is y – 1.

H4[1-4][2-13]: The bits are reserved for future use and shall be set to "0000".

N1[5-8]: Bits 5 to 8 of the VC-4-Xc are copied to bits 5 to 8 of all VC-4s of the VC-4-Xv.

Defects

None.

Consequent actions

aAIS ← CI_SSF

aSSF[n] ← CI_SSF

On declaration of aAIS, the function shall output all-ONEs signal within 250 µs; on clearing of aAIS, the function shall output normal data within 250 µs.

Defect correlations

None.

Performance monitoring

None.

12.5.2.2 VC-4-Xv to VC-4-Xc Interworking Function S4-Xv>S4-Xc_I

Symbol

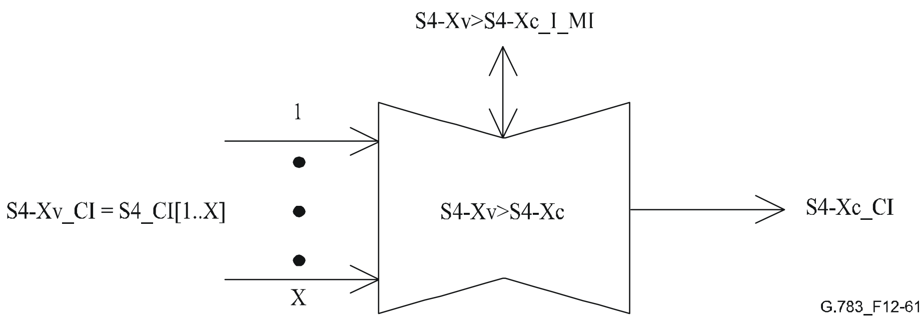


Figure 12-61/G.783 – S4-Xv>S4-Xc_I symbol

Interfaces

Table 12-41/G.783 – S4-Xv>S4-Xc_I input and output signals

Inputs	Outputs
S4-Xv_CI_D = S4_CI[1..X]_D S4-Xv_CI_CK = S4_CI[1..X]_Ck S4-Xv_CI_FS = S4_CI[1..X]_FS S4-Xv_CI_SSF = S4_CI[1..X]_SSF S4-Xv>S4-Xc_I_MI_TPmode S4-Xv>S4-Xc_I_MI_SSF_Reported S4-Xv>S4-Xc_I_MI_ExTI[1..X] S4-Xv>S4-Xc_I_1second S4-Xv>S4-Xc_I_TIMdis[1..X]	S4-Xc_CI_D S4-Xc_CI_CK S4-Xc_CI_FS S4-Xc_CI_SSF S4-Xv>S4-Xc_I_MI_cTIM[1..X] S4-Xv>S4-Xc_I_MI_cUNEQ[1..X] S4-Xv>S4-Xc_I_MI_cSSF[1..X] S4-Xv>S4-Xc_I_MI_AcTI[1..X] S4-Xv>S4-Xc_I_MI_cLOM[1..X] S4-Xv>S4-Xc_I_MI_cSQM[1..X] S4-Xv>S4-Xc_I_MI_cLOA S4-Xv>S4-Xc_I _MI_AcSQ[1..X]

Processes

This function shall convert the incoming S4-Xv_CI (= S4_CI[1..X]) to the outgoing S4-Xc_CI. The main processes are shown in Figure 12-62.

Values of X = 4, 16, 64, 256 are allowed. Higher values of X are for further study.

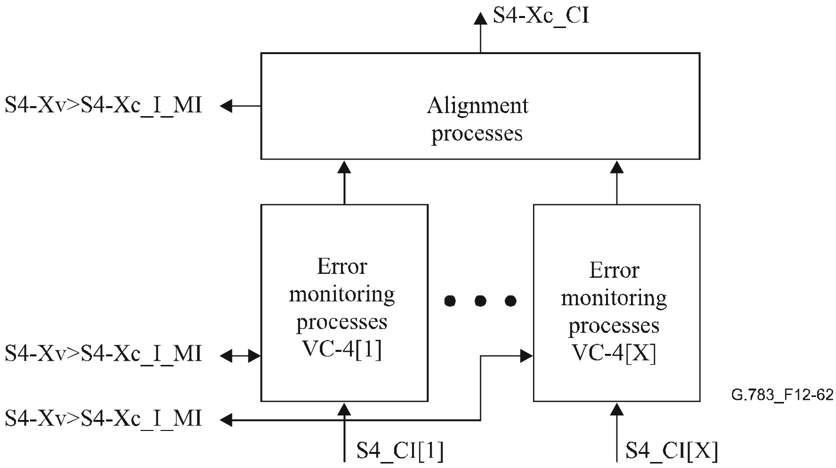


Figure 12-62/G.783 – S4-Xv>S4-Xc_I main processes

Error monitoring processes [n = 1..X]

These processes are performed per individual VC-4.

J1: The Received Trail Trace Identifier RxTI[n] shall be recovered from the J1 byte and shall be made available as AcTI[n] for network management purposes. The application and acceptance and mismatch detection process shall be performed as specified in 6.2.2.2/G.806.

NOTE 1 – If no individual traces are configured for VC-4[2...X] in the S4-xc>S4Xv_I function, the expected traces for VC-4[2..X] shall be set identical to the expected trace of the first VC-4, or trace supervision shall be disabled for these VC-4s.

C2: The signal label bits shall be recovered. For further description of unequipped defect processing, see 6.2.1.3/G.806. The function shall detect for an AIS VC (dAIS) condition by monitoring the VC PSL for code "1111 1111". For further description of VC AIS defect processing, see 6.2.6.2/G.806.

NOTE 2 – dUNEQ and dAIS shall not result in consequent actions.

Multiframe process (H4[5-8], H4[1-4][0-1]): See 8.2.5.1.

Sequence process (H4[1-4][14-15])

The received sequence number (SQ) shall be recovered from the H4 byte, bits 1-4 in multiframe 14 and 15. It shall be made available as AcSQ[y] for network management purposes. A new sequence number is accepted if the received sequence has the same value in m consecutive multiframes of the first stage, with $3 \leq m \leq 10$.

Alignment process

The function shall align the individual VC-4s to a common multiframe start if CI_SSF, dTIM, dLOM or dSQM is not active for any individual VC-4. The alignment process shall cover at least a differential delay of 125 µs.

The function shall perform the following payload and overhead processing if alignment is possible:

Payload

The VC-4-Xv payload area (C-4-Xc) shall be inserted in the VC-4-Xc payload area as defined in Table 12-42.

Table 12-42/G.783 – Payload mapping S4-Xv_CI → S4-Xc_CI

S4-Xv_CI		S4-Xc_CI column
S4_CI column	**S4_CI number**	
2	1	X + 1
...	...	...
2	X	2 × X
3	1	2 × X + 1
...	...	...
261	X	261 × X

J1: The byte of the first VC-4 of the VC-4-Xv shall be inserted to the VC-4-Xc.

B3: The BIP-8 shall be calculated for each VC-4 frame n – 1 of the VC-4-Xv and compared with the related B3 of frame n to determine the bit errors per VC-4. The bit errors of all VC-4s of the VC-4-Xc shall be added together and the result shall be limited to 8. The BIP-8 shall be calculated for VC-4-Xc frame n – 1. As many bits of the BIP-8 shall be inverted as indicated by the result above before insertion into the related B3 of frame n. (See Figure 12-63.)

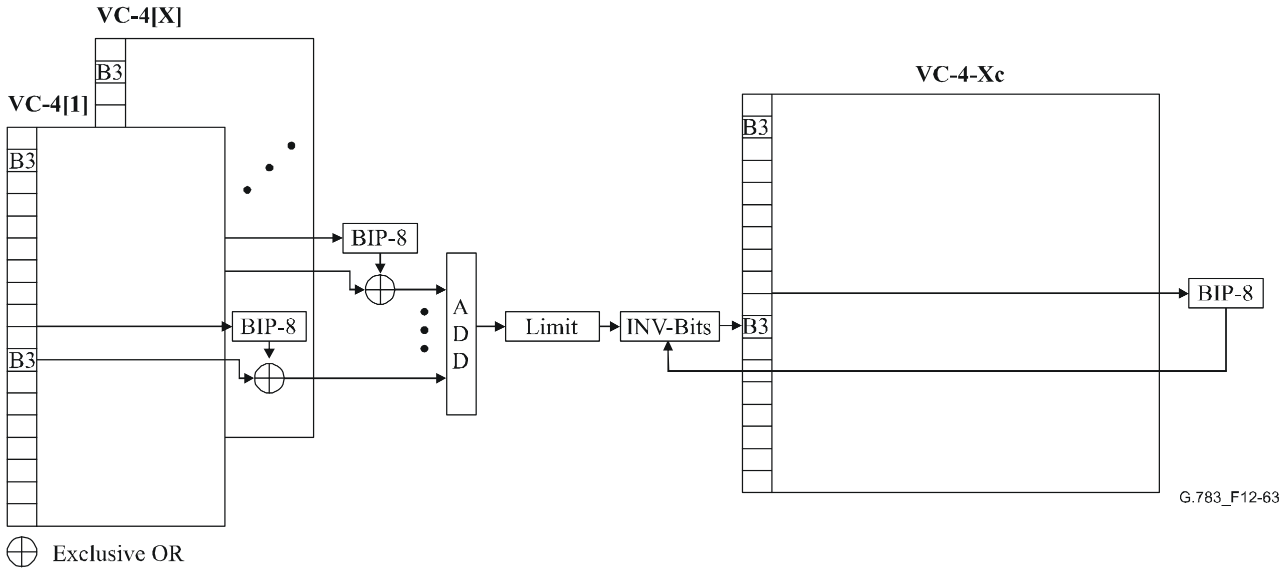


Figure 12-63/G.783 – B3 processing

C2: The byte of the first VC-4 of the VC-4-Xv shall be inserted to the VC-4-Xc.

G1[1-4]: The REI values (bits 1 to 4) of all VC-4s of the VC-4-Xv shall be added together. The result shall be limited to 8 and inserted in bits 1 to 4 of the VC-4-Xc.

G1[5]: If bit 5 (RDI) of any VC-4 of the VC-4-Xv contains the code "1", bit 5 of G1 for the VC-4-Xc shall be set to "1".

G1[6-7]: The optional use of enhanced RDI is described in Appendix VI.

G1[8]: Bit 8 of the first VC-4 of the VC-4-Xv shall be inserted to bit 8 of the VC-4-Xc.

F2: The F2 byte of the first VC-4 of the VC-4-Xv shall be inserted to the VC-4-Xc.

H4: The byte of the VC-4-Xc shall be set to 0.

F3: The F3 byte of the first VC-4 of the VC-4-Xv shall be inserted to the VC-4-Xc.

K3: The K3 byte of the first VC-4 of the VC-4-Xv shall be inserted to the VC-4-Xc.

N1[1-4]: If bits 1 to 4 (IEC) of any VC-4 of the VC-4-Xv contain the code "1110" (Incoming AIS), bits 1 to 4 of the VC-4-Xc shall be set to "1110". If bits 1 to 4 (IEC) of the first VC-4 of the VC-4-Xv contain the code "0000" (TC Unequipped), bits 1 to 4 of the VC-4-Xc shall be set to "0000". Otherwise the IEC values (bits 1 to 4) of all VC-4s of the VC-4-Xv shall be added together. The result shall be limited to 8 and shall be inserted as IEC in bits 1 to 4 of the VC-4-Xc.

N1[5-8]: Bits 5 to 8 of the first VC-4 of the VC-4-Xv shall be inserted to bits 5 to 8 of the VC-4-Xc.

Defects

The function shall detect for dUNEQ, dAIS and dTIM defects per individual VC-4 according to the specification in 6.2/G.806. It shall be possible to disable the trace id mismatch detection (TIMdis).

Loss of Multiframe defect (dLOM): see 6.2.5.4.

Loss of Sequence defect (dSQM): dSQM shall be detected if the accepted sequence number (AcSQ) does not match the expected Sequence number (ExSQ). dSQM shall be cleared if AcSQ matches ExSQ. The ExSQ of VC-4[y] is y – 1.

Loss of Alignment (dLOA): dLOA shall be detected if the alignment process cannot perform the alignment of the individual VC-4s to a common multiframe start (e.g., dLOA is activated if the differential delay exceeds the size of the alignment buffer). The details are for further study.

Consequent actions

aAIS ← dTIM[1..X] or dLOM[1..X] or dSQM[1..X] or dLOA

aSSF ← CI_SSF[1..X] or dTIM[1..X] or dLOM[1..X] or dSQM[1..X] or dLOA

On declaration of aAIS, the function shall output all-ONEs signal within 250 µs; on clearing of aAIS, the function shall output normal data within 250 µs.

Defect correlations

cUNEQ[n] ← dUNEQ[n] and MON

cTIM[n] ← dTIM[n] and (not dUNEQ[n]) and MON

cSSF[n] ← (CI_SSF[n] or dAIS[n]) and MON and SSF_Reported

cLOM[n] ← dLOM[n] and (not dTIM[n]) and (not CI_SSF[n])

cSQM[n] ← dSQM[n] and (not dLOM[n]) and (not dTIM[n]) and (not CI_SSF[n])

cLOA ← dLOA and (not dSQM[1..X]) and (not dLOM[1..X]) and (not dTIM[1..X]) and (not CI_SSF[1..X])

Performance monitoring

None.

12.5.3 LCAS-capable virtual concatenated VC-n path layer functions Sn-Xv-L (n = 3, 4; X ≥ 1)

The LCAS-capable virtual concatenated VC-n path layer functions (Sn-Xv-L, n=3, 4) are instantiations of the generic functions defined in 10.1/G.806 (P-Xv-L), particularized with some technology-specific aspects.

The definitions in the present clause provide references to the appropriate generic function definitions in 10.1/G.806 and specify the technology-specific particularizations where necessary.

12.5.3.1 VC-n-Xv-L Layer Trail Termination Function Sn-Xv-L_TT

The Sn-Xv-L_TT function is further decomposed as defined in 10.1.1/G.806 and shown in Figure 12-64.

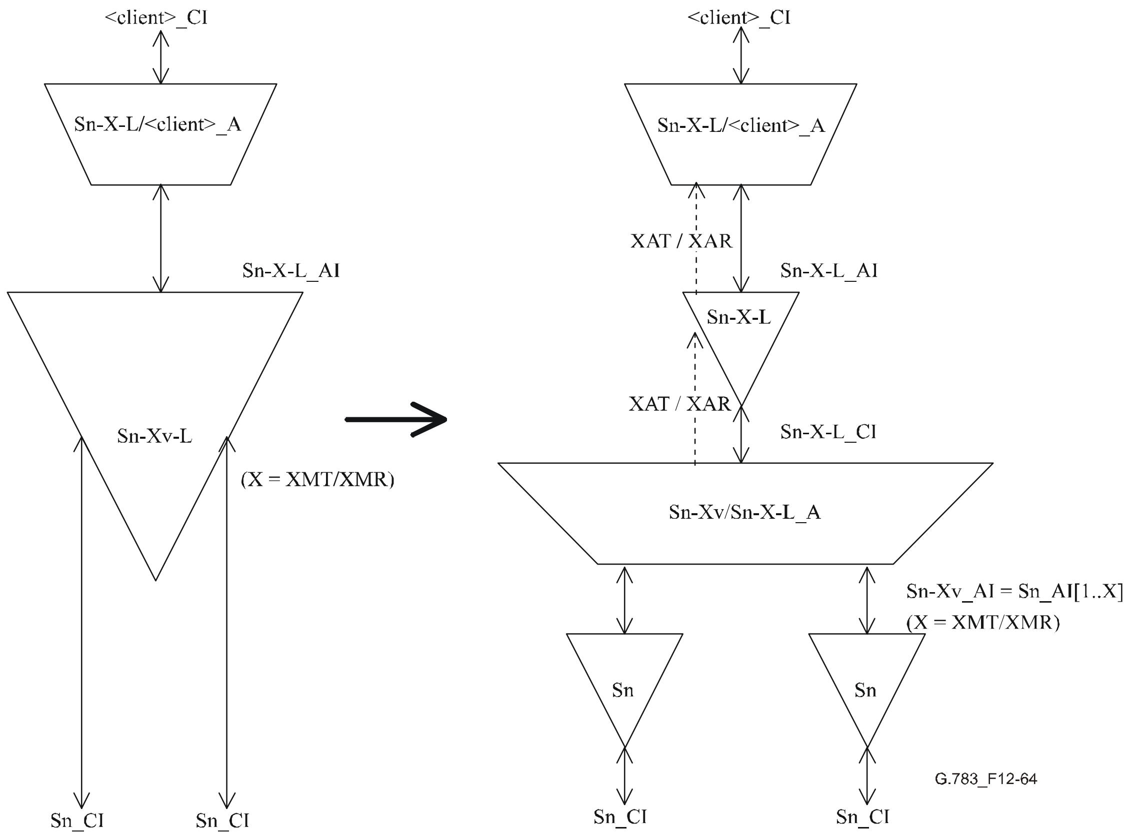


Figure 12-64/G.783 – Decomposition of Sn-Xv-L_TT function

The decomposition for this function is the same as for the corresponding generic function P-Xv-L_TT as defined in 10.1.1/G.806, with the following technology-specific particularizations:

- The path-layer "P-" is the Sn- layer.
- The Sn_TT functions are the normal VC-n trail termination functions as defined in 12.2.1.
- X_{MT}, $X_{MR} \leq 256$, according to the definitions in 11.2/G.707/Y.1322.

12.5.3.1.1 VC-n-Xv/VC-n-X-L Adaptation Source Function Sn-Xv/Sn-X-L_A_So

Symbol

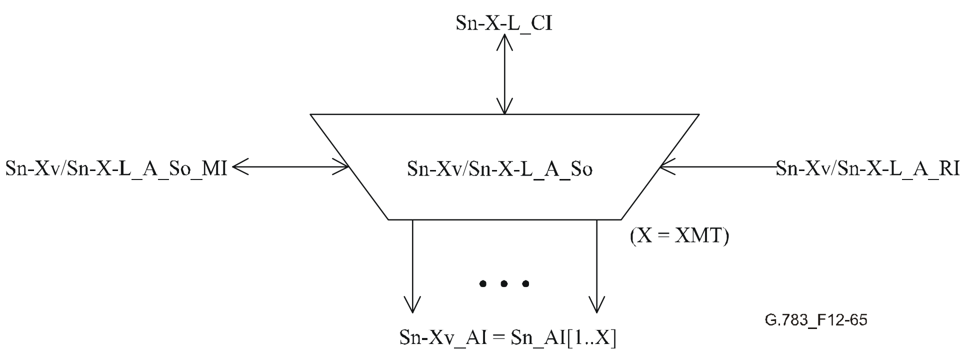


Figure 12-65/G.783 – Sn-Xv/Sn-X-L_A_So symbol

Interfaces

The interfaces for this function are the same as for the corresponding generic function P-Xv/P-X-L_A_So as defined in 10.1.1.1/G.806, with the following technology-specific particularizations:

- The path-layer "P-" is the Sn- layer.
- MST_Range = 255 (corresponding to the range as defined in 11.2/G.707/Y.1322).

Processes

The process definitions for this function are the same as for the corresponding generic function P-Xv/P-X-L_A_So as defined in 10.1.1.1/G.806, with the following technology-specific particularizations:

– **OH Extract**

The extracted overhead information _CI_OH consists of the following VC-n-X POH bytes: C2, F2, F3, K3.

– **Deinterleave (distribution process)**

The distribution process shall be as follows:

Starting from column 1 the Sn-X-L_CI_D signal shall be distributed to the X_{AT} VC-n as defined in Table 12-43.

Table 12-43/G.783 – Sn-X Distribution Mapping

Sn-X-L_CI_D column	Deinterleave output number	Deinterleave output column
1	1	1
…	…	…
X_{AT}	X_{AT}	1
$X_{AT} + 1$	1	2
...	...	...
$2 \times X_{AT}$	X_{AT}	2
$2 \times X_{AT} + 1$	1	3
...	...	...
$261/85 \times X_{AT}$	X_{AT}	261/85

Note that this mapping is uniform throughout the path overhead and payload columns. Also, note that this mapping is equivalent to the mapping defined in Table 12-34 for the payload columns.

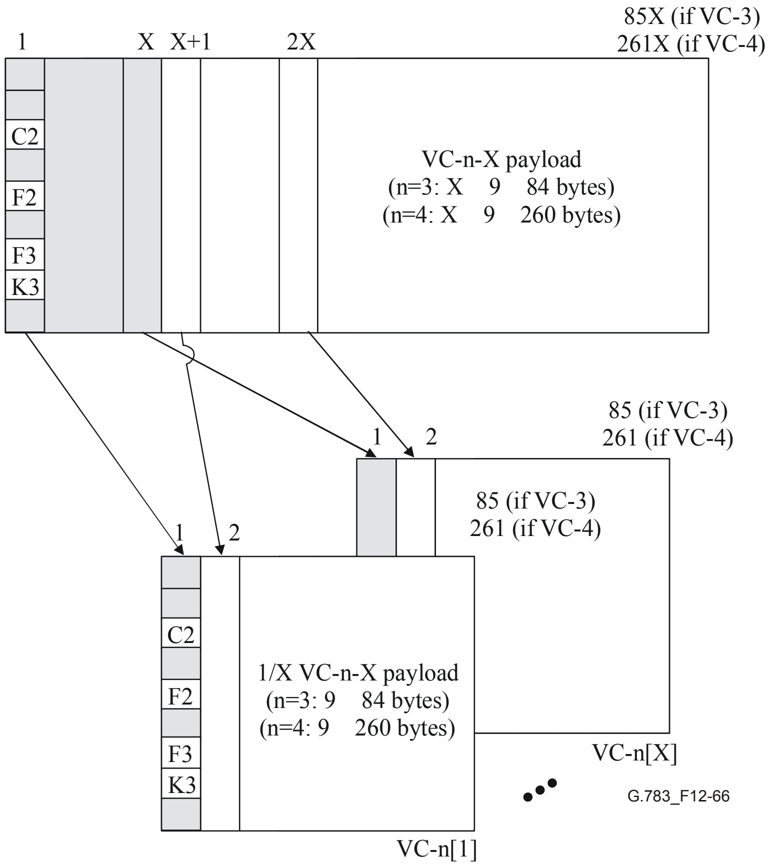


Figure 12-66/G.783 – Sn-Xv/Sn-X-L_A_So deinterleave process

For the outputs X_{AT}+1, X_{AT}+2, …, X_{MT}, this block inserts an all-ZEROS signal with the rate and format of a VC-n signal.

– **"Switch 1" (assignment of sequence numbers)**

For all non-payload-carrying outputs (_PC[s]=0) this process inserts an all-ZEROS signal with the rate and format of a VC-n signal.

– **VLI Insertion**

The VLI information consists of the value of the H4 byte, and has the coding defined in 11.2/G.707/Y.1322 for that overhead byte.

– **VLI Assemble and CRC**

The VLI information consists of the value of the H4 byte, and has the coding defined in 11.2/G.707/Y.1322 for that overhead byte. The CRC code used is the CRC-8 defined in 11.2/G.707/Y.1322.

Irrespective of the value of MI_LCASEnable, all unused fields in the H4 multiframe structure shall be sourced as zeros.

– **OH Insert**

The inserted overhead information _CI_OH consists of the following VC-n POH bytes: C2, F2, F3, K3.

Defects

See 10.1.1.1/G.806.

Consequent actions

See 10.1.1.1/G.806.

Defect correlations

See 10.1.1.1/G.806.

Performance monitoring

See 10.1.1.1/G.806.

12.5.3.1.2 VC-n-Xv/VC-n-X-L Adaptation Sink Function Sn-Xv/Sn-X-L_A_Sk

Symbol

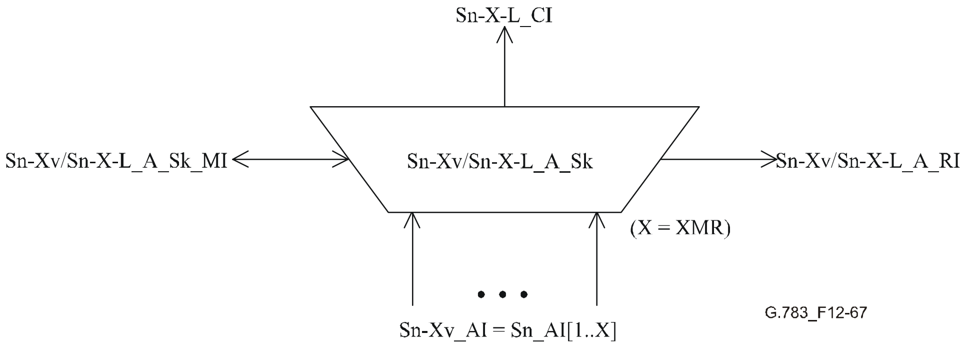


Figure 12-67/G.783 – Sn-Xv/Sn-X-L_A_Sk symbol

Interfaces

The interfaces for this function are the same as for the corresponding generic function P-Xv/P-X-L_A_Sk as defined in 10.1.1.2/G.806, with the following technology-specific particularizations:

- The path-layer "P-" is the Sn- layer.
- MST_Range = 255 (corresponding to the range as defined in 11.2/G.707/Y.1322).

Processes

The process definitions for this function are the same as for the corresponding generic function P-Xv/P-X-L_A_Sk as defined in 10.1.1.2/G.806, with the following technology-specific particularizations:

– **MFI Extract**

The multiframe alignment process shall be according to 8.2.5.1.

The _MFI[i] output consists of a 12-bit word with the value of the MFI contained in the H4 byte position in AI_D[i]. If AI_TSF[i]=true, then the _MFI[i] output of this process shall be an all-ONES 12-bit word.

The dLOM[i] detection for each member shall be as described in Defects below.

– **VLI, TSx Extract**

The VLI information consists of the value of the H4 byte, and has the coding defined in 11.2/G.707/Y.1322 for that overhead byte.

If _TSF[i] is false and dMND[i] is false, then the _VLI[i] output of this process is the value of the H4 byte position at the input of this process.

If _TSF[i] is true or dMND[i] is true, then the _VLI[i] output of this process shall be an all-ONES byte.

– **VLI Disassemble and CRC**

The VLI information consists of the value of the H4 byte, and has the coding defined in 11.2/G.707/Y.1322 for that overhead byte. The CRC code used is the CRC-8 defined in 11.2/G.707/Y.1322.

– **"Interleave process"**

The recovery process shall be as follows:

Starting from column 1, the Sn-X-L_CI signal shall be recovered from the X_{AR} VC-n as defined in Table 12-44.

Table 12-44/G.783 – Sn-X-L Recovery Mapping

Interleave input number	Interleave input column	Sn-X-L_CI column
1	1	1
…	…	…
X_{AR}	1	X_{AR}
1	2	$X_{AR} + 1$
...	...	...
X_{AR}	2	$2 \times X_{AR}$
1	3	$2 \times X_{AR} + 1$
...	...	...
X_{AR}	261/85	$261/85 \times X_{AR}$

Note that this mapping is uniform throughout the path overhead and payload columns. Also, note that this mapping is equivalent to the mapping defined in Table 12-36 for the payload columns. In particular, note that the POH column (column 1) of the Sn-X-L_CI signal will be obtained from the POH column from interleaver input 1, which in turn will be the payload-carrying member with the lowest sequence number.

Defects

Loss of Multiframe defect (dLOM): See 6.2.5.4.

Loss of Sequence defect (dSQM): See 10.1.1.2/G.806.

Member Not Deskewable (dMND): See 10.1.1.2/G.806.

Loss of Alignment (dLOA): See 10.1.1.2/G.806.

Consequent actions

See 10.1.1.2/G.806.

On declaration of aAIS, the function shall output all-ONEs signal within 250 µs; on clearing of aAIS, the function shall output normal data within 250 µs. The bit rate of this all-ONEs signal shall be consistent with the value of $\_X_{AR}$ as calculated by the processes involved.

Defect correlations

See 10.1.1.2/G.806.

Performance monitoring

See 10.1.1.2/G.806.

12.5.3.1.3 LCAS-capable VC-n-X-L Trail Termination Source Function Sn-X-L_TT_So

Symbol

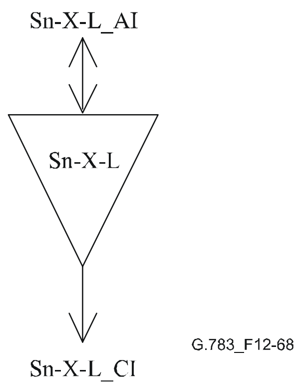


Figure 12-68/G.783 – Sn-X-L_TT_So symbol

Interfaces

The interfaces for this function are the same as for the corresponding generic function P-Xv/P-X-L_TT_So as defined in 10.1.1.3/G.806, with the following technology-specific particularizations:

- The path-layer "P-" is the Sn- layer.

Processes

See 10.1.1.3/G.806.

Defects

See 10.1.1.3/G.806.

Consequent actions

See 10.1.1.3/G.806.

Defect correlations

See 10.1.1.3/G.806.

Performance monitoring

See 10.1.1.3/G.806.

12.5.3.1.4 LCAS-capableVC-n-X-L Layer Trail Termination Sink Function Sn-X-L_TT_Sk

Symbol

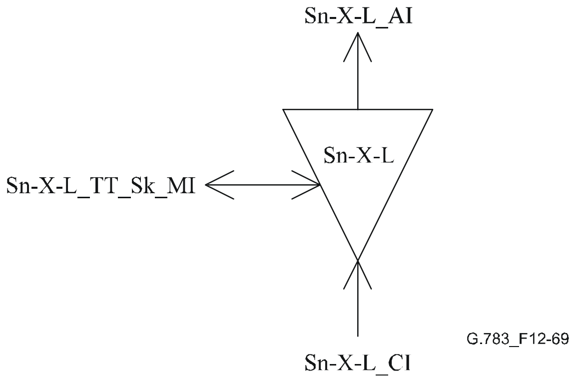


Figure 12-69/G.783 – Sn-X-L_TT_Sk symbol

Interfaces

The interfaces for this function are the same as for the corresponding generic function P-Xv/P-X-L_TT_Sk as defined in 10.1.1.4/G.806, with the following technology-specific particularizations:

- The path-layer "P-" is the Sn- layer.

Processes

See 10.1.1.4/G.806.

Defects

See 10.1.1.4/G.806.

Consequent actions

See 10.1.1.4/G.806.

Defect correlations

See 10.1.1.4/G.806.

Performance monitoring

See 10.1.1.4/G.806.

13 VC-m Path (Sm) Layer (m = 2, 12, 11)

The VC-m path layers are the VC-2, VC-12 and VC-11 path layers. In addition, virtually concatenated Sm-Xv (m = 2, 12, 11) signals may be carried by distributing the signal over X individual Sm signals. (See Figure 13-1.)

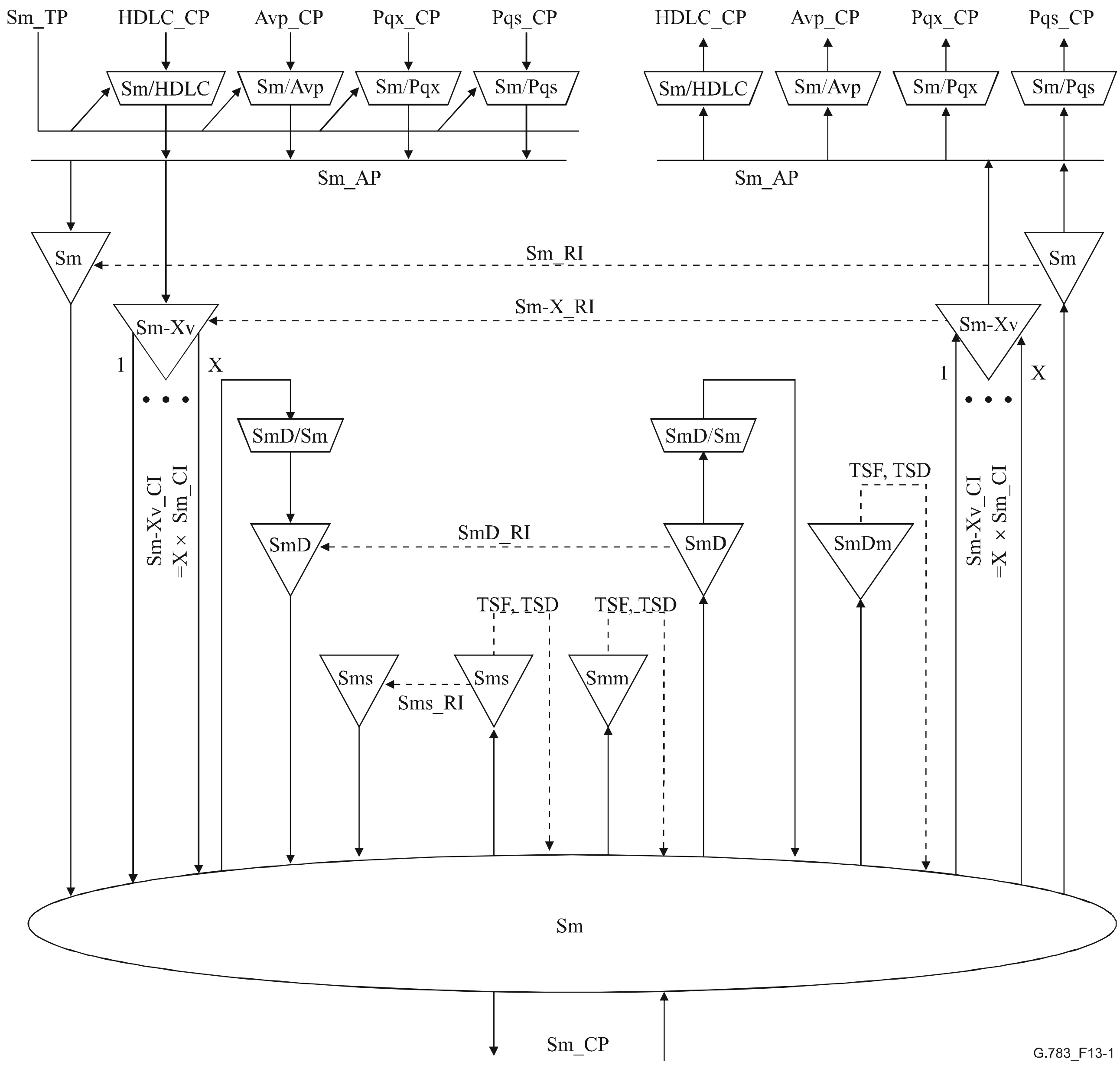


Figure 13-1/G.783 – VC-m path layer atomic functions

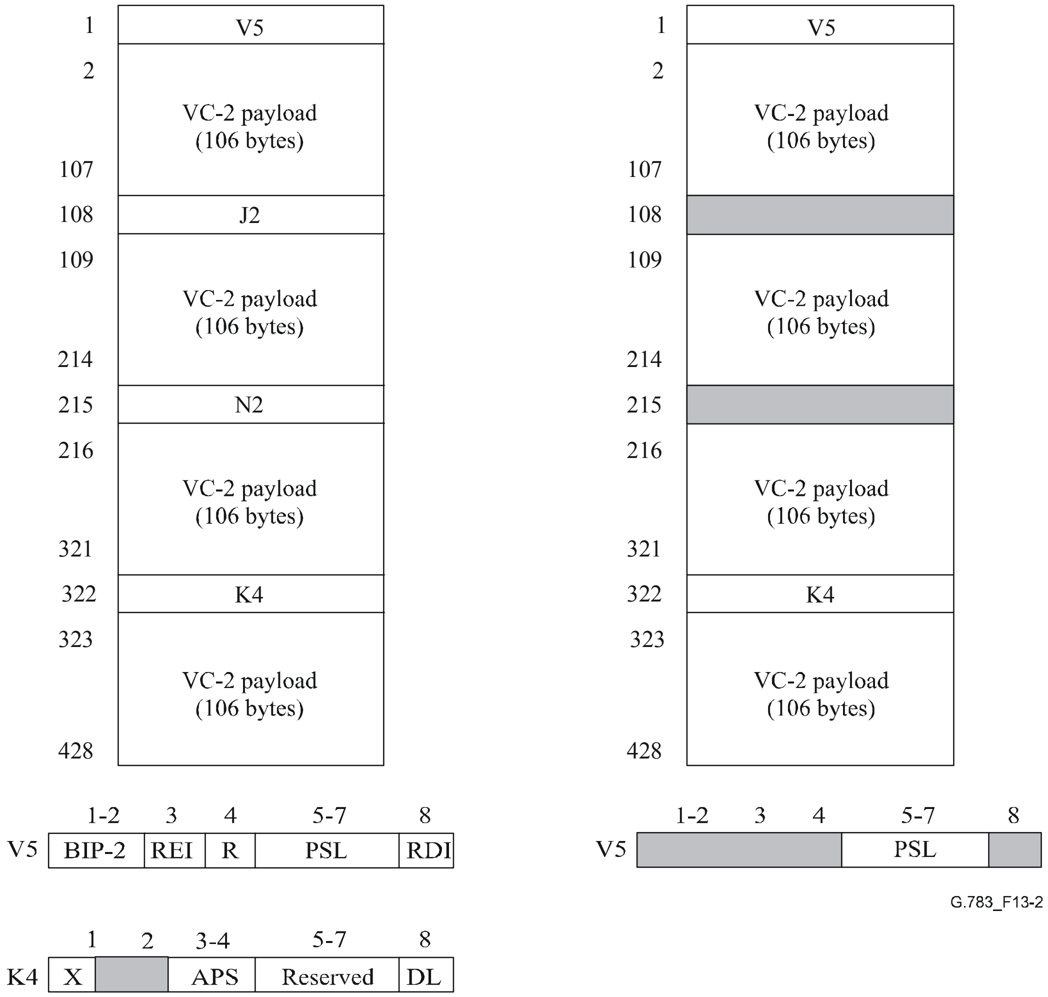
Sm Layer Characteristic Information

The Characteristic Information Sm_CI has co-directional timing and is octet structured with a 500 µs frame, as shown in Figures 13-2 to 13-7, left frames. Its format is characterized as the VC-m (m = (11, 12, 2)) trail termination overhead in the V5 and J2 bytes as defined in ITU-T Rec. G.707/Y.1322 plus the Sm Adapted Information given in the next subclause. Alternatively, it may be an unequipped signal as defined in ITU-T Rec. G.707/Y.1322.

For the case of a signal within the tandem connection sublayer, the Characteristic Information has defined Sm tandem connection trail termination overhead in location N2 as shown in Figures 13-3, 13-5 and 13-7.

Sm Layer Adaptation Information

The Adaptation Information AI is octet structured with an 500 µs frame as shown in Figures 13-2 to 13-7, right frames. It represents adapted client layer information comprising of client layer information, the signal label, and client-specific information. For the case where the signal has passed the trail protection sublayer (SmP), Sm_AI has defined APS bits (3 to 4) in byte K4.



NOTE 1 – Bit 4 of byte V5 is reserved. Currently, its value is undefined.

NOTE 2 – Bits 5 to 7 of byte K4 are reserved for an optional use as described in Appendix VII/G.707/Y.1322.

NOTE 3 – Bit 8 of K4 is allocated as path data link; its value will be undefined when the S2_CI has not been processed in a path data link sublayer atomic function.

Figure 13-2/G.783 – S2_CI_D (left) and S2_AI_D (right)

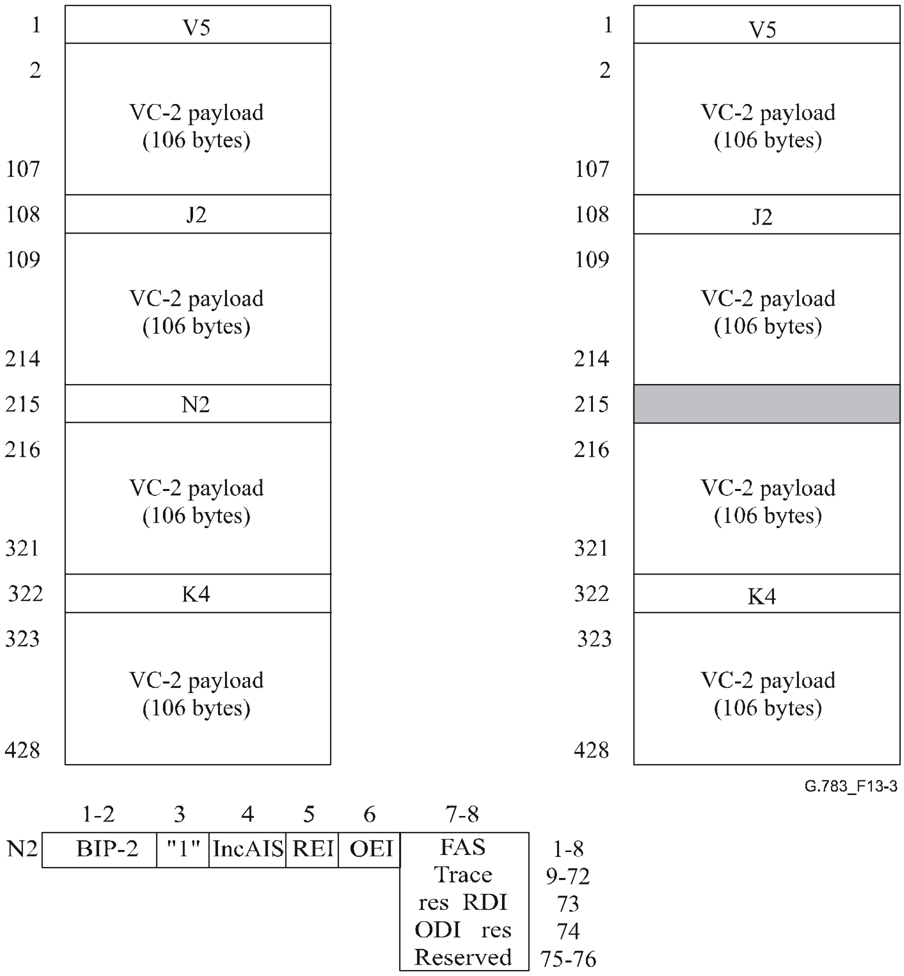
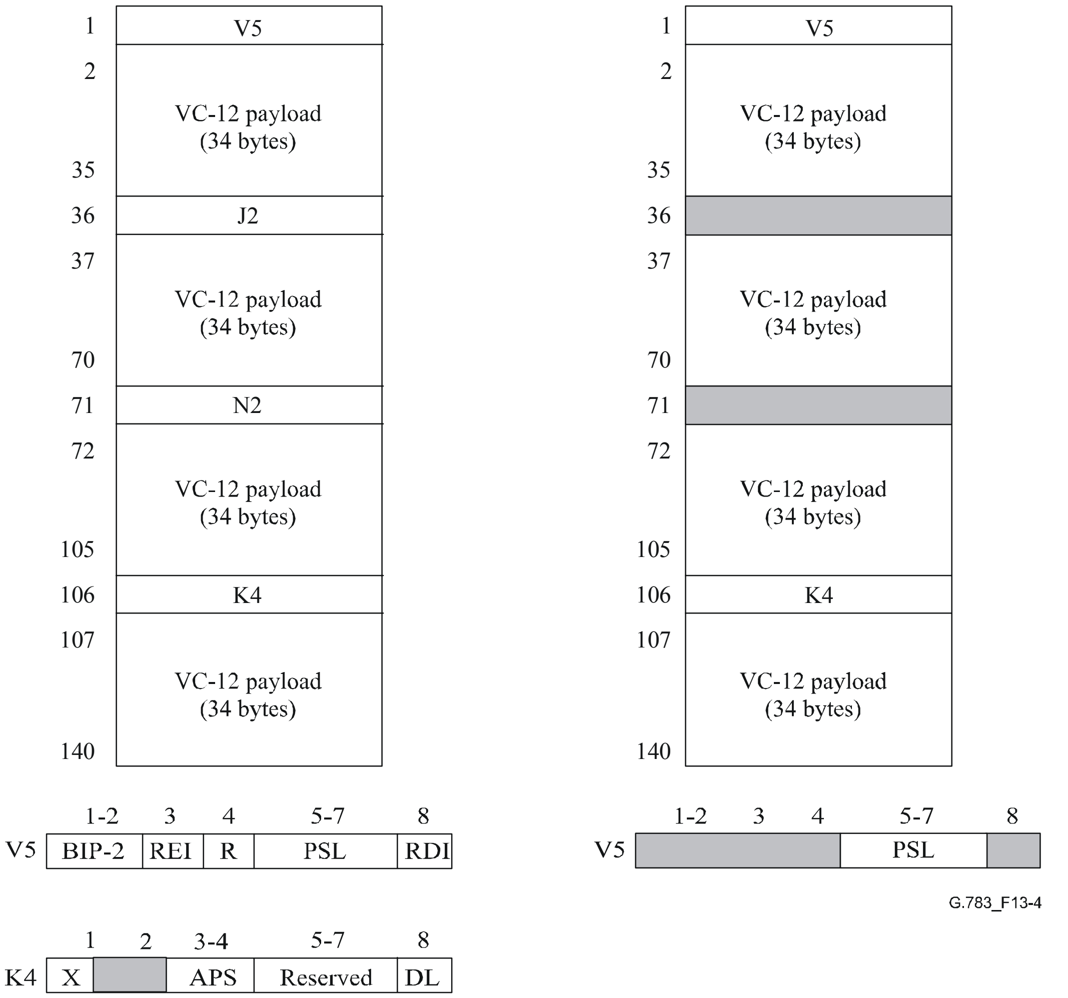


Figure 13-3/G.783 – S2_CI_D (left) with defined N2 and S2D_AI_D (right)



NOTE 1 – Bit 4 of byte V5 is reserved. Currently, its value is undefined.

NOTE 2 – Bits 5 to 7 of byte K4 are reserved for an optional use as described in Appendix VII/G.707/Y.1322.

NOTE 3 – Bit 8 of K4 is allocated as path data link; its value will be undefined when the S12_CI has not been processed in a path data link sublayer atomic function.

Figure 13-4/G.783 – S12_CI_D (left) and S12_AI_D (right)

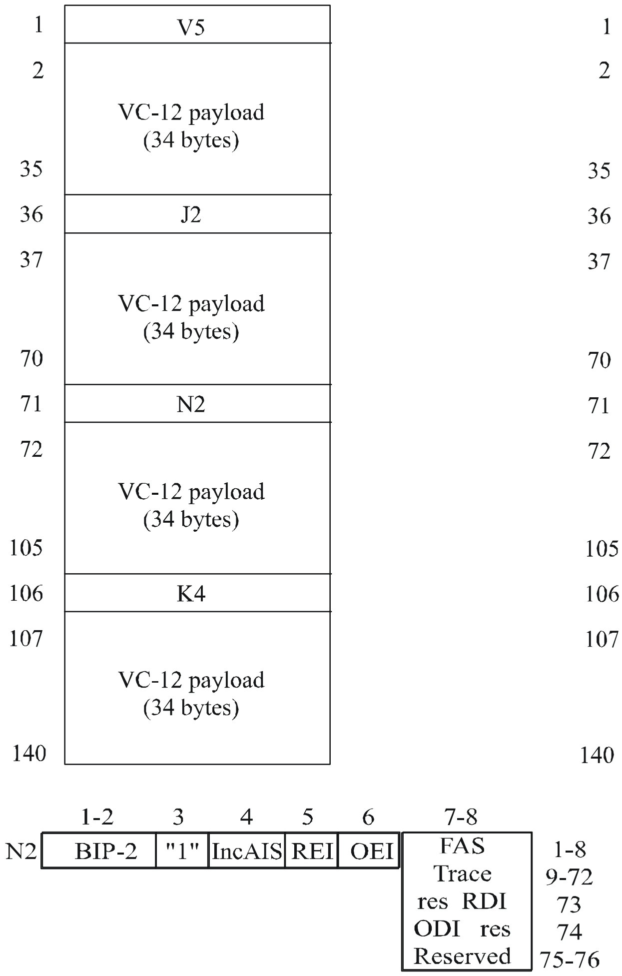
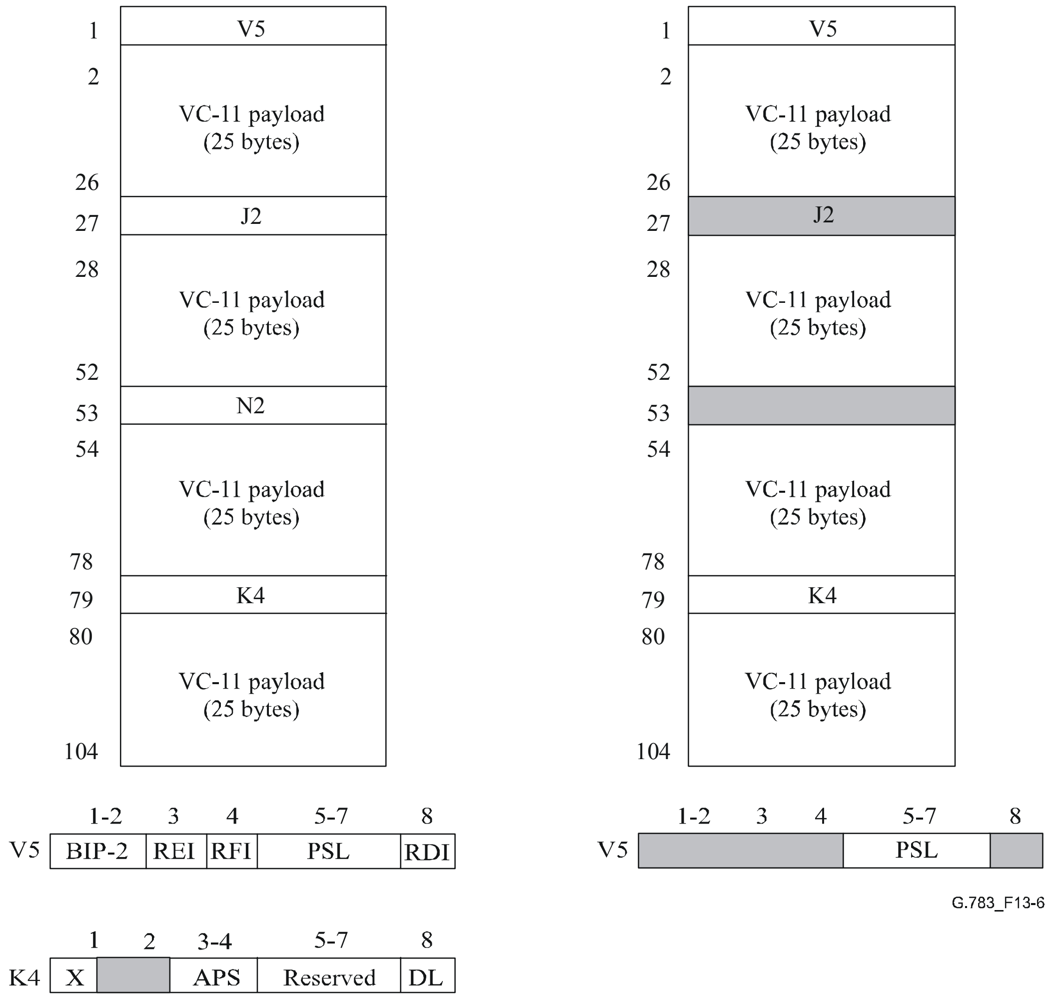


Figure 13-5/G.783 – S12_CI_D (left) with defined N2 and S12D_AI_D (right)



NOTE 1 – Bit 4 of byte V5 is defined as RFI for the case of 1544 kbit/s byte synchronous mapping into VC-11. In other mappings, e.g., asynchronous mapping, this bit is fixed to "0".
NOTE 2 – Bits 5 to 7 of byte K4 are reserved for an optional use as described in Appendix VII/G.707/Y.1322.
NOTE 3 – Bit 8 of K4 is allocated as path data link; its value will be undefined when the S11_C1 has not been processed in a path data link sublayer atomic function.

Figure 13-6/G.783 – S11_CI_D (left) and S11_AI_D (right)

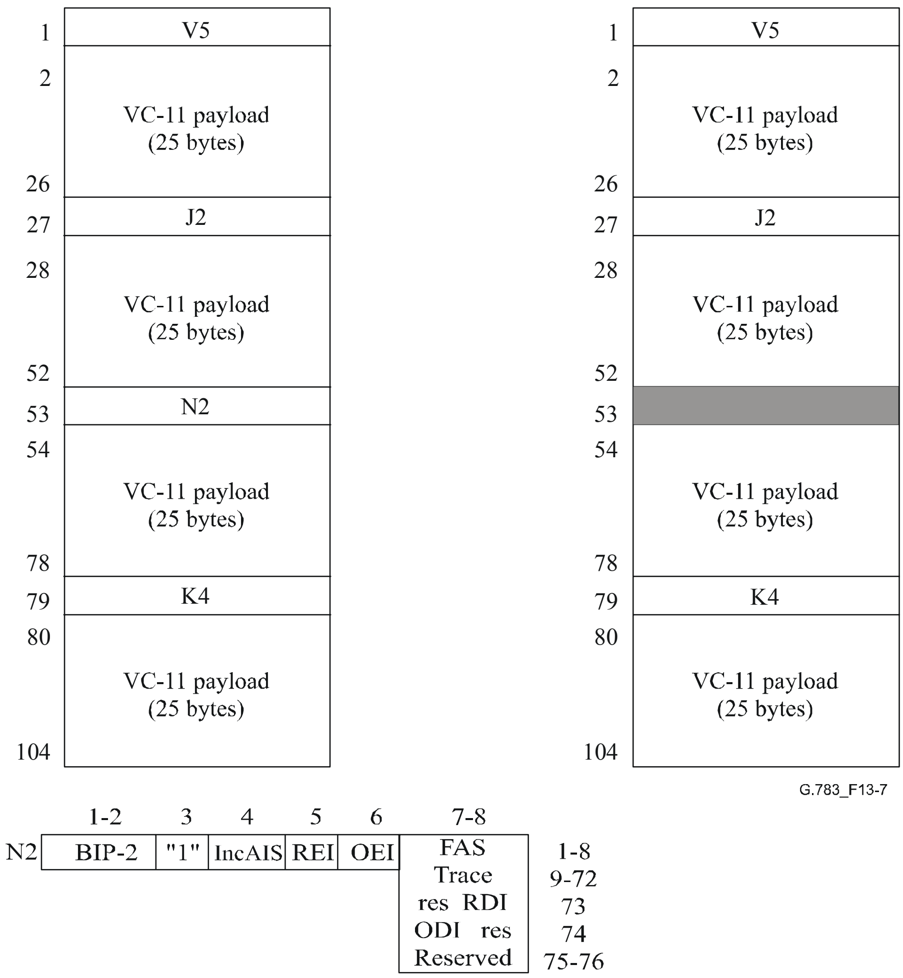


Figure 13-7/G.783 – S11_CI_D (left) with defined N2 and S11D_AI_D (right)

Layer functions:

Sm_C	VC-m layer connection function
Sm_TT	VC-m layer trail termination function
Smm_TT	VC-m non-intrusive monitor function
Sms_TT	VC-m supervisory-unequipped termination function
Sm/Pq_A	VC-m layer to Pq layer adaptation functions
SmP_C	VC-m linear trail protection connection function
SmP_TT	VC-m linear protection trail termination function
Sm/User_A	VC-m layer to user data adaptation function
Sm/RFI_A	VC-m layer to remote failure indication adaptation function
Sm/SmP_A	VC-m layer to VC-m linear trail protection adaptation function
SmD_TT	VC-m tandem connection trail termination function
SmD/Sm_A	VC-m tandem connection to VC-m adaptation function
SmDm_TT	VC-m tandem connection non-intrusive monitor function
Sm-X_TT	VC-m-X layer trail termination function
Sm/Sm-X_A	VC-m layer to VC-m-X layer adaptation function

13.1 Connection functions

13.1.1 VC-m Layer Connection Sm_C

Sm_C is the function which assigns VCs of level m (m = 11, 12, 2) at its input ports to VCs of level m at its output ports.

The Sm_C connection process is a unidirectional function as illustrated in Figure 13-8. The signal formats at the input and output ports of the function are similar, differing only in the logical sequence of the VC-ms. As the process does not affect the nature of the characteristic information of the signal, the reference point on either side of the Sm_C function is the same, as illustrated in Figure 13-8.

Incoming VC-ms at the Sm_CP are assigned to available outgoing VC-m capacity at the Sm_CP.

An unequipped VC-m shall be applied at any outgoing VC-m which is not connected to an incoming VC-m.

Symbol:

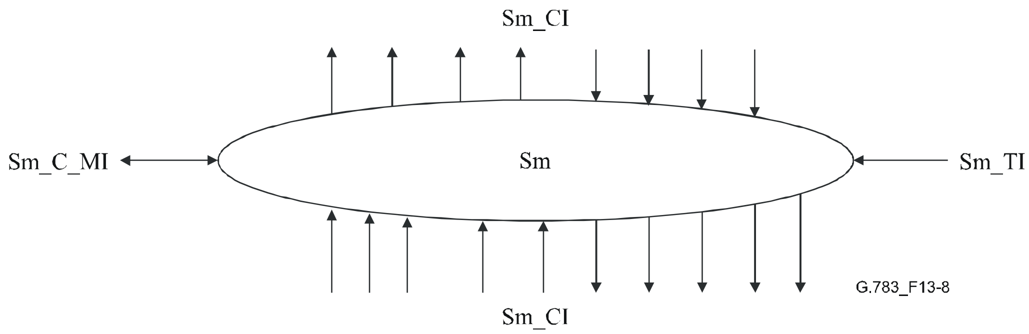


Figure 13-8/G.783 – Sm_C symbol

Interfaces

Table 13-1/G.783 – Sm_C input and output signals

Inputs	Outputs
Per Sm_CI, n × for the function: Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart Sm_CI_SSF Sm_AI_TSF Sm_AI_TSD 1 × per function: Sm_TI_Clock Sm_TI_FrameStart Per input and output connection point: Sm_C_MI_ConnectionPortIds Per matrix connection: Sm_C_MI_ConnectionType Sm_C_MI_Directionality Per SNC protection group: Sm_C_MI_PROTtype Sm_C_MI_OPERtype Sm_C_MI_WTRtime Sm_C_MI_HOtime Sm_C_MI_EXTCMD	Per Sm_CI, m × per function: Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart Sm_CI_SSF
NOTE – Protection status reporting signals are for further study.	

Processes

In the Sm_C function VC-m Layer Characteristic Information is routed between input (termination) connection points ((T)CPs) and output (T)CPs by means of matrix connections. (T)CPs may be allocated within a protection group.

NOTE 1 – Neither the number of input/output signals to the connection function, nor the connectivity, is specified in this Recommendation. That is a property of individual network elements. Examples of Sm_C configurations are the same as the Sn_C examples given in Appendix I/G.806, except that they refer to the Sm_CP rather than the Sn_CP.

Figure 13-1 presents a subset of the atomic functions that can be connected to this VC-m connection function: VC-m trail termination functions, VC-m non-intrusive monitor trail termination sink function, VC-m unequipped-supervisory trail termination functions, VC-m tandem connection trail termination and adaptation functions. In addition, adaptation functions in the VC-m server (e.g., VC 4 or VC-3) layers will be connected to this VC-m connection function.

Routing: The function shall be able to connect a specific input with a specific output by means of establishing a matrix connection between the specified input and output. It shall be able to remove an established matrix connection.

Each (matrix) connection in the Sm_C function should be characterized by the:

Type of connection:	unprotected, 1 + 1 protected (SNC/I, SNC/N or SNC/S protection)
Traffic direction:	unidirectional, bidirectional
Input and output connection points:	set of connection point

NOTE 2 – Broadcast connections are handled as separate connections to the same input CP.

NOTE 3 – For the case where a network element supports 1 + 1 protected matrix connections in its Sm_C function, this function may contain at any moment in time either all unprotected matrix connections, or all 1 + 1 protected matrix connections, or a mixture of unprotected and 1 + 1 protected matrix connections. The actual set of matrix connections and associated connection types and directions is an operational parameter controlled by network management.

Provided no protection switching action is activated/required, the following changes to (the configuration of) a connection shall be possible without disturbing the CI passing the connection:

– addition and removal of protection;
– addition and removal of connections to/from a broadcast connection;
– change between operation types;
– change of WTR time;
– change of Hold-off time.

Unequipped VC generation: The function shall generate an unequipped VC-m signal, as defined in ITU-T Rec. G.707/Y.1322.

Defects

None.

Consequent actions

If an output of this function is not connected to one of its inputs, the function shall connect the unequipped VC-m (with valid frame start (FS) and SSF = false) to the output.

Defect correlations

None.

Performance monitoring

None.

13.1.1.1 VC-m Subnetwork Connection Protection process

NOTE 1 – This process is active in the Sm_C function as many times as there are 1 + 1 protected matrix connections.

VC-m subnetwork connection protection mechanism is described in ITU-T Rec. G.841.

Figure 13-9 gives the atomic functions involved in SNC protection. Bottom to the left is the two (working and protection) adaptation function (Sn/Sm_A) pairs. Above them is the non-intrusive monitoring functions (Smm_TT_Sk); in case of SNC/I they are not present. To the right is either the trail termination functions (Sm_TT) or the adaptation functions (Sn/Sm_A) depending on whether the Sm trail is terminated at the same point the SNC protection is terminated, or at a later point.

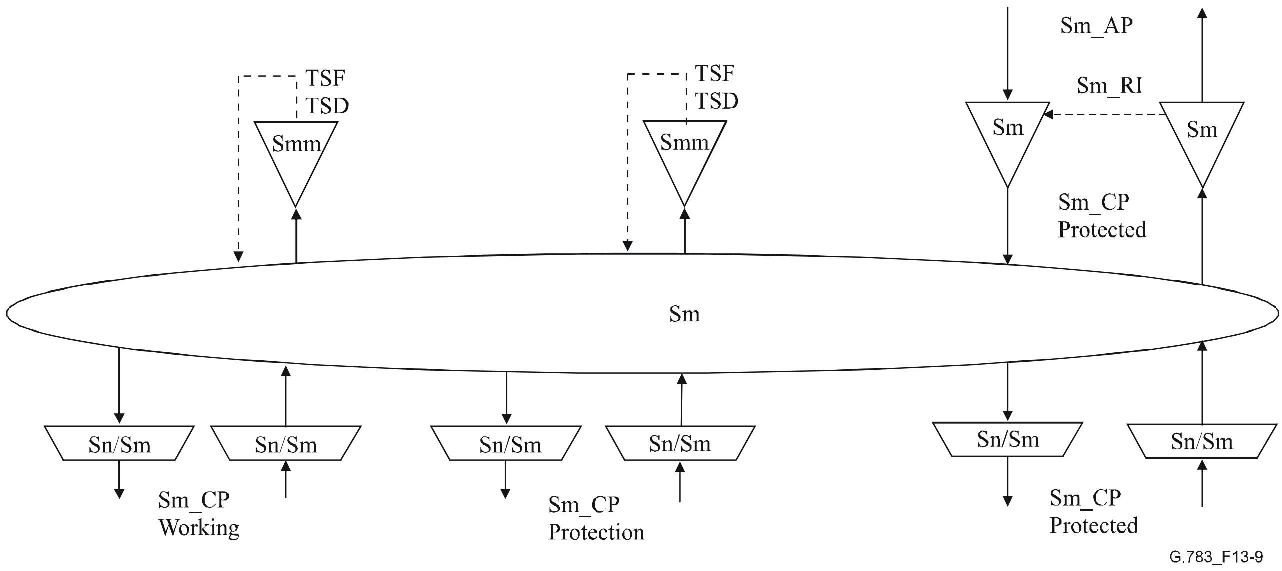


Figure 13-9/G.783 – VC-m SNC/N protection atomic functions

The Sm_C function may provide protection for the trail against channel-associated defects within a (sub)network connection.

The Sm_C functions at both ends operate the same way, by monitoring the subnetwork connections for defects, evaluating the system status taking into consideration the priorities of defect conditions and of external switch requests, and switching the appropriate channel to the protection (sub)network connection.

The signal flow associated with the Sm_C SNC protection process is described with reference to Figures 13-10 and 13-11. The Sm_C SNC protection process receives control parameters and external switch requests at the Sm_C_MP reference point from the synchronous equipment management function and outputs status indicators at the Sm_C_MP to the synchronous equipment management function, as a result of switch commands described in ITU-T Rec. G.841.

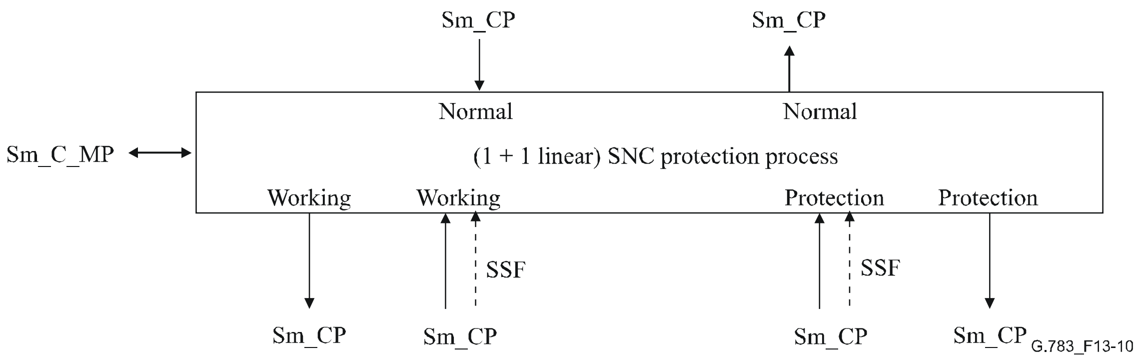


Figure 13-10/G.783 – VC-m inherent monitored subnetwork connection (SNC/I) protection process

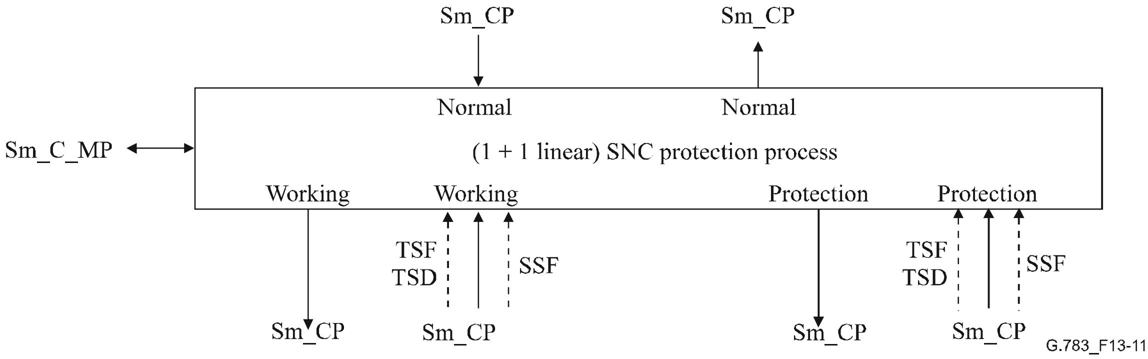


Figure 13-11/G.783 – VC-m non-intrusive monitored subnetwork connection (SNC/N) protection process

Source direction

Data at the Sm_CP is a VC-m trail signal.

For 1 + 1 architecture, the signal received at the Sm_CP from the Sn/Sm_A (or Sm_TT) function is bridged permanently at the Sm_CP to both working and protection Sn/Sm_A functions.

NOTE 2 – The basic element connected at the Sm_CP to the Sm_C is either a Sn/Sm_A or a Sm_TT. When the VC-m signal is terminated in this network element, it will be connected at the Sm_CP to a Sm_TT; otherwise, it will be connected at the Sm_CP to a Sn/Sm_A (for further transport).

Sink direction

Framed trail signals (data) Sm_CI are presented at the Sm_CP along with incoming timing references. The defect condition(s) SSF (and TSF and TSD) are also received at the Sm_CP from all Sn/Sm_A (or Smm_TT_Sk, m = (11, 12, 2)) functions.

For the SNC/I protection (see Figure 13-10), the trail signals pass the Sn/Sm_A functions. The SSF signals from the Sn/Sm_A_Sk are used by the Sm_C SNC protection process.

For the SNC/N protection (see Figure 13-11), the trail signals are broadcast to Smm_TT_Sk function for non-intrusive monitoring of the trail. The resultant TSF, TSD signals are used by the Sm_C SNC protection process instead of the SSF signal from the Sn/Sm_A.

Under normal conditions, Sm_C passes the data and timing from the working Sn/Sm_A functions to the Sn/Sm_A (or Sm_TT) function at the Sm_CP. The data and timing from the protection (sub)network connection is not forwarded.

If a switch is to be performed, then the data and timing received from the protection Sn/Sm_A at the Sm_CP is switched to the Sn/Sm_A (or Sm_TT) function at the Sm_CP, and the signal received from the working Sn/Sm_A at the Sm_CP is not forwarded.

Switch initiation criteria

Automatic protection switching is based on the defect conditions of the working and protection (sub)network connections. These condition(s) are for SNC/I server signal fail (SSF) and for SNC/N trail signal fail (TSF) and trail signal degrade (TSD). Detection of these conditions is described in 11.3.1 for Sn/Sm_A and in 12.2.2 for Smm_TT_Sk, m = (11, 12, 2).

The protection switch can also be initiated by switch commands received via the synchronous equipment management function. See the switch initiation criteria described in ITU-T Rec. G.841.

Switching time

Refer to ITU-T Rec. G.841 [19].

Switch restoration

In the revertive mode of operation, the working channel shall be restored, i.e., the signal on the protection (sub)network connection shall be switched back to the working (sub)network connection, when the working (sub)network connection has recovered from the fault.

To prevent frequent operation of the protection switch due to an intermittent fault, a failed (sub)network connection must become fault-free. After the failed (sub)network connection 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 SSF, TSF or TSD condition shall override the WTR.

13.2 Termination functions

13.2.1 VC-m Layer Trail Termination Sm_TT

The Sm_TT source function creates a VC-m (m = 11, 12, 2) at the Sm_CP by generating and adding POH to a container C-m from the Sm_AP. 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 ITU-T Rec. G.707/Y.1322.

Data at the Sm_AP takes the form of a container C-m (m = 1, 2) which is synchronized to the timing reference Sm_TP.

Synchronously adapted information in the form of synchronous containers (data) and the associated container frame offset information (frame offset) are received at the Sm_AP.

13.2.1.1 VC-m Layer Trail Termination Source Sm_TT_So

This function adds error monitoring and status overhead bits to the Sm_AP.

Data at the Sm_AP is a VC-m (m = 11, 12, 2), having a payload as described in ITU-T Rec. G.707/Y.1322, but with indeterminate VC-m POH bytes: J2, V5. These POH bytes are set as part of the Sm_TT function and the complete VC-m is forwarded to the Sm_CP.

Symbol

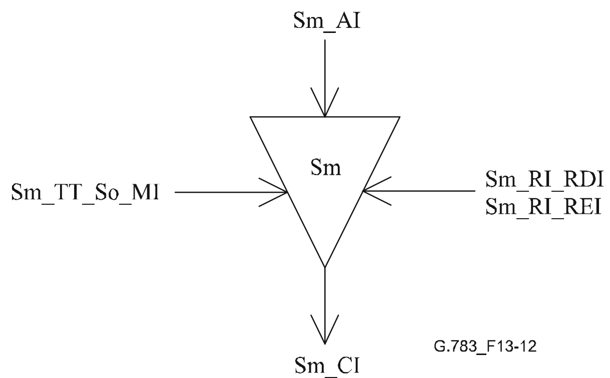


Figure 13-12/G.783 – Sm_TT_So symbol

Interfaces

Table 13-2/G.783 – Sm_TT_So input and output signals

Inputs	Outputs
Sm_AI_Data Sm_AI_Clock Sm_AI_FrameStart Sm_RI_RDI Sm_RI_REI Sm_TT_So_MI_TxTI	Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart

Processes

J2: The trail trace identifier should be generated. Its value is derived from reference point Sm_TT_So_MP. The path trace format is described in 6.2.2.2/G.806.

V5[1, 2]: BIP-2 shall be calculated on data at the Sm_CP on the previous frame and the result transmitted in bits 1 and 2 of the V5 byte.

V5[3]: The number of errors indicated in RI_REI is encoded in the REI bit. Upon the detection of a number of errors at the termination sink function, the trail termination source function shall have inserted that value in the REI bit within 4 ms.

V5[8]: When there is an active RI_RDI, the RDI indication shall be sent in bit 8 of the V5 byte. Upon the declaration/clearing of aRDI at the termination sink function, the trail termination source function shall have inserted/removed the RDI code within 4 ms.

K4[5-7]: Reserved for optional use of enhanced-RDI (E-RDI) described in Appendix VI. If this option is not used, bits 5-7 of byte K4 shall be set to "000" or "111".

N2: This byte is undefined.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

13.2.1.2 VC-m Layer Trail Termination Sink Sm_TT_Sk

This function monitors the VC-m (m = (11, 12 or 2)) for errors, and recovers the trail termination status. It extracts the payload-independent overhead bytes/bits (J2, V5[1-2], V5[3], V5[5-7], V5[8]) from the VC-m layer Characteristic Information.

Symbol

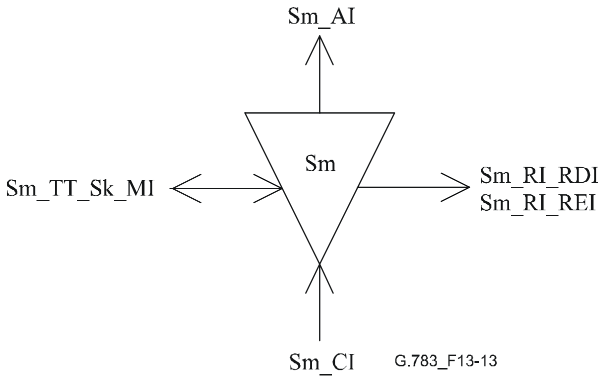


Figure 13-13/G.783 – Sm_TT_Sk symbol

Interfaces

Table 13-3/G.783 – Sm_TT_Sk input and output signals

Inputs	Outputs
Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart Sm_CI_SSF Sm_TT_Sk_MI_TPmode Sm_TT_Sk_MI_ExTI Sm_TT_Sk_MI_RDI_Reported Sm_TT_Sk_MI_SSF_Reported Sm_TT_Sk_MI_DEGTHR Sm_TT_Sk_MI_DEGM Sm_TT_Sk_MI_EXC_X Sm_TT_Sk_MI_DEG_X Sm_TT_Sk_MI_1second Sm_TT_Sk_MI_TIMdis Sm_TT_Sk_MI_TIMAISdis	Sm_AI_Data Sm_AI_Clock Sm_AI_FrameStart Sm_AI_TSF Sm_AI_TSD Sm_RI_RDI Sm_RI_REI Sm_TT_Sk_MI_cTIM Sm_TT_Sk_MI_cUNEQ Sm_TT_Sk_MI_cEXC Sm_TT_Sk_MI_cDEG Sm_TT_Sk_MI_cRDI Sm_TT_Sk_MI_cSSF Sm_TT_Sk_MI_AcTI Sm_TT_Sk_MI_pN_EBC Sm_TT_Sk_MI_pN_DS Sm_TT_Sk_MI_pF_EBC Sm_TT_Sk_MI_pF_DS

Processes

J2: The trail trace identifier is recovered from VC-m POH at the Sm_CP and processed as specified in 6.2.2.2/G.806. The accepted value of J2 is also available at the Sm_TT_Sk_MP. For further description of trace identifier mismatch processing, see 6.2.2.2/G.806

V5[5-7]: The unequipped defect is processed as described in 6.2.1.3/G.806.

V5[1, 2]: The error monitoring bits at the Sm_CP shall be recovered. 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 and 2 from the following frame.

The process for detecting excessive errors and signal degrade is described in 6.2.3.1/G.806.

V5[3]: The REI shall be recovered and the derived performance primitives should be reported at the Sm_TT_Sk_MP.

V5[8]: The RDI defect is processed as described in 6.2.6.3/G.806.

N2: The network operator byte is defined for TC monitoring. It shall be ignored by this function.

K4[5-7]: These bits are reserved for an optional use of enhanced RDI (E-RDI) described in Appendix VI. If this option is not used, the content of these bits shall be ignored.

Defects

The function shall detect for dUNEQ, dTIM, dEXC, dDEG and dRDI defects according to the specification in 6.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aAIS ← dUNEQ or (dTIM and not TIMAISdis)

aRDI ← CI_SSF or dUNEQ or dTIM

aREI ← "number of error detection code violations"

aTSF ← CI_SSF or dUNEQ or (dTIM and not TIMAISdis)

aTSFprot ← aTSF or dEXC

aTSD ← dDEG

Defect correlations

The function shall perform the following defect correlation to determine the most probable fault cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cSSF ← CI_SSF and MON and SSF_Reported

cUNEQ ← dUNEQ and MON

cTIM ← dTIM and (not dUNEQ) and MON

cEXC ← dEXC and (not dTIM or TIMAISdis) and MON

cDEG ← dDEG and (not dTIM or TIMAISdis) and MON

cRDI ← dRDI and (not dUNEQ) and (not dTIM or TIMAISdis) and MON and RDI_Reported

Performance monitoring

The function shall perform the following performance monitoring primitives processing (see 6.5/G.806). The performance monitoring primitives shall be reported to the SEMF.

pN_DS ← CI_SSF or dUNEQ or dTIM or dEQ

pF_DS ← dRDI

pN_EBC ← Σ nN_B

pF_EBC ← Σ nF_B

NOTE – There may be a possible discrepancy between PM reports at an S12m_TT_Sk and a S11_TT_Sk for a VC-11 trail (refer to S4/S11*_A).

13.2.2 VC-m Layer non-intrusive monitor

Two versions of the VC-m non-intrusive monitor are defined.

Version 1 is only applicable for the supervision of equipped VC-ms. It cannot be used for the supervision of supervisory-unequipped VCs as the unequipped defect will constantly be active and as a consequence activates TSF and suppresses other defects.

Version 2 is applicable for the supervision of equipped and supervisory-unequipped VCs, as the unequipped defect is correlated with an accepted trace identifier of all 0s.

13.2.2.1 VC-m Layer Non-Intrusive Monitor, version 1 Smm1_TT_Sk

Version 1 of the VC-m Path overhead monitoring functions is only applicable for the supervision of equipped VCs.

This function monitors the VC-m (m = (11, 12 or 2)) for errors, and recovers the trail termination status. It extracts the payload-independent overhead bytes/bits (J2, V5[1-2], V5[3], V5[5-7], V5[8]) from the VC-m layer Characteristic Information.

Symbol

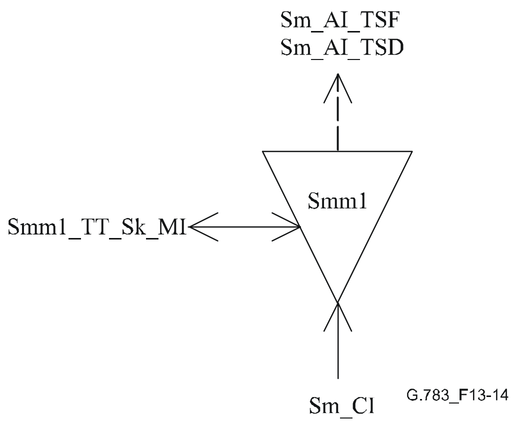


Figure 13-14/G.783 – Smm1_TT_Sk symbol

Interfaces

Table 13-4/G.783 – Smm1_TT_Sk input and output signals

Inputs	Outputs
Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart Sm_CI_SSF Smm1_TT_Sk_MI_TPmode Smm1_TT_Sk_MI_ExTI Smm1_TT_Sk_MI_RDI_Reported Smm1_TT_Sk_MI_SSF_Reported Smm1_TT_Sk_MI_DEGTHR Smm1_TT_Sk_MI_DEGM Smm1_TT_Sk_MI_EXC_X Smm1_TT_Sk_MI_DEG_X Smm1_TT_Sk_MI_1second Smm1_TT_Sk_MI_TIMdis	Sm_AI_TSF Sm_AI_TSD Smm1_TT_Sk_MI_cTIM Smm1_TT_Sk_MI_cUNEQ Smm1_TT_Sk_MI_cDEG Smm1_TT_Sk_MI_cEXC Smm1_TT_Sk_MI_cRDI Smm1_TT_Sk_MI_cSSF Smm1_TT_Sk_MI_AcTI Smm1_TT_Sk_MI_pN_EBC Smm1_TT_Sk_MI_pF_EBC Smm1_TT_Sk_MI_pN_DS Smm1_TT_Sk_MI_pF_DS

Processes

J2: The trail trace identifier is recovered from VC-m POH at the Sm_CP. The accepted value of J2 is also available at the Smm1_TT_Sk_MP. For further description of trace identifier mismatch processing, see 6.2.2.2/G.806.

V5[5-7]: The signal label bits at the Sm_CP shall be recovered. For further description of unequipped defect processing, see 6.2.1.3/G.806. The function shall detect for an AIS VC (VC-AIS) condition by monitoring the VC SL for code "111". For further description of VC AIS defect processing, see 6.2.6.2/G.806.

V5[1, 2]: The error monitoring bits at the Sm_CP shall be recovered. 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 and 2 from the following frame.

The process for detecting excessive errors and signal degrade from V5 bits [1, 2] is described in 6.2.3.1/G.806.

V5[3]: REI in bit 3 shall be recovered and the derived performance primitives should be reported at the Smm1_TT _MP. See below.

V5[8]: The path RDI information in bit 8 shall be recovered and reported at the Smm1_TT_Sk_MP. For further description of RDI defect processing, see 6.2.6.3/G.806.

N2: The network operator byte is defined for TC monitoring. It shall be ignored by this function.

Defects

The function shall detect for dUNEQ, dTIM, dEXC, dDEG, dAIS and dRDI defects according to the specification in 6.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aTSF ← CI_SSF or dAIS or dUNEQ or (dTIM and not TIMAISdis)

aTSFprot ← dEXC or aTSF

aTSD ← dDEG

Defect correlations

The function shall perform the following defect correlation to determine the most probable fault cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cSSF ← (CI_SSF or dAIS) and SSF_Reported and MON

cUNEQ ← dUNEQ and MON

cTIM ← dTIM and (not dUNEQ) and MON

cEXC ← dEXC and (not dTIM or TIMAISdis) and MON

cDEG ← dDEG and (not dTIM or TIMAISdis) and MON

cRDI ← dRDI and (not dUNEQ) and (not dTIM or TIMAISdis) and MON and RDI_Reported

Performance monitoring

The function shall perform the following performance monitoring primitives processing (see 6.5/G.806). The performance monitoring primitives shall be reported to the SEMF.

pN_DS ← CI_SSF or dAIS or dUNEQ or dTIM or dEQ

pF_DS ← dRDI

pN_EBC ← Σ nN_B

pF_EBC ← Σ nF_B

NOTE – There may be a possible discrepancy between PM reports at an S12m1_TT_Sk and a S11_TT_Sk for a VC-11 trail (refer to S4/S11*_A).

13.2.2.2 VC-m Layer Non-Intrusive Monitor, version 2 Smm2_TT_Sk

Version 2 of the VC-m Path overhead monitor functions is applicable for supervision of equipped and supervisory unequipped VCs.

This function monitors the VC-m (m = (11, 12 or 2)) for errors, and recovers the trail termination status. It extracts the payload-independent overhead bytes/bits (J2, V5[1-2], V5[3], V5[5-7], V5[8]) from the VC-m layer Characteristic Information.

Symbol

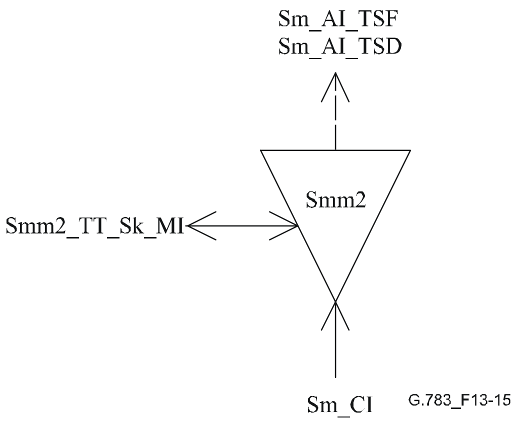


Figure 13-15/G.783 – Smm2_TT_Sk symbol

Interfaces

Table 13-5/G.783 – Smm2_TT_Sk input and output signals

Inputs	Outputs
Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart Sm_CI_SSF Smm2_TT_Sk_MI_TPmode Smm2_TT_Sk_MI_ExTI Smm2_TT_Sk_MI_RDI_Reported Smm2_TT_Sk_MI_DEGTHR Smm2_TT_Sk_MI_DEGM Smm2_TT_Sk_MI_EXC_X Smm2_TT_Sk_MI_DEG_X Smm2_TT_Sk_MI_1second Smm2_TT_Sk_MI_TIMdis Smm2_TT_Sk_MI_SSF_Reported	Sm_AI_TSF Sm_AI_TSD Smm2_TT_Sk_MI_cTIM Smm2_TT_Sk_MI_cUNEQ Smm2_TT_Sk_MI_cDEG Smm2_TT_Sk_MI_cEXC Smm2_TT_Sk_MI_cRDI Smm2_TT_Sk_MI_cSSF Smm2_TT_Sk_MI_AcTI Smm2_TT_Sk_MI_pN_EBC Smm2_TT_Sk_MI_pF_EBC Smm2_TT_Sk_MI_pN_DS Smm2_TT_Sk_MI_pF_DS

Processes

J2: The trail trace identifier is recovered from VC-m POH at the Sm_CP. The accepted value of J2 is also available at the Smm2_TT_Sk_MP. For further description of trace identifier mismatch processing, see 6.2.2.2/G.806.

V5[5-7]: The signal label bits at the Sm_CP shall be recovered. For further description of unequipped defect processing, see 6.2.1.3/G.806. The function shall detect for an AIS VC (VC-AIS) condition by monitoring the VC SL for code "111". For further description of VC AIS defect processing, see 6.2.6.2/G.806.

V5[1, 2]: The error monitoring bits at the Sm_CP shall be recovered. 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 and 2 from the following frame.

The process for detecting excessive errors and signal degrade from V5 bits [1, 2] is described in 6.2.3.1/G.806.

V5[3]: REI in bit 3 shall be recovered and the derived performance primitives should be reported at the Smm2_TT _MP. See below.

V5[8]: The path RDI information in bit 8 shall be recovered and reported at the Smm2_TT_Sk_MP. For further description of RDI defect processing, see 6.2.6.3/G.806.

N2: The network operator byte is defined for TC monitoring. It shall be ignored by this function.

Defects

The function shall detect for dUNEQ, dTIM, dEXC, dDEG, dAIS and dRDI defects according to the specification in 6.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aTSF ← CI_SSF or dAIS or (dUNEQ and (AcTI = all "0"s)) or (dTIM and not TIMAISdis)

aTSFprot ← dEXC or aTSF

aTSD ← dDEG

Defect correlation

The function shall perform the following defect correlation to determine the most probable fault cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cUNEQ ← dUNEQ and (AcTI = all "0"s) and MON

cTIM ← dTIM and not (dUNEQ and (AcTI = all "0"s)) and MON

cEXC ← dEXC and (not dTIM or TIMAISdis) and MON

cDEG ← dDEG and (not dTIM or TIMAISdis) and MON

cRDI ← dRDI and not (dUNEQ and (AcTI = all "0"s)) and (not dTIM or TIMAISdis) and MON and RDI_Reported

cSSF ← (CI_SSF or dAIS) and MON and SSF_Reported

Performance monitoring

The function shall perform the following performance monitoring primitives processing (see 6.5/G.806). The performance monitoring primitives shall be reported to the SEMF.

pN_DS ← CI_SSF or dAIS or (dUNEQ and (AcTI = all "0"s)) or dTIM or dEQ

pF_DS ← dRDI

pN_EBC ← Σ nN_B

pF_EBC ← Σ nF_B

NOTE – There may be a possible discrepancy between PM reports at an S12m2_TT_Sk and a S11_TT_Sk for a VC-11 trail (refer to S4/S11*_A).

13.2.3 VC-m Layer Supervisory-Unequipped Termination Sms_TT

The Smm_TT function creates a VC-m (m = 11, 12, 2) at the Sm_CP by generating and adding POH to an undefined 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 ITU-T Rec. G.707/Y.1322.

NOTE – The Sms_TT (m = (11, 12, 2)) function generates and monitors supervisory unequipped signals.

13.2.3.1 VC-m Layer Supervisory-Unequipped Termination Source Sms_TT_So

This function generates error monitoring and status overhead bytes to an undefined VC-m (m = (11, 12 or 2)).

Symbol

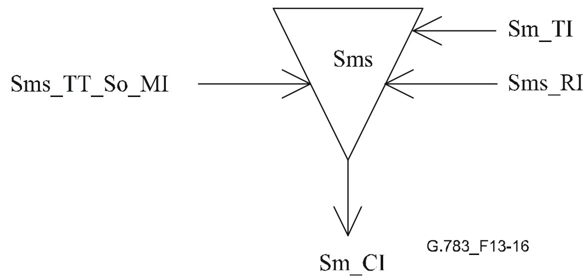


Figure 13-16/G.783 – Sms_TT_So symbol

Interfaces

Table 13-6/G.783 – Sms_TT_So input and output signals

Inputs	Outputs
Sms_RI_RDI Sms_RI_REI Sm_TI_Clock Sm_TI_FrameStart Sms_RI_RDI Sms_RI_REI Sms_TT_So_MI_TxTI	Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart

Processes

An undefined VC-m (m = (11, 12 or 2)) should be generated.

V5[5-7]: Signal label 000 (unequipped) should be inserted in the VC-m.

J2: The trail trace identifier should be generated. Its value is derived from reference point Sms_TT_MP. The trail trace format is described in 6.2.2.2/G.806.

V5[1, 2]: BIP-2 shall be calculated on data at the Sms_AP on the previous frame and the result transmitted in bits 1 and 2 of the V5 byte.

V5[3]: The number of errors indicated in RI_REI is encoded in the REI. Upon the detection of a number of errors at the termination sink function the trail termination source function shall have inserted that value in the REI bit within 4 ms.

V5[8]: Bit 8 of byte V5, a RDI indication, shall be set to "1/0" on activation/clearing of RI_RDI. Upon the declaration/clearing of aRDI at the termination sink function, the trail termination source function shall have inserted/removed the RDI code within 4 ms.

K4[5-7]: The function shall insert in bits 5, 6 and 7 of byte K4 the code "000" or "111".

NOTE – The support of the enhanced RDI application is for further study.

N2: In the TCM byte, 00000000 should be inserted.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

13.2.3.2 VC-m Layer Supervisory-Unequipped Termination Sink Sms_TT_Sk

This function monitors VC-m (m = (11, 12 or 2)) for errors, and recovers the trail termination status. It extracts the payload-independent overhead bytes/bits (J2, V5[1-2], V5[3], V5[5-7], V5[8]) from the VC-m layer Characteristic Information.

Symbol

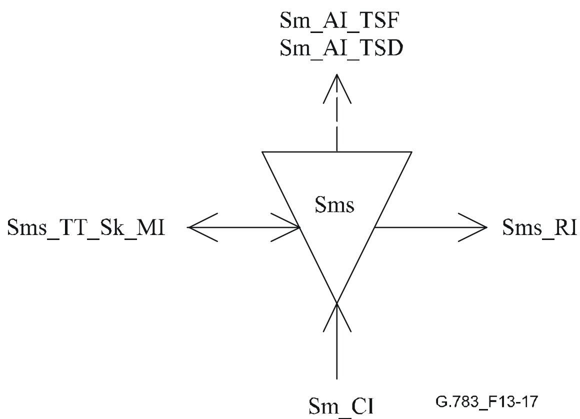


Figure 13-17/G.783 – Sms_TT_Sk symbol

Interfaces

Table 13-7/G.783 – Sms_TT_Sk input and output signals

Inputs	Outputs
Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart Sm_CI_SSF Sms_TT_Sk_MI_TPmode Sms_TT_Sk_MI_ExTI Sms_TT_Sk_MI_RDI_Reported Sms_TT_Sk_MI_SSF_Reported Sms_TT_Sk_MI_DEGTHR Sms_TT_Sk_MI_DEGM Sms_TT_Sk_MI_EXC_X Sms_TT_Sk_MI_DEG_X Sms_TT_Sk_MI_1second Sms_TT_Sk_MI_TIMdis	Sm_AI_TSF Sm_AI_TSD Sm_RI_RDI Sm_RI_REI Sms_TT_Sk_MI_cTIM Sms_TT_Sk_MI_cUNEQ Sms_TT_Sk_MI_cDEG Sms_TT_Sk_MI_cEXC Sms_TT_Sk_MI_cRDI Sms_TT_Sk_MI_cSSF Sms_TT_Sk_MI_AcTI Sms_TT_Sk_MI_pN_EBC Sms_TT_Sk_MI_pF_EBC Sms_TT_Sk_MI_pN_DS Sms_TT_Sk_MI_pF_DS

Processes

J2: The trail trace identifier is recovered from VC-m POH at the Sm_CP. The accepted value of the trail trace identifier is also available at the Sms_TT _MP. For further description of trace identifier mismatch processing, see 6.2.2.2/G.806.

V5[5-7]: The signal label at the Sm_CP shall be recovered. Note that the Sms_TT sink direction always expects an unequipped signal label. For further description of unequipped defect processing, see 6.2.1.3/G.806.

V5[1, 2]: The error monitoring bits at the Sm_CP shall be recovered. 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 and 2 from the following frame.

The process for detecting excessive errors and signal degrade from BIP-2 is described in 6.2.3.1/G.806.

V5[3]: The REI shall be recovered and the derived performance primitives should be reported at the Sms_TT_MP. See below.

V5[8]: The path RDI information shall be recovered and reported at the Sms_TT_MP. For further description of RDI defect processing, see 6.2.6.3/G.806.

K4[5-7]: The function shall be able to ignore the content of bits 5, 6 and 7 of byte K4.

NOTE – The support of the enhanced RDI application is for further study.

N2: The network operator byte is defined for TC monitoring. It shall be ignored by this function.

Defects

The function shall detect for dUNEQ, dTIM, dEXC, dDEG and dRDI defects according to the specification in 6.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aRDI ← CI_SSF or dTIM

aREI ← "number of error detection code violations" aTSF ← CI_SSF or (dTIM and not TIMAISdis)

aTSFprot ← aTSF or dEXC

aTSD ← dDEG

Defect correlations

The function shall perform the following defect correlations to determine the most probable fault cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cSSF ← CI_SSF and SSF_Reported and MON

cUNEQ ← dTIM and (AcTI = all ZEROs) and dUNEQ and MON

cTIM ← dTIM and (not (dUNEQ and AcTI = all ZEROs)) and MON

cEXC ← dEXC and (not dTIM or TIMAISdis) and MON

cDEG ← dDEG and (not dTIM or TIMAISdis) and MON

cRDI ← dRDI and (not dTIM or TIMAISdis) and MON and RDI_Reported

Performance monitoring

The function shall perform the following performance monitoring primitives processing (see 6.5/G.806). The performance monitoring primitives shall be reported to the SEMF.

pN_DS ← CI_SSF or dTIM or dEQ

pF_DS ← dRDI

pN_EBC ← Σ nN_B

pF_EBC ← Σ nF_B

13.3 Adaptation functions

13.3.1 VC-m Layer to Pqx and Pqs layer Adaptation Sm/Pqx_A, Sm/Pqs_A

Sm/Pqx_A or Sm/Pqs_A (m = (11, 12, 2), q = (11, 12, 21)) operates at the access port to a synchronous network or subnetwork and adapts user data for transport in the synchronous domain. The Sm/Pqx_A or Sm/Pqs_A function acts also as a source and sink for the POH payload-dependent information. For asynchronous user data, VC-m adaptation involves bit justification. The Sm/Pqx_A or Sm/Pqs_A function maps G.703 (PDH) signals into VC-m which may subsequently be mapped into higher order containers.

Adaptation functions are defined for each of the levels in the existing plesiochronous hierarchies. Each adaptation function defines the manner in which a user signal can be mapped into one of a range of synchronous containers C-m of appropriate size. The container sizes have been chosen for ease of mapping various combinations of sizes into high order containers; see Table 13-8. Detailed specifications for mapping user data into containers are given in ITU-T Rec. G.707/Y.1322.

Table 13-8/G.783 – Container sizes

Atomic function	Server layer	Client layer	Signal label	Container size	Mapping type
S11/P11x-bit_A	S11	P11x	011	C-11	bit sync.
S11/P11s-b_A_Sk S11/P11s-x_A_So	S11	P11s	100	C-11	byte sync.
S11/P11x_A	S11	P11x or P11s	010	C-11	async.
S12/P12s-b_A_So S12/P12s-x_A_Sk	S12	P12s	100	C-12	byte sync.
S12/P12x_A	S12	P12x or P12s	010	C-12	async.
S2/P21x_A	S2	P21x	010	C-2	async.

13.3.1.1 VC-m Layer to Pqx and Pqs layer Adaptation Source Sm/Pqx_A_So, Sm/Pqs_A_So

Symbol

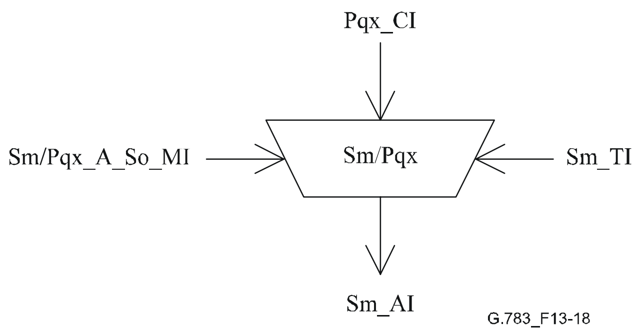


Figure 13-18/G.783 – Sm/Pqx_A_So symbol

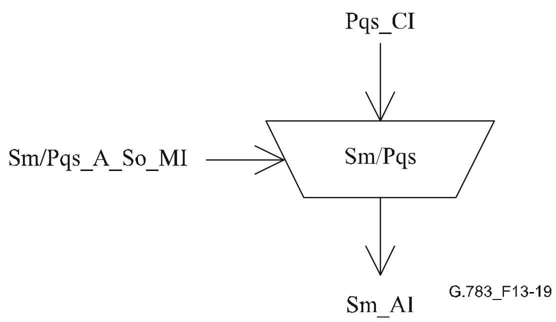


Figure 13-19/G.783 – Sm/Pqs_A_So symbol

Interfaces

Table 13-9/G.783 – Sm/Pqx_A_So input and output signals

Inputs	Outputs
Pqx_CI_Data Pqx_CI_Clock Sm_TI_Clock Sm_TI_FrameStart Sm/Pqx_A_So_MI_Active	Sm_AI_Data Sm_AI_Clock Sm_AI_FrameStart

Table 13-10/G.783 – Sm/Pqs_A_So input and output signals

Inputs	Outputs
Pqs_CI_Data Pqs_CI_Clock Pqs_CI_FrameStart Sm/Pqs_A_So_MI_Active	Sm_AI_Data Sm_AI_Clock Sm_AI_FrameStart

Processes

Data at the Pqx_CP (or Pqs_CP) is the user information stream. Timing of the data is also delivered as timing at the CP. Data is adapted according to one of the adaptation functions referred to above. This involves synchronization and mapping of the information stream into a container as described in ITU-T Rec. G.707/Y.1322 and adding of payload-dependent functions.

The container is passed to the Sm_AP as data together with frame offset which represents the offset of the container frame with respect to reference point Sm_TP. In byte synchronous mappings, the frame offset is obtained from the associated framer in the PDH layer function (E11/P11s_A_Sk or E12/P12s_A_Sk). This frame offset is constrained by the requirements of the client layer; e.g., for SDH equipment, the timing of the client layer is defined in ITU-T Rec. G.813. In other mappings, a convenient fixed offset can be generated internally.

V5[5-8]: The signal label shall be inserted in bits 5, 6, and 7 of V5 byte according to the type of mapping used by the adaptation function; see Table 13-8.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

13.3.1.2 VC-m Layer to Pqx and Pqs layer Adaptation Sink Sm/Pqx_A_Sk, Sm/Pqs_A_Sk

Symbol

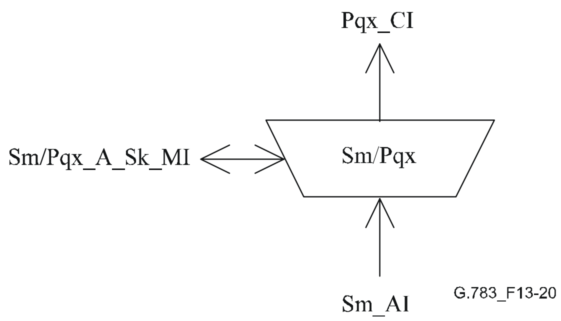


Figure 13-20/G.783 – Sm/Pqx_A_Sk symbol

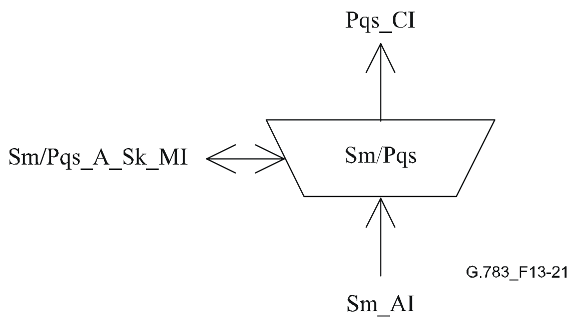


Figure 13-21/G.783 – Sm/Pqs_A_Sk symbol

Interfaces

Table 13-11/G.783 – Sm/Pqx_A_Sk input and output signals

Inputs	Outputs
Sm_AI_Data Sm_AI_Clock Sm_AI_FrameStart Sm_AI_TSF Sm/Pqx_A_Sk_MI_Active	Pqx_CI_Data Pqx_CI_Clock Sm/Pqx_A_Sk_MI_cPLM Sm/Pqx_A_Sk_MI_AcSL

Table 13-12/G.783 – Sm/Pqs_A_Sk input and output signals

Inputs	Outputs
Sm_AI_Data Sm_AI_Clock Sm_AI_FrameStart Sm_AI_TSF Sm/Pqx_A_Sk_MI_Active	Pqs_CI_Data Pqs_CI_Clock Sm/Pqs_A_Sk_MI_cPLM Sm/Pqs_A_Sk_MI_AcSL

Processes

The information stream data at the Sm_AP 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 Pqx_CP (or Pqs_CP) as data and timing. This involves de-mapping and desynchronizing as described in ITU-T Rec. G.707/Y.1322 and payload-dependent information.

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

V5[5-7]: Signal label, bits 5, 6, and 7 of V5 byte, is recovered. For further description of signal label processing, see 6.2.4.2/G.806.

Defects

The function shall detect for dPLM defects according to the specification in 6.2.4.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aAIS ← AI_TSF or dPLM

aSSF ← AI_TSF or dPLM

When AIS is applied at the Sm_AP, or an dPLM defect is detected (mismatch between expected value of signal label and received value of signal label), the adaptation function shall generate an all-ONEs signal (AIS) in accordance with the relevant G.700-series Recommendations.

Defect correlations

The function shall perform the following defect correlation to determine the most probable fault cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cPLM $\leftarrow$ dPLM and (not AI_TSF)

Performance monitoring

None.

13.3.2 VC-m Layer to ATM VP Adaptation Sm/Avp_A

13.3.2.1 VC-m Layer to ATM VP Adaptation source Sm/Avp_A_So

This function is described in ITU-T Rec. I.732 [21].

13.3.2.2 VC-m Layer to ATM VP Adaptation sink Sm/Avp_A_Sk

This function is described in ITU-T Rec. I.732.

13.3.3 VC-m Layer to RFI Adaptation Sm/RFI_A

The processing of Remote Failure Indication (RFI) bit (V5 bit 4) is for further study.

13.4 Sublayer functions

13.4.1 VC-m Layer Trail Protection Functions

VC-m trail protection switching is described in ITU-T Rec. G.841.

The SmP_C function provides protection for the trail against channel-associated defects within a trail from trail termination source to trail termination sink. In Figure 13-22, the trail protection sublayer is given. The sublayering is performed at the Sm_AP creating the SmP sublayer. The protection is performed in the sublayered connection point (SmP_CP).

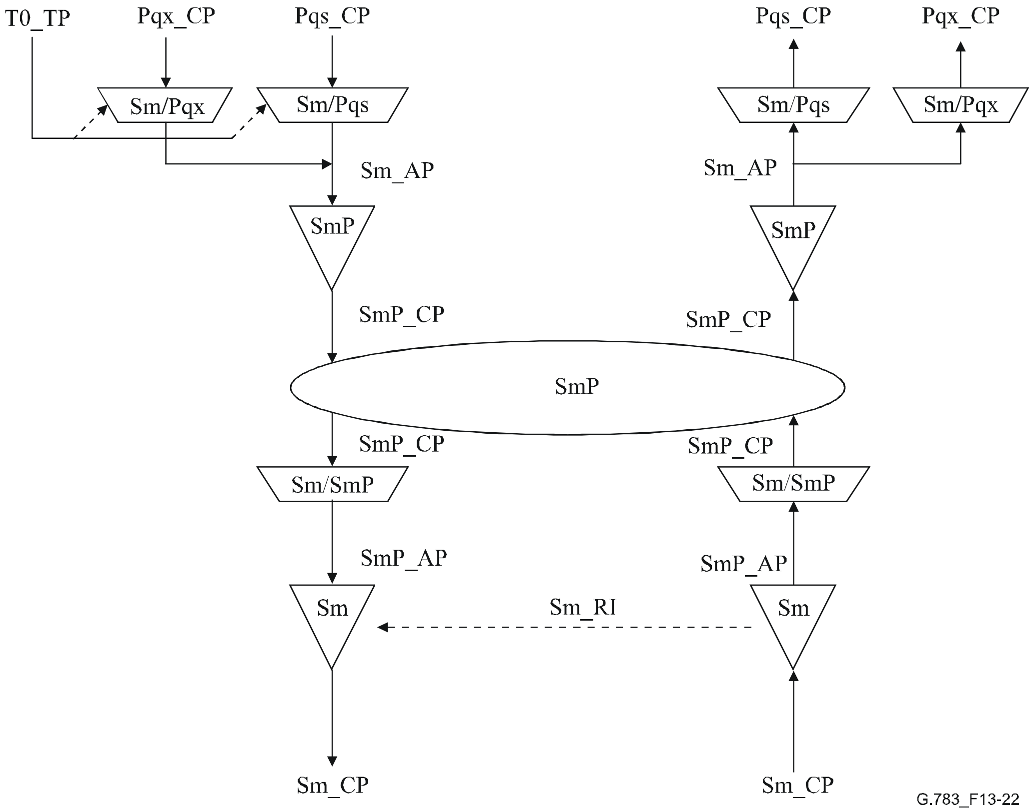


Figure 13-22/G.783 – VC-m linear trail protection sublayer functions

The SmP_C functions at both ends operate the same way, by monitoring VC-m (m = (11, 12, 2)) signals for defects, evaluating the system status taking into consideration the priorities of defect conditions and of external and remote switch requests, and selecting the signal from the appropriate path. The two SmP_C functions may communicate with each other via a bit-oriented protocol defined for the SmP_C characteristic information bytes (K4 byte in the POH of the protection path). This protocol is described in ITU-T Rec. G.841.

The trail protection function is explained in Figure 13-23. The working and protection lines are shown in Figures 13-24 to 13-26.

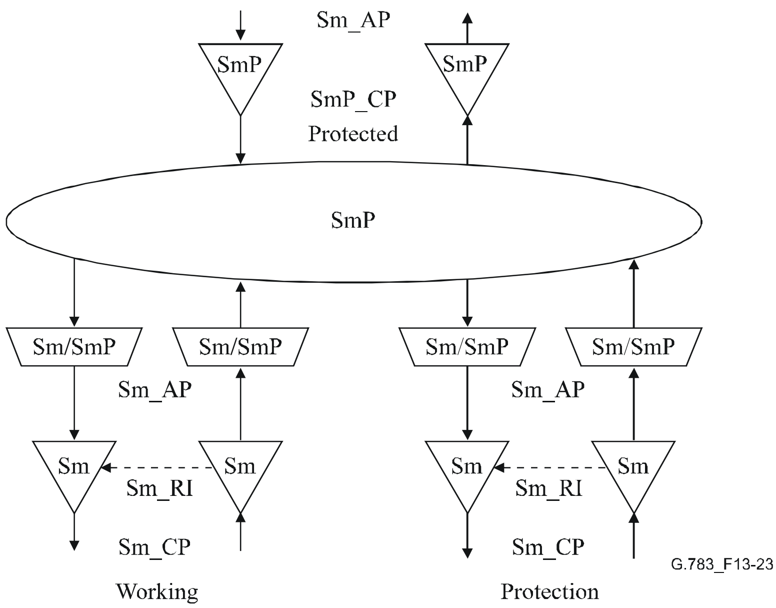


Figure 13-23/G.783 – VC-m linear trail protection atomic functions

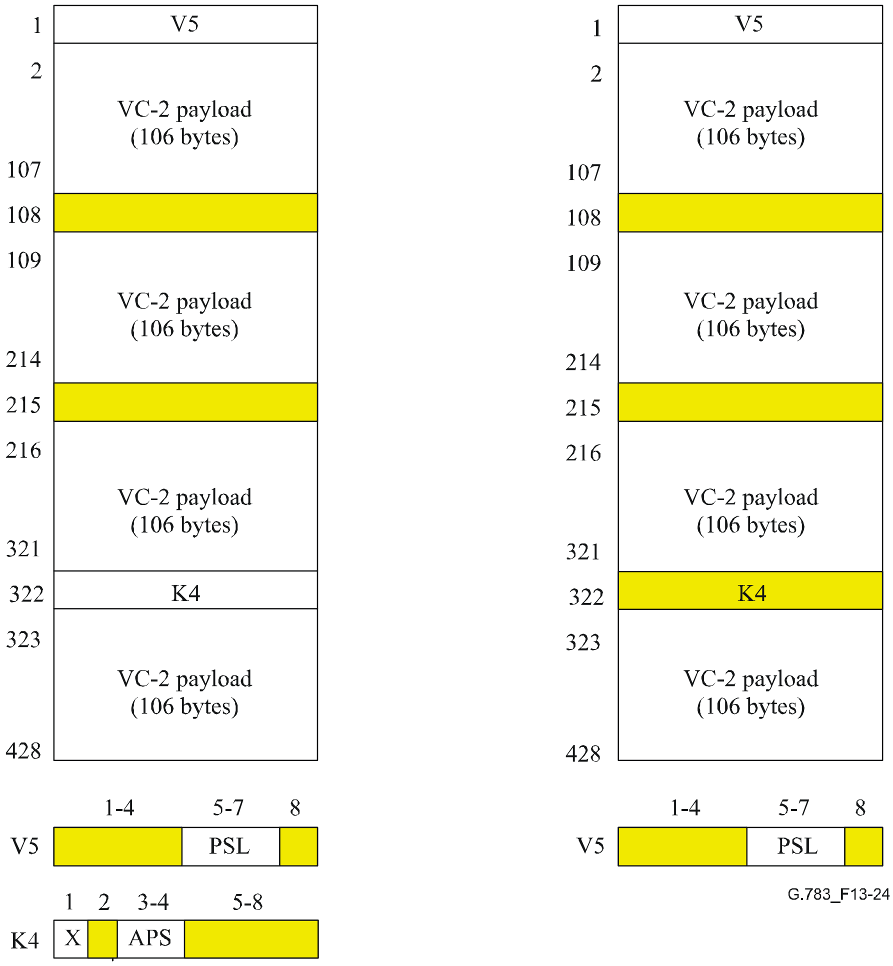


Figure 13-24/G.783 – S2P_AI_D (left) and S2P_CI_D (right)

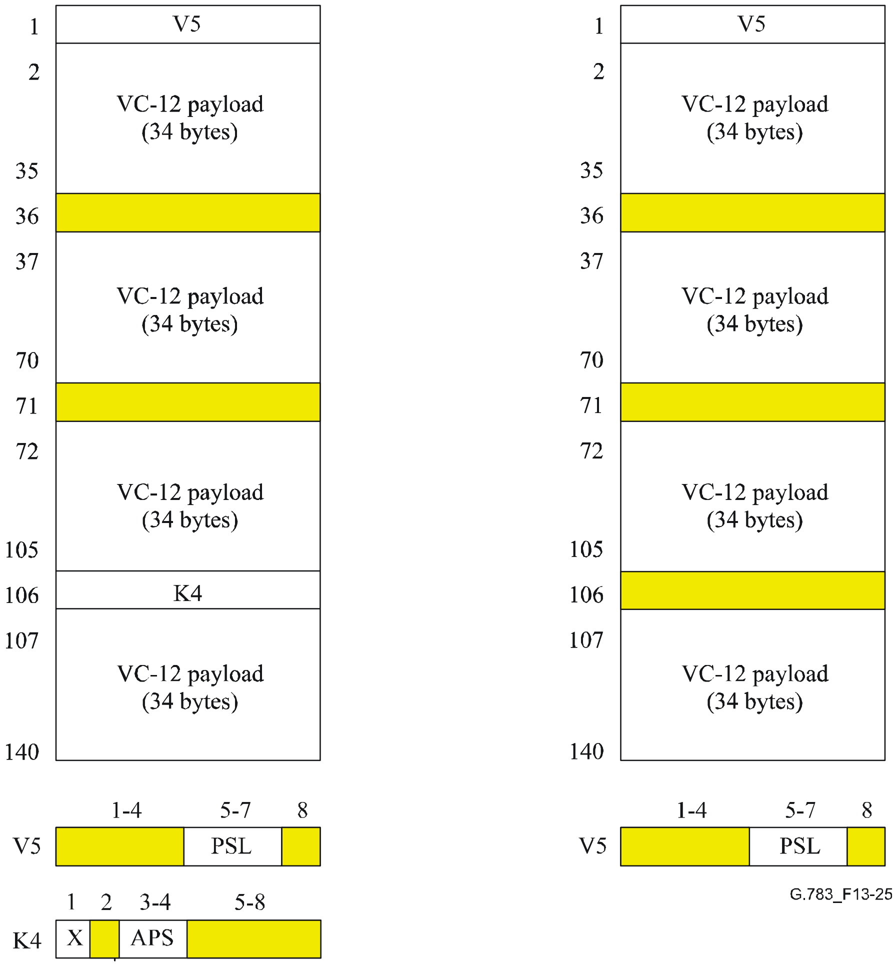


Figure 13-25/G.783 – S12P_AI_D (left) and S12P_CI_D (right)

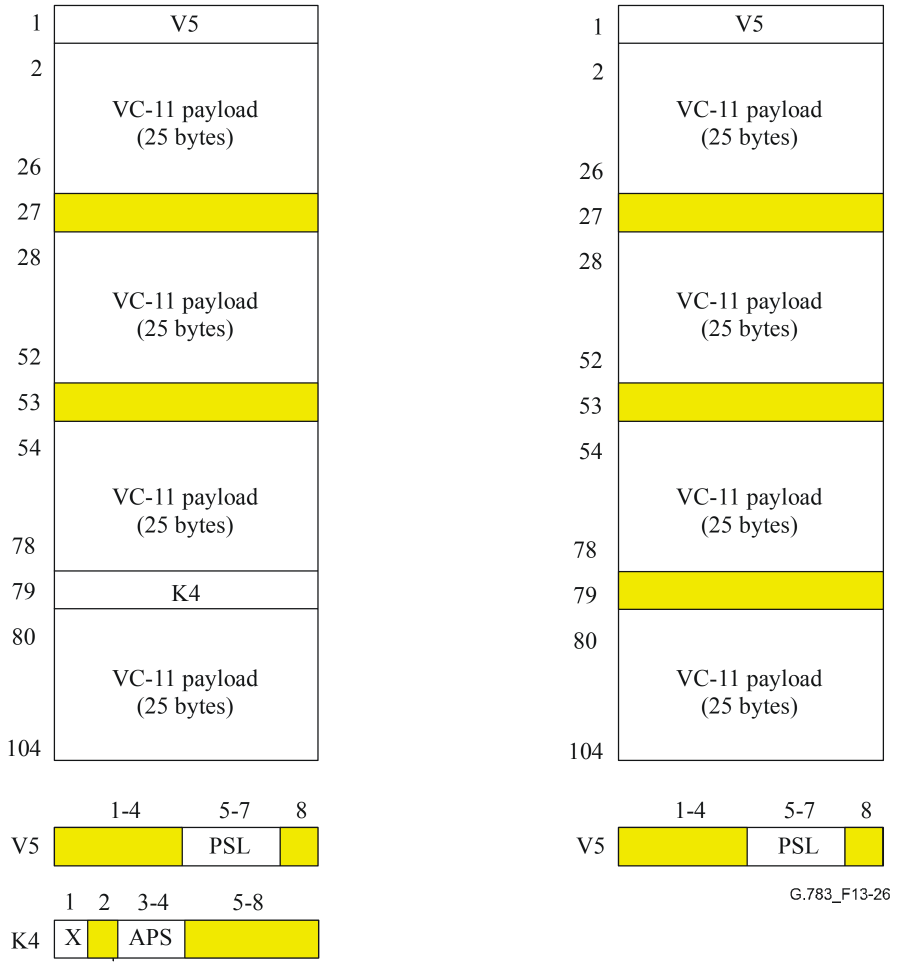


Figure 13-26/G.783 – S11P_AI_D (left) and S11P_CI_D (right)

13.4.1.1 VC-m Layer Trail Protection Connection SmP_C

The SmP_C function receives control parameters and external switch requests at the SmP_C _MP reference point from the synchronous equipment management function and outputs status indicators at the SmP_C_MP to the synchronous equipment management function, as a result of switch commands described in ITU-T Rec. G.841.

Symbol

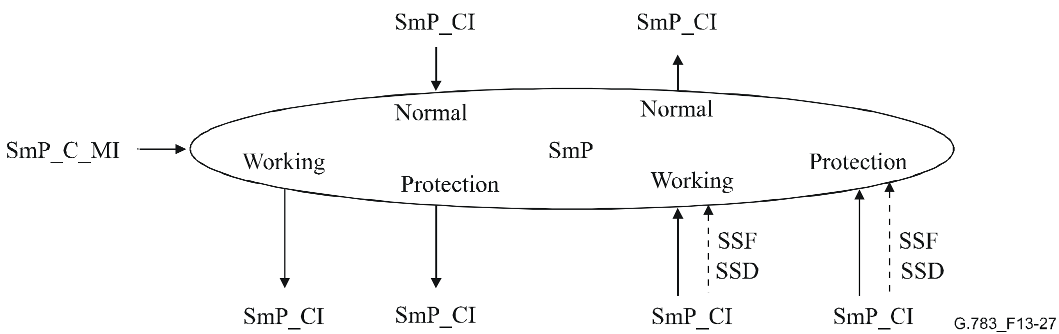


Figure 13-27/G.783 – SmP_C symbol

Interfaces

Table 13-13/G.783 – SmP_C input and output signals

Inputs	Outputs
For connection points W and P: SmP_CI_Data SmP_CI_Clock SmP_CI_FrameStart SmP_CI_SSF SmP_CI_SSD For connection point N: SmP_CI_Data SmP_CI_Clock SmP_CI_FrameStart For connection point P: SmP_CI_APS SmP_C_MI_OPERType SmP_C_MI_WTRTime SmP_C_MI_HOTime SmP_C_MI_EXTCMD	For connection points W and P: SmP_CI_Data SmP_CI_Clock SmP_CI_FrameStart For connection point N: SmP_CI_Data SmP_CI_Clock SmP_CI_FrameStart SmP_CI_SSF For connection point P: SmP_CI_APS
NOTE – Protection status reporting signals are for further study.	

Processes

Source direction

Data at the SmP_CP is a trail signal, timed from the Sm_TP reference point, with indeterminate Sm layer POH bytes.

For 1 + 1 architecture, the signal received at the SmP_CP from the protection trail termination function (SmP_TT_So) is bridged permanently at the SmP_CP to both protection and working Protection trail termination (SmP_TT_So).

The APS information generated according to the rules in ITU-T Rec. G.841 are presented at the SmP_CP to the protection trail. This APS signal may also be presented to the working trails Protection trail termination (SmP_TT_So).

Sink direction

Framed trail signals (data) SmP_CI whose trail POH bytes have already been recovered by the Sm_TT_Sk are presented at the SmP_CP along with incoming timing references. The defect conditions SSF and SSD are also received at the SmP_CP from all Sm_TT_Sk functions.

The recovered APS information from the protection trail's adaptation function (Sm/SmP_A_Sk) is presented at the SmP_CP. Working trail's adaptation functions may also present these bytes to the SmP_C. The SmP_C must be able to ignore these bytes from the working adaptation functions.

Under normal conditions, SmP_C passes the data, timing, and signal fail from the working Sm/SmP_A_Sk functions to the corresponding SmP_TT_Sk functions at the SmP_TCP. The data and timing from the protection trail is not forwarded.

Under a fault condition on the working path, SmP_C passed the data, timing, and signal fail from the protection Sm/SmP_A_Sk function to the corresponding SmP_TT_Sk at the SmP_TCP. The signal received from the working Sm/SmP_A_Sk is not forwarded.

Switch initiation criteria

Automatic protection switching is based on the TSF and TSD conditions of the working and protection paths. Detection of these conditions is described in 13.2.1.2.

The protection switch can also be initiated by switch commands received via the synchronous equipment management function. See the switch criteria described in ITU-T Rec. G.841.

Switching time

Refer to ITU-T Rec. G.841.

Switch restoration

Switch restoration is a function related to revertive operation, when the working path has recovered from defect. It is not applicable to trail protection which supports non-revertive operation only. See the description of revertive 1 + 1 unidirectional protection switching in ITU-T Rec. G.841.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

13.4.1.2 VC-m Layer Trail Protection Trail Termination SmP_TT

13.4.1.2.1 VC-m Layer Trail Protection Trail Termination Source SmP_TT_So

Symbol

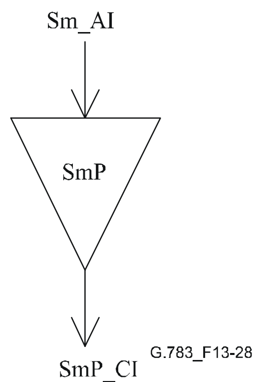


Figure 13-28/G.783 – SmP_TT_So symbol

Interfaces

Table 13-14/G.783 – SmP_TT_So input and output signals

Inputs	Outputs
SmP_AI_Data SmP_AI_Clock SmP_AI_FrameStart	SmP_CI_Data SmP_CI_Clock SmP_CI_FrameStart

Processes

No information processing is required in the SmP_TT_So since the Sm_AI at its output is identical to the SmP_CI.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

13.4.1.2.2 VC-m Layer Trail Protection Trail Termination Sink SmP_TT_Sk

Symbol

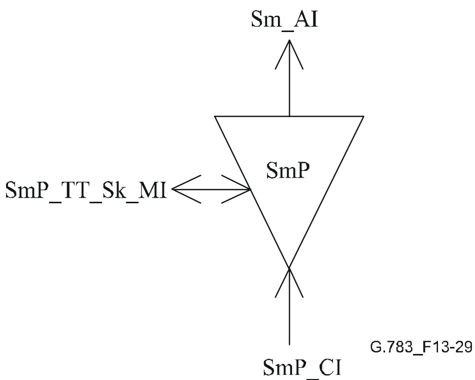


Figure 13-29/G.783 – SmP_TT_Sk symbol

Interfaces

Table 13-15/G.783 – SmP_TT_Sk input and output signals

Inputs	Outputs
SmP_CI_Data SmP_CI_Clock SmP_CI_FrameStart SmP_CI_SSF SmP_TT_Sk_MI_SSF_Reported	SmP_AI_Data SmP_AI_Clock SmP_AI_FrameStart SmP_AI_TSF SmP_TT_Sk_MI_cSSF

Processes

The SmP_TT_Sk function report, as part of the Sm layer, the state of the protected Sm trail. In case all trails are unavailable, the SmP_TT_Sk reports the signal fail condition of the protected trail.

Defects

None.

Consequent actions

aTSF ← CI_SSF

Defect correlations

cSSF ← CI_SSF and SSF_Reported

Performance monitoring

None.

13.4.1.3 VC-m Trail to VC-m Trail Protection Layer Adaptation Sm/SmP_A

13.4.1.3.1 VC-m Trail to VC-m Trail Protection Layer Adaptation Source Sm/SmP_A_So

Symbol

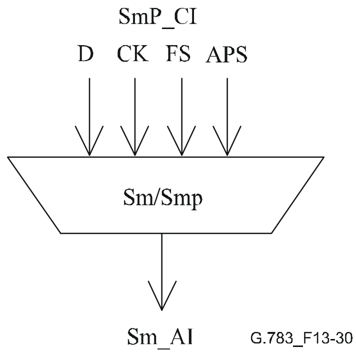


Figure 13-30/G.783 – Sm/SmP_A_So symbol

Interfaces

Table 13-16/G.783 – Sm/SmP_A_So input and output signals

Inputs	Outputs
SmP_AI_Data SmP_AI_Clock SmP_AI_FrameStart SmP_AI_APS	SmP_CI_Data SmP_CI_Clock SmP_CI_FrameStart

Processes

The function shall multiplex the Sm APS signal and Sm data signal onto the Sm_AP.

K4[3, 4]: The insertion of the APS signal is for further study. This process is required only for the protection trail.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

13.4.1.3.2 VC-m Trail to VC-m Trail Protection Layer Adaptation Sink Sm/SmP_A_Sk

Symbol

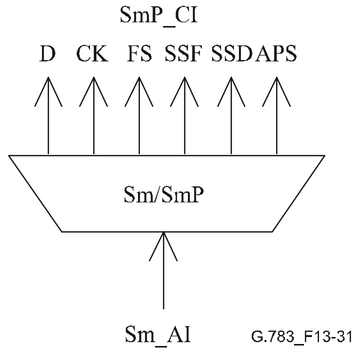


Figure 13-31/G.783 – Sm/SmP_A_Sk symbol

Interfaces

Table 13-17/G.783 – Sm/SmP_A_Sk input and output signals

Inputs	Outputs
SmP_AI_Data SmP_AI_Clock SmP_AI_FrameStart SmP_AI_TSF SmP_SI_TSD	SmP_CI_Data SmP_CI_Clock SmP_CI_FrameStart SmP_CI_SSF SmP_CI_SSD SmP_CI_APS (for protection signal only)

Processes

The function shall extract and output the SmP_CI_D signal from the SmP_AI_D signal.

K4[3, 4]: The extraction and persistency processing of the APS signal is for further study. This process is required only for the protection trail.

Defects

None.

Consequent actions

aSSF ← AI_TSF

aSSD ← AI_TSD

Defect correlations

None.

Performance monitoring

None.

13.4.2 VC-m Tandem Connection Sublayer Functions

NOTE – Service could be affected when activating TCM on an existing connection.

13.4.2.1 VC-m Tandem Connection Trail Termination SmD_TT

This function acts as source and sink for the VC-m tandem connection overhead (TCOH) described in Annex E/G.707/Y.1322 [6] in case of VC-1/2.

13.4.2.1.1 VC-m Tandem Connection Trail Termination Source SmD_TT_So

Symbol

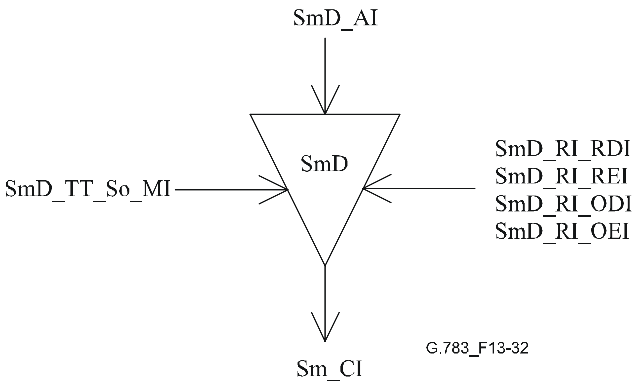


Figure 13-32/G.783 – SmD_TT_So symbol

Interfaces

Table 13-18/G.783 – SmD_TT_So input and output signals

Inputs	Outputs
SmD_AI_Data SmD_AI_Clock SmD_AI_FrameStart SmD_AI_SF SmD_RI_RDI SmD_RI_REI SmD_RI_ODI SmD_RI_OEI SmD_TT_So_MI_TxTI	Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart

Processes

N2[8][73]: The function shall insert the TC RDI code. Upon the declaration/clearing of aRDI at the termination sink function, the trail termination source function shall have inserted/removed the RDI code within 80 ms.

N2[3]: The function shall insert a "1" in this bit.

N2[4]: The function shall insert an incoming AIS code in this bit. If AI_SF is true, this bit will be set to the value "1"; otherwise, value "0" shall be inserted.

N2[5]: The function shall insert the RI_REI value in the REI bit. Upon the detection of a number of errors at the termination sink function, the trail termination source function shall have inserted that value in the REI bit within 80 ms.

N2[7][74]: The function shall insert the ODI code. Upon the declaration/clearing of an ODI at the termination sink function, the trail termination source function shall have inserted/removed the ODI code within 80 ms.

N2[6]: The function shall insert the RI_OEI value in the OEI bit. Upon the detection of a number of errors at the termination sink function, the trail termination source function shall have inserted that value in the OEI bit within 80 ms.

N2[7-8]: The function shall insert in the multiframed N2[7-8] channel:

– the Frame Alignment Signal (FAS) "1111 1111 1111 1110" in FAS bits in frames 1 to 8;

– the TC trace identifier, received via reference point SmD_TT_So_MP, in the TC trace ID bits in frames 9 to 72;

– the TC RDI (N2[8][73]) and ODI (N2[7][74]) signals; and

– all-0s in the six reserved bits in frames 73 to 76.

V5[1-2]: The function shall correct the VC-1/2 BIP-2 (in bits 1 and 2 of byte V5) as specified in 8.4/G.806.

N2[1-2]: The function shall calculate a BIP-2 over the egressing VC, and insert this value in TC BIP-2 in the next frame (Figure 13-33).

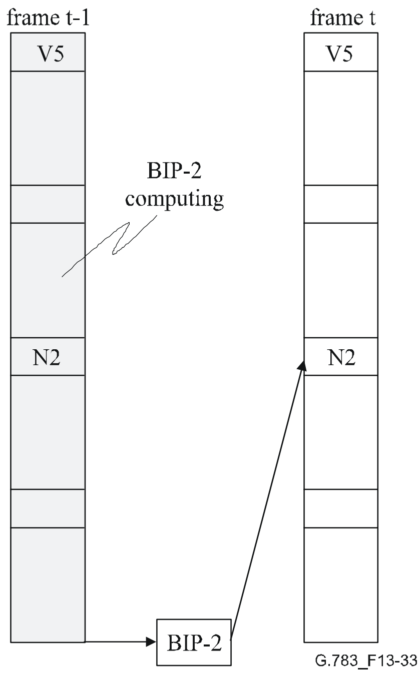


Figure 13-33/G.783 – TC BIP-2 computing and insertion

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

13.4.2.1.2 VC-m Tandem Connection Trail Termination Sink SmD_TT_Sk

Symbol

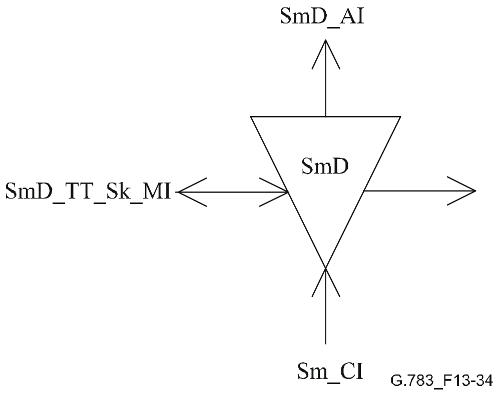


Figure 13-34/G.783 – SmD_TT_Sk symbol

Interfaces

Table 13-19/G.783 – SmD_TT_Sk input and output signals

Inputs	Outputs
Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart Sm_CI_SSF SmD_TT_Sk_MI_ExTI SmD_TT_Sk_MI_RDI_Reported SmD_TT_Sk_MI_ODI_Reported SmD_TT_Sk_MI_SSF_Reported SmD_TT_Sk_MI_AIS_Reported SmD_TT_Sk_MI_TIMdis SmD_TT_Sk_MI_DEGM SmD_TT_Sk_MI_DEGTHR SmD_TT_Sk_MI_1second SmD_TT_Sk_MI_TPmode	SmD_AI_Data SmD_AI_Clock SmD_AI_FrameStart SmD_AI_TSF SmD_AI_TSD SmD_AI_OSF SmD_RI_RDI SmD_RI_REI SmD_RI_ODI SmD_RI_OEI SmD_TT_Sk_MI_cLTC SmD_TT_Sk_MI_cTIM SmD_TT_Sk_MI_cUNEQ SmD_TT_Sk_MI_cDEG SmD_TT_Sk_MI_cRDI SmD_TT_Sk_MI_cODI SmD_TT_Sk_MI_cSSF SmD_TT_Sk_MI_cIncAIS SmD_TT_Sk_MI_AcTI SmD_TT_Sk_MI_pN_EBC SmD_TT_Sk_MI_pF_EBC SmD_TT_Sk_MI_pN_DS SmD_TT_Sk_MI_pF_DS SmD_TT_Sk_MI_pON_EBC SmD_TT_Sk_MI_pOF_EBC SmD_TT_Sk_MI_pON_DS SmD_TT_Sk_MI_pOF_DS

Processes

N2[1-2]: See 8.3.1.

N2[7-8][9-72]: The Received Trail Trace Identifier shall be recovered from the tandem connection trail trace identifier overhead. The accepted value of TC trace identifier is also available at the SmD_TT_MP.

N2[4]: The function shall extract the Incoming AIS code.

N2[5], N2[8][73]: The information carried in the REI, RDI bits in byte N2 shall be extracted to enable single-ended maintenance of a bidirectional tandem connection Trail. The REI shall be used to monitor the error performance of the other direction of transmission, and the RDI shall be used to provide information as to the status of the remote receiver. A "1" indicates a Remote Defect Indication state, while a "0" indicates the normal, working state.

N2[6], N2[7][74]: The information carried in the OEI, ODI bits in byte N2 shall be extracted to enable single-ended (intermediate) maintenance of the VC-1/2 egressing the tandem connection Trail. The OEI (OF_B) shall be used to monitor the error performance of the other direction of transmission, and the ODI shall be used to provide information as to the status of the remote receiver. A"1" indicates an Outgoing Defect Indication state, while a "0" indicates the normal, working state.

N2[7-8]: Multiframe alignment: See 8.2.4.

V5[1-2]: Even BIP-2 is computed for each bit par of every byte of the preceding VC-1/2 including V5 and compared with bit N2 and 2 of V5 recovered from the current frame. A difference between the computed and recovered BIP-2 values is taken as evidence of one or more errors (ON_B) in the computation block.

N2: The function shall terminate N2 channel by inserting an all-ZEROs pattern.

V5[1-2]: The function shall compensate the VC-1/2 BIP-2 in bits 1 and 2 of byte V5 according to the algorithm defined in the source direction.

Defects

The function shall detect for dUNEQ, dLTC, dTIM, dDEG, dRDI, dODI, IncAIS defects according to the specification in 6.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aAIS ← dUNEQ or dTIM or dLTC

aOSF ← CI_SSF or dUNEQ or dTIM or dLTC or IncAIS

aTSF ← CI_SSF or dUNEQ or dTIM or dLTC

aTSD ← dDEG

aRDI ← CI_SSF or dUNEQ or dTIM or dLTC

aREI ← nN_B

aODI ← CI_SSF or dUNEQ or dTIM or IncAIS or dLTC

aOEI ← nON_B

The function shall insert the all-ONEs (AIS) signal within 1 ms after AIS request generation, and cease the insertion within 1 ms after the AIS request has cleared.

Defect correlations

The function shall perform the following defect correlation to determine the most probable fault cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cSSF ← CI_SSF and SSF_Reported and MON

cIncAIS ← dIncAIS and (not CI_SSF) and (not dLTC) and (not dTIM) and AIS_Reported and MON

cUNEQ ← dUNEQ and MON

cLTC ← (not dUNEQ) and dLTC and (not CI_SSF)

cTIM ← dTIM and (not dUNEQ) and (not dLTC) and MON

cDEG ← dDEG and (not dTIM) and (not dLTC) and MON

cRDI ← dRDI and (not dUNEQ) and (not dTIM) and (not dLTC) and MON and RDI_Reported

cODI ← dODI and (not dUNEQ) and (not dTIM) and (not dLTC) and MON and ODI_Reported

Performance monitoring

The function shall perform the following performance monitoring primitives processing (see 6.5/G.806). The performance monitoring primitives shall be reported to the SEMF.

pN_DS ← aTSF or dEQ

pF_DS ← dRDI

pN_EBC ← Σ nN_B

pF_EBC ← Σ nF_B

pON_DS ← aODI or dEQ

pOF_DS ← dODI

pON_EBC ← Σ nON_B

pOF_EBC ← Σ nOF_B

13.4.2.2 VC-m Tandem Connection Non-Intrusive Monitor SmDm_TT_Sk

This function can be used to perform the following:

1) single-ended maintenance of the TC by monitoring at an intermediate node, using remote information (RDI, REI);
2) aid in fault localization within TC trail by monitoring near-end defects;
3) monitoring of VC performance at TC egressing point (except for connectivity defects before the TC) using remote outgoing information (ODI, OEI);
4) performing non-intrusive monitor function within SNC/S protection.

This function acts as a non-intrusive monitor for the VC-m tandem connection overhead (TCOH) described in Annex E/G.707/Y.1322 in case of VC-1/2.

The information flows associated with the SmD/Sm_A function are described with reference to Figure 13-35.

Symbol

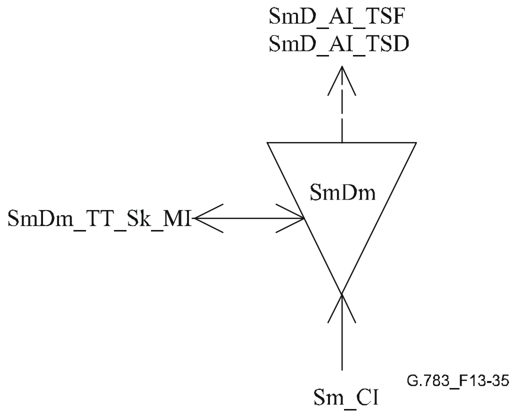


Figure 13-35/G.783 – SmDm_TT_Sk symbol

Interfaces

Table 13-20/G.783 – SmDm_TT_Sk input and output signals

Inputs	Outputs
Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart Sm_CI_SSF SmDm_TT_Sk_MI_ExTI SmDm_TT_Sk_MI_RDI_Reported SmDm_TT_Sk_MI_ODI_Reported SmDm_TT_Sk_MI_SSF_Reported SmDm_TT_Sk_MI_AIS_Reported SmDm_TT_Sk_MI_TIMdis SmDm_TT_Sk_MI_DEGM SmDm_TT_Sk_MI_DEGTHR SmDm_TT_Sk_MI_1second SmDm_TT_Sk_MI_Tpmode	SmD_AI_TSF SmD_AI_TSD SmDm_TT_Sk_MI_cLTC SmDm_TT_Sk_MI_cTIM SmDm_TT_Sk_MI_cUNEQ SmDm_TT_Sk_MI_cDEG SmDm_TT_Sk_MI_cRDI SmDm_TT_Sk_MI_cODI SmDm_TT_Sk_MI_cSSF SmDm_TT_Sk_MI_cIncAIS SmDm_TT_Sk_MI_AcTI SmDm_TT_Sk_MI_pN_EBC SmDm_TT_Sk_MI_pF_EBC SmDm_TT_Sk_MI_pN_DS SmDm_TT_Sk_MI_pF_DS SmDm_TT_Sk_MI_pON_DS SmDm_TT_Sk_MI_pON_EBC SmDm_TT_Sk_MI_pOF_EBC SmDm_TT_Sk_MI_pOF_DS

Processes

N2[1-2]: See 8.3.1.

N2[7-8][9-72]: The Received Trail Trace Identifier shall be recovered from the tandem connection trail trace identifier overhead. The accepted value of TC trace identifier is also available at the SmDm_TT_MP. The mismatch detection process shall be as specified below.

N2[4]: The function shall extract the Incoming AIS code.

N2[5], N2[8][73]: The information carried in the REI, RDI bits in byte N2 shall be extracted to enable single-ended maintenance of a bidirectional tandem connection Trail. The REI shall be used to monitor the error performance of the other direction of transmission, and the RDI shall be used to provide information as to the status of the remote receiver. A "1" indicates a Remote Defect Indication state, while a "0" indicates the normal, working state.

N2[6], N2[7][74]: The information carried in the OEI, ODI bits in byte N2 shall be extracted to enable single-ended (intermediate) maintenance of the VC-1/2 egressing the tandem connection Trail. The OEI (OF_B) shall be used to monitor the error performance of the other direction of transmission, and the ODI shall be used to provide information as to the status of the remote receiver. A"1" indicates an Outgoing Defect Indication state, while a "0" indicates the normal, working state.

N2[7-8]: See 8.2.4.

Defects

The function shall detect for dUNEQ, dLTC, dTIM, dDEG, dRDI, dODI, dIncAIS defects according to the specification in 6.2/G.806.

Consequent actions

The function shall perform the following consequent actions (see 6.3/G.806):

aTSF ← CI_SSF or dUNEQ or dTIM or dLTC

aTSD ← dDEG

Defect correlations

The function shall perform the following defect correlation to determine the most probable cause (see 6.4/G.806). This fault cause shall be reported to the SEMF.

cSSF ← CI_SSF and SSF_Reported and MON

cUNEQ ← dUNEQ and MON

cLTC ← (not dUNEQ) and dLTC and (not CI_SSF)

cIncAIS ← dIncAIS and (not CI_SSF) and (not dLTC) and (not dTIM) and AIS_Reported and MON

cTIM ← (not dUNEQ) and (not dLTC) and dTIM and MON

cDEG ← (not dTIM) and (not dLTC) and dDEG and MON

cRDI ← (not dUNEQ) and (not dTIM) and (not dLTC) and dRDI and MON and RDI_Reported

cODI ← (not dUNEQ) and (not dTIM) and (not dLTC) and dODI and MON and ODI_Reported

Performance monitoring

The function shall perform the following performance monitoring primitives processing (see 6.5/G.806). The performance monitoring primitives shall be forwarded to the SEMF.

pN_DS ← aTSF or dEQ

pF_DS ← dRDI

pN_EBC ← Σ nN_B

pF_EBC ← Σ nF_B

pON_DS ← CI_SSF or dUNEQ or dTIM or IncAIS or dLTC or dEQ

pON_EBC ← Σ nON_B

pOF_DS ← dODI

pOF_EBC ← Σ nOF_B

13.4.2.3 VC-m Tandem Connection to VC-m Adaptation SmD/Sm_A

This function acts as a source and sink for the adaptation of Sm layer to SmD sublayer. This function is applicable for networks that support the VC-m tandem connection monitoring protocol option 2 described in Annex E/G.707/Y.1322 in case of VC-1/2.

13.4.2.3.1 VC-m Tandem Connection to VC-m Adaptation Source SmD/Sm_A_So

Symbol

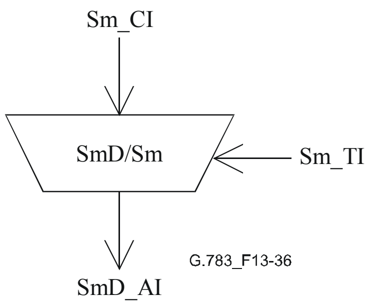


Figure 13-36/G.783 – SmD/Sm_A_So symbol

Interfaces

Table 13-21/G.783 – SmD/Sm_A_So input and output signals

Inputs	Outputs
Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart Sm_CI_SSF Sm_TI_Clock	SmD_AI_Data SmD_AI_Clock SmD_AI_FrameStart SmD_AI_SSF

Processes

NOTE 1 – The function has no means to verify the existence of a tandem connection within the incoming signal. Nested tandem connections are not supported.

The function shall replace the incoming Frame Start signal by a local generated one (i.e., enter "holdover") if an all-ONEs (AIS) VC is received (i.e., this function replaces an all-ONEs incoming VC by a VC-AIS signal).

NOTE 2 – This replacement of the (invalid) incoming frame start signal results in the generation of a valid pointer in the Sn/Sm_A_So function.

Defects

None.

Consequent actions

This function shall perform the following consequent actions:

aSSF ← CI_SSF

Defect correlations

None.

Performance monitoring

None.

13.4.2.3.2 VC-m Tandem Connection to VC-m Adaptation Sink SmD/Sm_A_Sk

Symbol

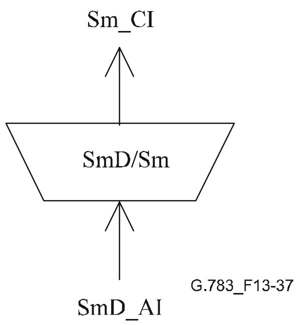


Figure 13-37/G.783 – SmD/Sm_A_Sk symbol

Interfaces

Table 13-22/G.783 – SmD/Sm_A_Sk input and output signals

Inputs	Outputs
SmD_AI_Data SmD_AI_Clock SmD_AI_FrameStart SmD_AI_OSF	Sm_CI_Data Sm_CI_Clock Sm_CI_FrameStart Sm_CI_SSF

Processes

The function shall restore the invalid frame start condition (i.e., output aSSF = true) if that existed at the ingress of the tandem connection.

NOTE 1 – In addition, the invalid frame start condition is activated on a tandem connection connectivity defect condition that causes all-ONEs (AIS) insertion in the SmD_TT.

Defects

None.

Consequent actions

aAIS ← AI_OSF

aSSF ← AI_OSF

NOTE 2 – CI_SSF = true will result in TU-AIS generation by SmD/Sm_A_Sk function.

The function shall insert the all-ONEs (AIS) signal within 1 ms after AIS request generation, and cease the insertion within 1 ms after the AIS request has cleared.

Defect correlations

None.

Performance monitoring

None.

13.5 Virtual Concatenation Functions

13.5.1 Virtual concatenated VC-m path layer functions Sm-Xv (m = 11, 12, 2; X ≥ 1)

13.5.1.1 VC-m-Xv Layer Trail Termination Function Sm-Xv_TT

The Sm-Xv_TT function is further decomposed as defined in ITU-T Rec. G.803 and shown in Figure 13-38.

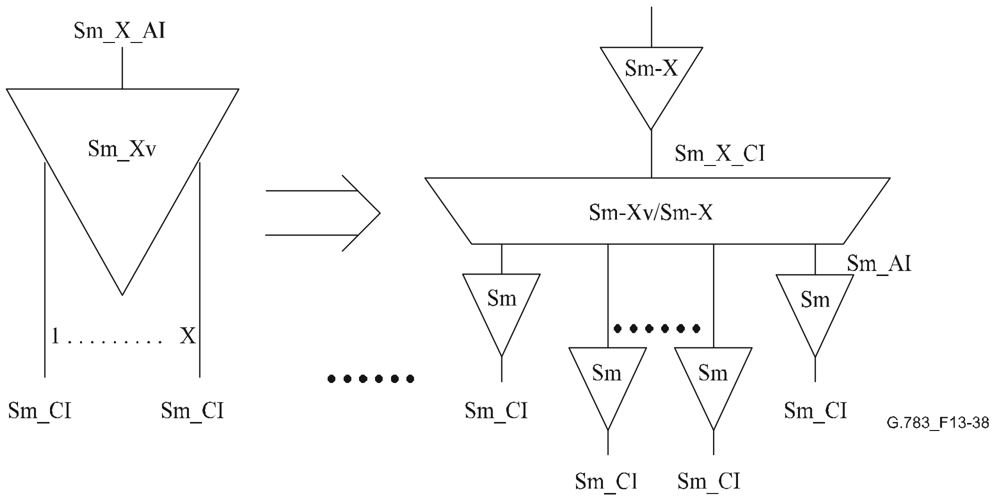


Figure 13-38/G.783 – Decomposition of Sm_Xv_TT function (m = 11, 12, 2)

For S11_Xv 1 ≤ X ≤ 64, S12_Xv 1 ≤ X ≤ 63, S2_Xv 1 ≤ X ≤ 21 when mapped in a VC-4.

NOTE – Even though 84 VC-11s can be multiplexed into a VC-4, the number of VC-11s that can be virtually concatenated is limited to 64 by the 6-bit sequence number.

For S11_Xv 1 ≤ X ≤ 28, S12_Xv 1 ≤ X ≤ 21, S2_Xv 1 ≤ X ≤ 7 when mapped in a higher-order VC-3.

13.5.1.1.1 Sm-Xv Layer Trail Termination Source Function Sm-X_TT_So

Symbol

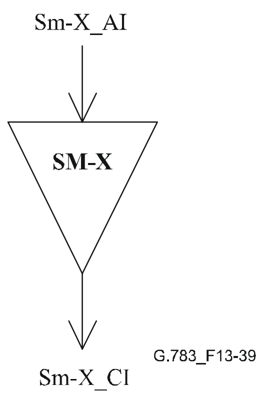


Figure 13-39/G.783 – Sm-X_TT_So symbol

Interfaces

Table 13-23/G.783 – Sm-X_TT_So input and output signals

Inputs	Outputs
Sm-X_AI_D Sm-X_AI_CK Sm-X_AI_FS	Sm-X_CI_D Sm-X_CI_CK Sm-X_CI_FS

Processes

None.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

13.5.1.1.2 Sm-Xv Layer Trail Termination Sink Function Sm-X_TT_Sk

Symbol

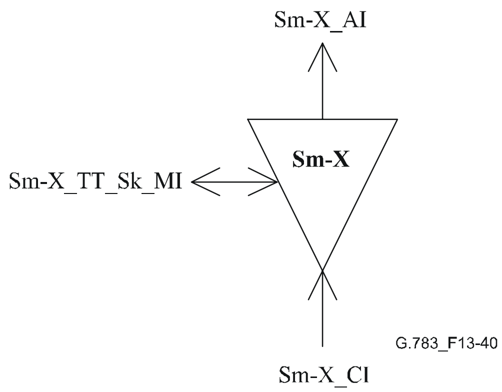


Figure 13-40/G.783 – Sm-X_TT_Sk symbol

Interfaces

Table 13-24/G.783 – Sm-X_TT_Sk input and output signals

Inputs	Outputs
Sm-X_CI_D Sm-X_CI_CK Sm-X_CI_FS Sm-X_CI_SSF Sm-X_TT_Sk_MI_SSF_Reported	Sm-X_AI_D Sm-X_AI_CK Sm-X_AI_FS Sm-X_TT_Sk_MI_cSSF

Processes

Report signal fail status.

Defects

None.

Consequent actions

None.

Defect correlations

cSSF ← CI_SSF and SSF_Reported

Performance monitoring

None.

13.5.1.2 Sm-Xv Layer Trail Adaptation Functions Sm/Sm-X_A

13.5.1.2.1 Sm-Xv Layer Trail Adaptation Source Function Sm/Sm-X_A_So

Symbol

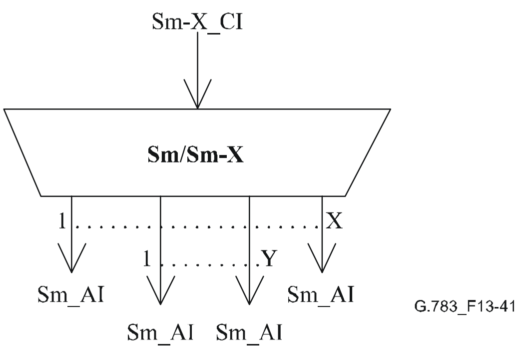


Figure 13-41/G.783 – Sm/Sm-X_A_So symbol

Interfaces

Table 13-25/G.783 – Sm/Sm-X_A_So input and output signals

Inputs	Outputs
Sm-X_CI_D Sm-X_CI_CK Sm-X_CI_FS	Sm_AI[1..X]_D Sm_AI[1..X]_CK Sm_AI[1..X]_FS

Processes

This function shall perform the distribution of the incoming Sm-X_CI to X Sm_AI and shall add the Virtual Concatenation overhead to form the Sm_AI[1..X].

Distribution process

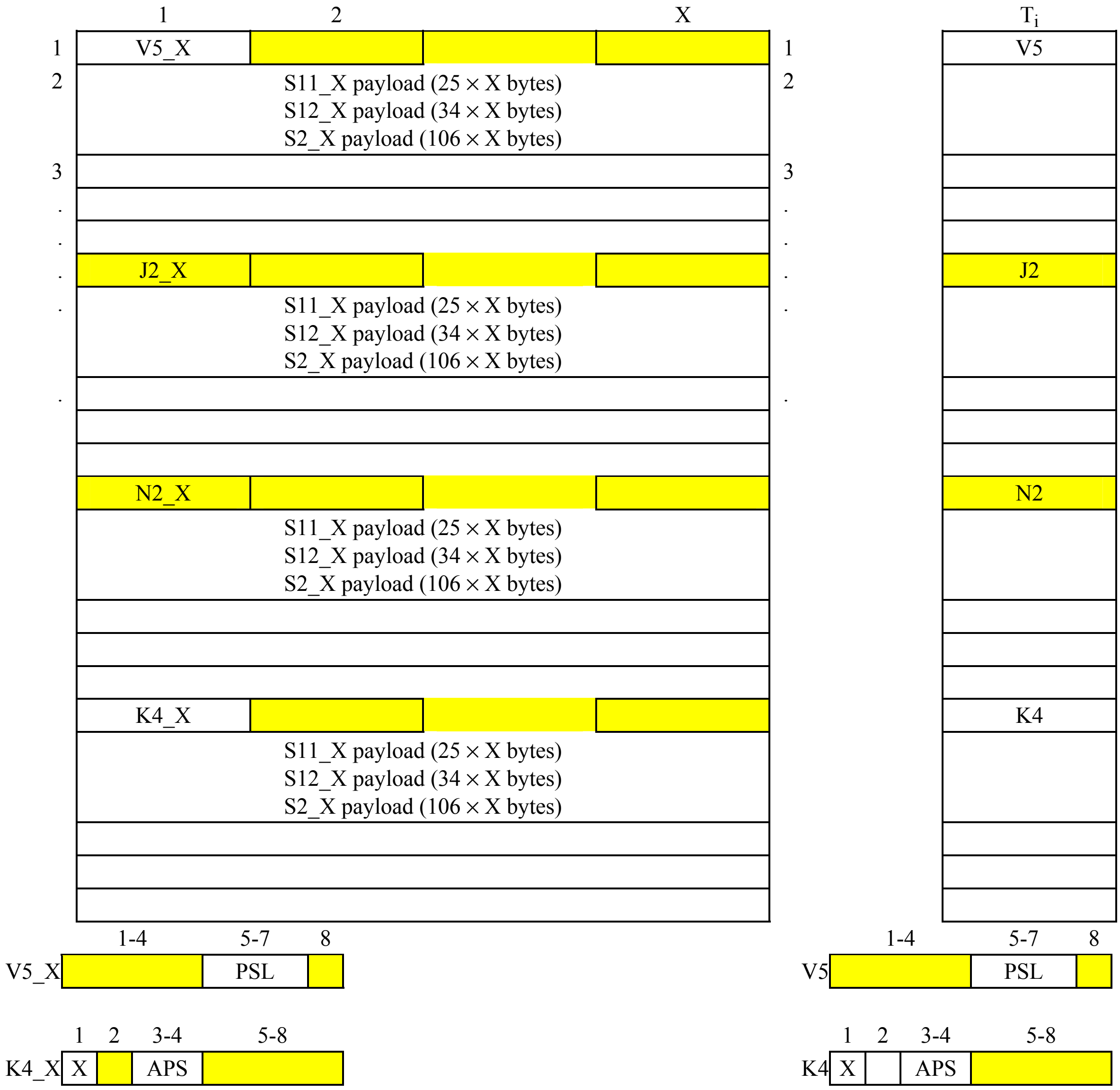


Figure 13-42/G.783 – Sm_X_CI_D (left) and Sm_AI_D (right)

The distribution function performs an 8-bit or byte deinterleave operation of the incoming signal; 8-bits/byte are mapped into the payload of signal T_i, the next 8-bits/byte into signal T_{i+1}, etc. T_i, T_{i+1}, etc. belong to the actual group and are not temporarily removed. The bits V5_X[5-7] (PSL) are copied to every individual signal T_i. The bits K4_X[3-4] (APS) are copied to every individual signal T_i. If an extended signal label is present in K4_X[1], it is copied to every individual signal T_i.

Payload

K4[1, 2]: Multiframe alignment and sequence; see 8.2.5.2.

Defects

None.

Consequent actions

None.

Defect correlations

None.

Performance monitoring

None.

13.5.1.2.2 Sm-Xv Layer Trail Adaptation Sink Function Sm/Sm-X_A_Sk

Symbol

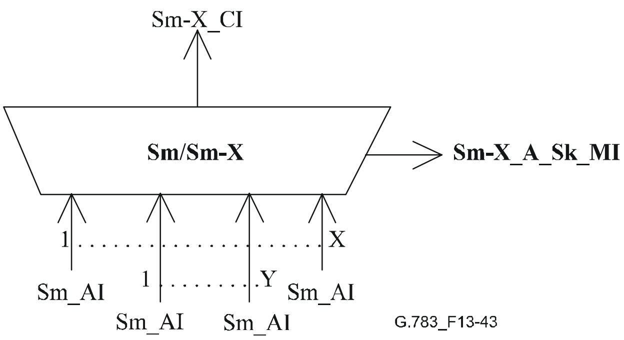


Figure 13-43/G.783 – Sm/Sm-X_A_Sk symbol

Interfaces

Table 13-26/G.783 – Sm/Sm-X_A_Sk input and output signals

Inputs	Outputs
Sm_AI[1..X]_D Sm_AI[1..X]_CK Sm_AI[1..X]_FS Sm-X_AI_TSF	Sm-X_CI_D Sm-X_CI_CK Sm-X_CI_FS Sm-X_A_Sk_MI_cLOM[1..X] Sm-X_A_Sk_MI_cSQM[1..X] Sm-X_A_Sk_MI_cLOA Sm-X_A_Sk_MI_AcSQ[1..X]

Processes

This function shall perform the monitoring and recovers the status of the X individual Sm which form the Sm-X_CI, the alignment of the X Sms and shall recover the outgoing Sm-X_AI.

Collection process

The collection function performs an 8-bit or byte deinterleave operation of the incoming signals; 8-bits/byte from signal T_i are mapped into the Sm-X payload, the next 8-bits/byte are taken from signal T_{i+1}, etc. T_i, T_{i+1}, etc. belong to the actual group and are not temporarily removed.

The bits V5_X[5-7] (PSL) are copied from signal T_j. Bits K4[1] (extended signal label) and K4_X[3-4] (APS) are copied from signal T_j. The value of j is for further study.

Multiframe Alignment processes: See 8.2.5.2.

Individual Sm Alignment processes

The function shall align the individual Sms to a common multiframe start if CI_SSF, dLOM or dSQM is not active for any individual Sm. The alignment process shall cover at least a differential delay of 125 µs.

Defects

Loss of Multiframe defect (dLOM): see 6.2.5.5.

Loss of Sequence defect (dSQM): dSQM shall be detected if the accepted sequence number (AcSQ) does not match the expected Sequence number (ExSQ). dSQM shall be cleared if AcSQ matches ExSQ. The ExSQ of Sm[n] is n – 1.

Loss of Alignment (dLOA): dLOA shall be detected if the alignment process cannot perform the alignment of the individual Sms to a common multiframe start (e.g., dLOA is activated if the differential delay exceeds the size of the alignment buffer). The details are for further study.

Consequent actions

aAIS ← dLOM[1..X] or dSQM[1..X] or dLOA

aTSF ← CI_SSF[1..X] or dLOM[1..X] or dSQM[1..X] or dLOA

On declaration of aAIS, the function shall output an all-ONEs signal within 250 µs; on clearing of aAIS, the function shall output normal data within 250 µs.

Defect correlations

cLOM[n] ← dLOM[n] and (not AI_TSF[n])

cSQM[n] ← dSQM[n] and (not dLOM[n]) and (not AI_TSF[n])

cLOA ← dLOA and (not dSQM[1..X]) and (not dLOM[1..X]) and (not AI_TSF[1..X])

Performance monitoring

The performance monitoring process is for further study.

13.5.2 LCAS-capable virtual concatenated VC-m path layer functions Sm-Xv-L (m = 11, 12, 2; X ≥ 1)

The LCAS-capable virtual concatenated VC-m path layer functions (Sm-Xv-L, m = 11, 12, 2) are instantiations of the generic functions defined in 10.1/G.806 (P-Xv-L), particularized with some technology-specific aspects.

The definitions in the present clause provide references to the appropriate generic function definitions in 10.1/G.806 and specify the technology-specific particularizations where necessary.

13.5.2.1 VC-m-Xv-L Layer Trail Termination Function Sm-Xv-L_TT

The Sm-Xv-L_TT function is further decomposed as defined in 10.1.1/G.806 and shown in Figure 13-44.

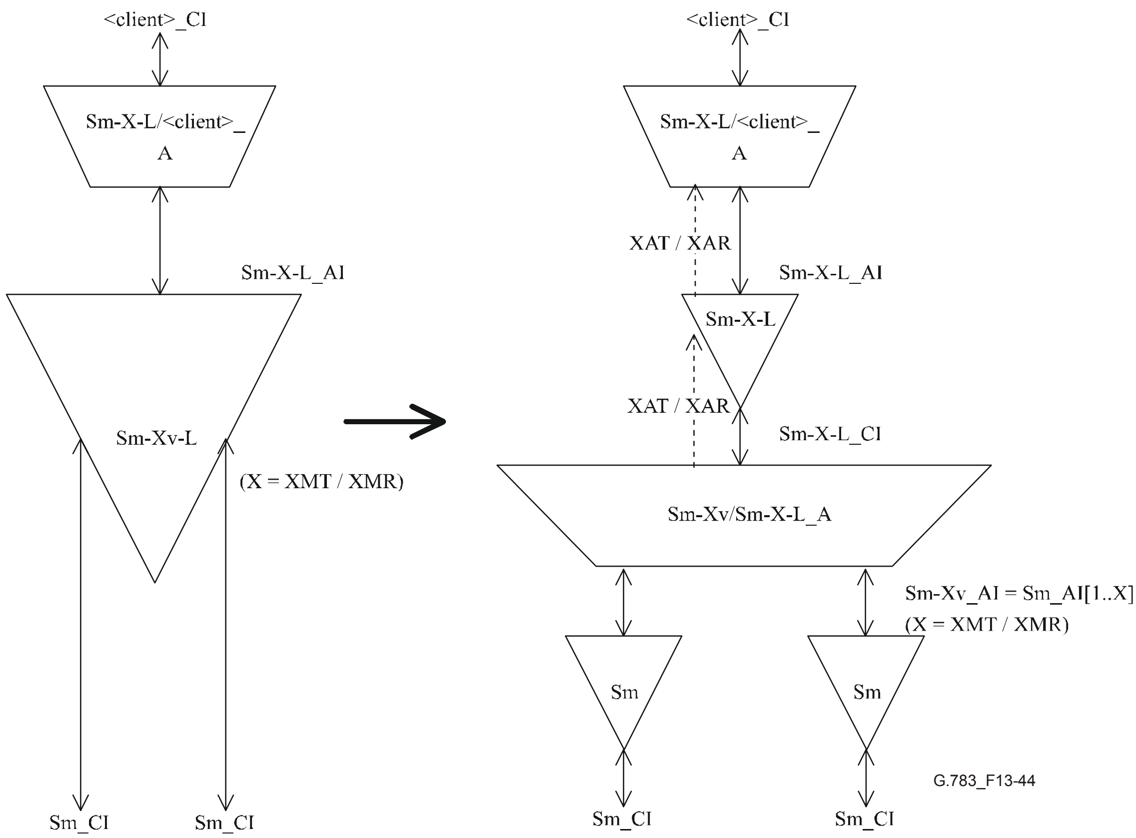


Figure 13-44/G.783 – Decomposition of Sm-Xv_TT function

The decomposition for this function is the same as for the corresponding generic function P-Xv-L_TT as defined in 10.1.1/G.806, with the following technology-specific particularizations:

- The path-layer "P-" is the Sm- layer.
- The Sm_TT functions are the normal VC-m trail termination functions as defined in 13.2.1.
- X_{MT}, $X_{MR} \leq 64$, according to the definitions in 11.4/G.707/Y.1322.

13.5.2.1.1 VC-m-Xv/VC-m-X-L Adaptation Source Function Sm-Xv/Sm-X-L_A_So

Symbol

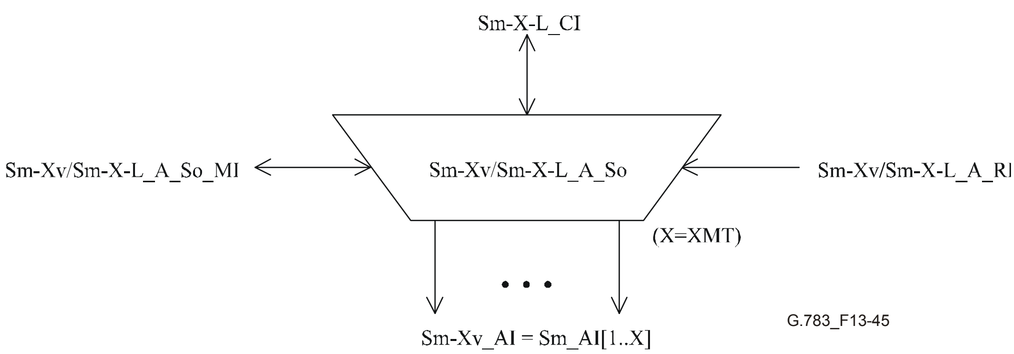


Figure 13-45/G.783 – Sm-Xv/Sm-X-L_A_So symbol

Interfaces

The interfaces for this function are the same as for the corresponding generic function P-Xv/P-X-L_A_So as defined in 10.1.1.1/G.806, with the following technology-specific particularizations:

- The path-layer "P-" is the Sm- layer.
- MST_Range = 63 (corresponding to the range as defined in 11.4/G.707/Y.1322).

Processes

The process definitions for this function are the same as for the corresponding generic function P-Xv/P-X-L_A_So as defined in 10.1.1.1/G.806, with the following technology-specific particularizations:

– **OH Extract**

The extracted overhead information _CI_OH consists of the following VC-m-X POH bytes: V5[5-7] (PSL), K4[1][12-19] (ESL), K4[3-4] (APS).

NOTE – If an ESL (extended signal label) is not present in K4[1], the "OH Extract" process shall propagate the default ESL value 0x08 ("Mapping under development", see 9.3.2.4/G.707/Y.1322).

– **Deinterleave (distribution process)**

The distribution process shall be as follows:

Starting from column 1 the Sm-X-L_CI_D signal shall be distributed to the X_{AT} VC-m as defined in Table 13-27.

Table 13-27/G.783 – Sm-X Distribution Mapping

Sm-X-L_CI_D column	Deinterleave output number	Deinterleave output column
1	1	1
…	…	…
X_{AT}	X_{AT}	1
$X_{AT} + 1$	1	2
...	...	...
$2 \times X_{AT}$	X_{AT}	2
$2 \times X_{AT} + 1$	1	3
...	...	...
$107/35/26 \times X_{AT}$	X_{AT}	107/35/26

Note that this mapping is uniform throughout the path overhead and payload columns. Also, note that this mapping is equivalent to the mapping defined in Figure 13-42.

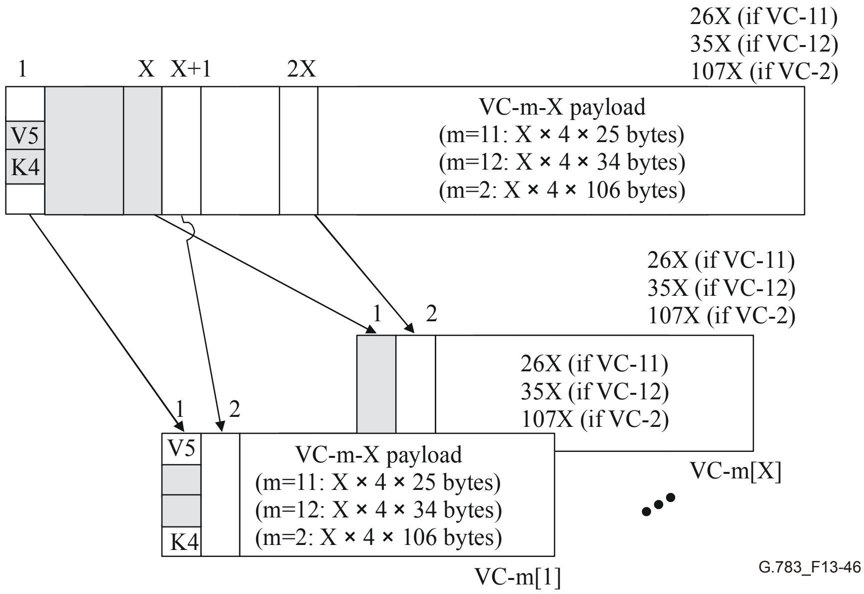


Figure 13-46/G.783 – Sm-Xv/Sm-X-L_A_So deinterleave process

For the outputs $X_{AT}+1$, $X_{AT}+2$, …, X_{MT}, this block inserts an all-ZEROS signal with the rate and format of a VC-m signal.

– **"Switch 1" (assignment of sequence numbers)**

For all non-payload-carrying outputs (_PC[s]=0) this process inserts an all-ZEROS signal with the rate and format of a VC-m signal.

– **VLI Insertion**

The VLI information consists of the value of K4[1][1-11] (MFAS) and K4[2], and has the coding defined in 11.4/G.707/Y.1322 for those overhead bits.

– **VLI Assemble and CRC**

The VLI information consists of the value of K4[1][1-11] (MFAS) and K4[2], and has the coding defined in 11.4/G.707/Y.1322 for those overhead bits. The CRC code used is the CRC-3 defined in 11.4/G.707/Y.1322.

Irrespective of the value of MI_LCASEnable, all unused fields in the K4[2] multiframe structure shall be sourced as zeros.

– **OH Insert**

The inserted overhead information _CI_OH consists of the following VC-m POH bytes: V5[5-7] (PSL), K4[1][12-19] (ESL), K4[3-4] (APS).

Defects

See 10.1.1.1/G.806.

Consequent actions

See 10.1.1.1/G.806.

Defect correlations

See 10.1.1.1/G.806.

Performance monitoring

See 10.1.1.1/G.806.

13.5.2.1.2 VC-m-Xv/VC-m-X-L Adaptation Sink Function Sm-Xv/Sm-X-L_A_Sk

Symbol

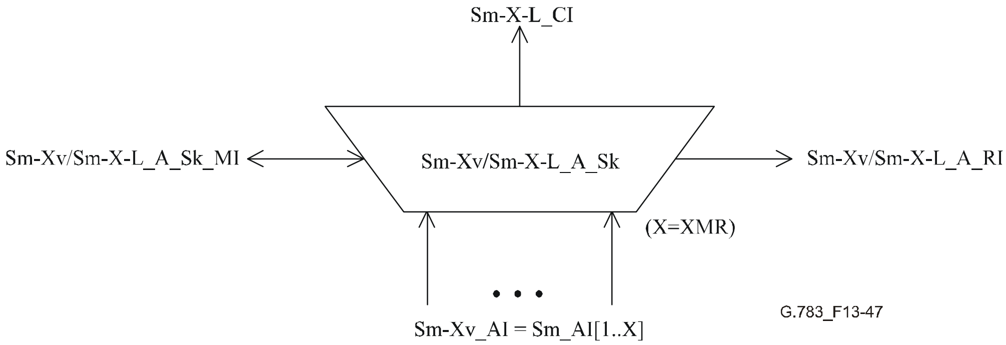


Figure 13-47/G.783 – Sm-Xv/Sm-X-L_A_Sk symbol

Interfaces

The interfaces for this function are the same as for the corresponding generic function P-Xv/P-X-L_A_Sk as defined in 10.1.1.2/G.806, with the following technology-specific particularizations:

- The path-layer "P-" is the Sm- layer.
- MST_Range = 63 (corresponding to the range as defined in 11.4/G.707/Y.1322).

Processes

The process definitions for this function are the same as for the corresponding generic function P-Xv/P-X-L_A_Sk as defined in 10.1.1.2/G.806, with the following technology-specific particularizations:

– **MFI Extract**

The multiframe alignment process shall be according to 8.2.5.2.

The _MFI[i] output consists of a 10-bit word, where the 5 least-significant bits contain the current value of the K4[1] multiframe (0-31) and the 5 most-significant bits the value of the MFI contained in the K4[2][1-5] in AI_D[i]. If AI_TSF[i]=true, then the _MFI[i] output of this process shall be an all-ONES 10-bit word.

The dLOM[i] detection for each member shall be as described in Defects below.

– **VLI, TSx Extract**

The VLI information consists of the value of K4[1][1-11] (MFAS) and K4[2], and has the coding defined in 11.4/G.707/Y.1322 for those overhead bits.

If _TSF[i] is false and dMND[i] is false, then the _VLI[i] output of this process is the value of the K4[1][1-11] (MFAS) and K4[2] at the input of this process.

If _TSF[i] is true or dMND[i] is true, then the _VLI[i] output of this process shall be an all-ONES sequence.

– **VLI Disassemble and CRC**

The VLI information consists of the value of K4[1][1-11] (MFAS) and K4[2], and has the coding defined in 11.4/G.707/Y.1322 for those overhead bits. The CRC code used is the CRC-3 defined in 11.4/G.707/Y.1322.

– **"Interleave process"**

The recovery process shall be as follows:

Starting from column 1 the Sm-x-L-Ci signal shall be recovered from the X_{AR} VC-m as defined in Table 13-28.

Table 13-28/G.783 – Sm-X-L Recovery Mapping

Interleave input number	Interleave input column	Sm-X-L_CI column
1	1	1
…	…	…
X_{AR}	1	X_{AR}
1	2	$X_{AR} + 1$
...	...	...
X_{AR}	2	$2 \times X_{AR}$
1	3	$2 \times X_{AR} + 1$
...	...	...
X_{AR}	26/35/107	$26/35/107 \times X_{AR}$

Note that this mapping is uniform throughout the path overhead and payload columns. Also, note that this mapping is equivalent to the mapping defined in 13.5.1.2.2. In particular, note that the POH column (column 1) of the Sm-X-L_CI signal will be obtained from the POH column from interleaver input 1, which in turn will be the payload-carrying member with the lowest sequence number.

Defects

Loss of Multiframe defect (dLOM): See 6.2.5.5.

Loss of Sequence defect (dSQM): See 10.1.1.2/G.806.

Member Not Deskewable (dMND): See 10.1.1.2/G.806.

Loss of Alignment (dLOA): See 10.1.1.2/G.806.

Consequent actions

See 10.1.1.2/G.806.

On declaration of aAIS, the function shall output all-ONEs signal within 250 µs; on clearing of aAIS, the function shall output normal data within 250 µs. The bit rate of this all-ONEs signal shall be consistent with the value of $\_X_{AR}$ as calculated by the processes involved.

Defect correlations

See 10.1.1.2/G.806.

Performance monitoring

See 10.1.1.2/G.806.

13.5.2.1.3 LCAS-capable VC-m-X-L Trail Termination Source Function Sm-X-L_TT_So

Symbol

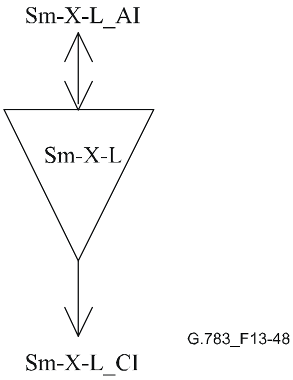


Figure 13-48/G.783 – Sm-X-L_TT_So symbol

Interfaces

The interfaces for this function are the same as for the corresponding generic function P-Xv/P-X-L_TT_So as defined in 10.1.1.3/G.806, with the following technology-specific particularizations:

- The path-layer "P-" is the Sm- layer.

Processes

See 10.1.1.3/G.806.

Defects

See 10.1.1.3/G.806.

Consequent actions

See 10.1.1.3/G.806.

Defect correlations

See 10.1.1.3/G.806.

Performance monitoring

See 10.1.1.3/G.806.

13.5.2.1.4 LCAS-capableVC-m-X-L Layer Trail Termination Sink Function Sm-X-L_TT_Sk

Symbol

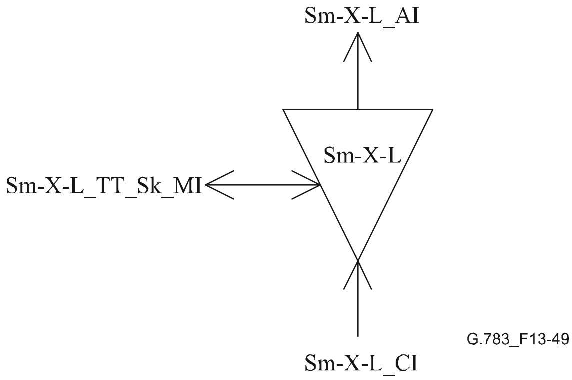


Figure 13-49/G.783 – Sm-X-L_TT_Sk symbol

Interfaces

The interfaces for this function are the same as for the corresponding generic function P-Xv/P-X-L_TT_Sk as defined in 10.1.1.4/G.806, with the following technology-specific particularizations:

- The path-layer "P-" is the Sm- layer.

Processes

See 10.1.1.4/G.806.

Defects

See 10.1.1.4/G.806.

Consequent actions

See 10.1.1.4/G.806.

Defect correlations

See 10.1.1.4/G.806.

Performance monitoring

See 10.1.1.4/G.806.

14 Timing functions

The synchronization layer functions are described in ITU-T Rec. G.781 [9].

15 Specification of jitter and wander

15.1 STM-N interfaces

15.1.1 Input jitter tolerance

Jitter tolerance for SDH line terminal and regenerators to used in line systems including type A regenerators is defined in OSn/RSn_A_Sk (see 9.3.1.2) or in ES1/RS1_A_Sk (see 9.3.2.2) atomic functions. As part of the jitter tolerance requirements in both these clauses, the type A regenerator shall tolerate jitter modulation applied to the input signal as specified in ITU-T Rec. G.825. The high-band portion of the G.825 sinusoidal jitter tolerance masks is given in Figure 15-2, with the parameters specified in Table 15-1, for each STM-N level.

SDH line terminals and regenerators to be used in line systems with only type B regenerators, or in line systems without regenerators, may have reduced jitter tolerance. Such equipment shall tolerate, as a minimum, the input jitter applied according to the mask in Figure 15-2, with the parameters specified in Table 15-1a for each STM-N level. SDH equipment with reduced jitter tolerance may require some jitter reduction in the case they follow a chain of type A regenerators.

Table 15-1a/G.783 – Parameters for reduced jitter tolerance

STM-N level	A_3 (UI)	A_4 (UI)	f_2 (kHz)	f_3 (kHz)
STM-1	1.5	0.15	1.2	12
STM-4	1.5	0.15	1.2	12
STM-16	1.5	0.15	1.2	12
STM-64	tbd	tbd	tbd	tbd
STM-256	tbd	tbd	tbd	tbd

15.1.2 Output jitter generation

Output jitter generation for STM-N signals is defined in the MSn-LC_A_So (see ITU-T Rec. G.781), OSn/RSn_A_ So (see 9.3.1.1), or ES1/RS1_A_So functions (see 9.3.2.1).

15.1.3 Jitter and wander transfer

Jitter transfer function for SDH terminal equipment:

The jitter transfer characteristics of a couple of SDH input and output are only applicable in the case where this input signal is selected as the synchronization source by the NS-C connection function specified in ITU-T Rec. G.781. In this case the transfer characteristics is specified in the clock adaptation function SD/NS-xxx_A_So of ITU-T Rec. G.781.

Jitter transfer specification for SDH regenerators:

The jitter transfer function is defined as the ratio of jitter on the output STM-N signal to the jitter applied on the input STM-N signal versus frequency.

The jitter transfer function of a Type A SDH regenerator shall be under the curve given in Figure 15-1, with the parameters specified for Type A in Table 15-2 for each bit rate, when input sinusoidal jitter up to the mask level in Figure 15-2 with the parameters specified in Table 15-1 is applied.

The jitter transfer function of a Type B SDH regenerator shall be under the curve given in Figure 15-1, with the parameters specified for Type B in Table 15-2 for each bit rate, when input sinusoidal jitter up to the mask level in Figure 15-2 with the parameters specified in Table 15-1a is applied.

In Figure 15-1 and Table 15-2, the jitter transfer measurement is made over the frequency range f_L to f_H. The lower frequency f_L is set to $f_C/100$ (where f_C is the corner frequency), and f_H is defined as the lower of either $100*f_C$ or the maximum frequency specified for the low pass filter function for measurement of jitter at each of the defined rates (Upper –3 dB frequency in Measurement Band column of Table 9-6 – Jitter Generation for STM-N type A Regenerators in 2048 kbit/s based networks, and Table 9-7 – Jitter Generation for STM-N Regenerators in 1544 kbit/s based networks). Jitter above f_H is generally agreed to be insignificant relative to regenerator jitter accumulation, and low levels of in-spec jitter generation can easily be confused with an out-of-spec jitter transfer measurement when attempting to measure jitter transfer at high input/output attenuation levels (i.e., below –40 dB). The limits set for f_L at $f_C/100$ will always include the frequency at which maximum gain peaking occurs, and limiting jitter transfer measurements to frequencies between f_L and f_H will help limit testing time.

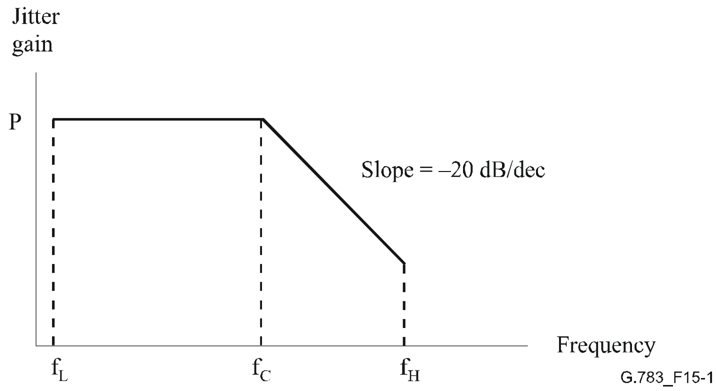
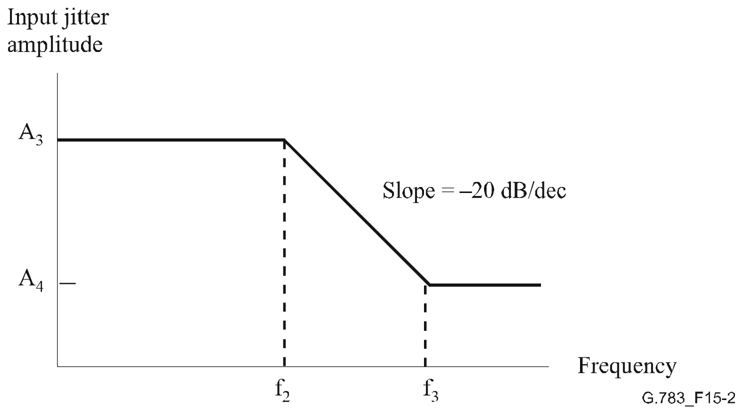


Figure 15-1/G.783 – Jitter transfer



NOTE – The values for A_3, A_4, f_2 and f_3 are from ITU-T Rec. G.825, and are summarized in Table 15-1.

Figure 15-2/G.783 – High-band portion of sinusoidal jitter tolerance mask (for type A, consistent with ITU-T Rec. G.825)

Table 15-1/G.783 – Parameter values for Figure 15-2

STM level	A3 (UI)	A4 (UI)	f_2 (kHz)	f_3 (kHz)	Reference
STM-1 Optical	1.5	0.15	6.5	65	Table 3/G.825 Figure 1/G.825
STM-1 Electrical (Note 1)	1.5	0.075	3.3	65	Table 4/G.825 Figure 2/G.825
STM-1 Electrical (Note 2)	1.5	0.15	6.5	65	Table 4/G.825 Figure 1/G.825
STM-4	1.5	0.15	25	250	Table 5/G.825 Figure 3/G.825
STM-16	1.5	0.15	100	1000	Table 6/G.825 Figure 4/G.825
STM-64	1.5	0.15	400	4000	Table 7/G.825 Figure 5/G.825
STM-256	tbd	tbd	tbd	tbd	tbd
NOTE 1 – These values apply to SDH networks optimized for the 2048 kbit/s hierarchy. NOTE 2 – These values apply to SDH networks optimized for the 1544 kbit/s hierarchy.					

Table 15-2/G.783 – Jitter transfer parameters

STM-N level (type)	f_L (kHz)	f_C (kHz)	f_H (kHz)	P (dB)
STM-1 (A)	1.3	130	1 300	0.1
STM-1 (B)	0.3	30	1 300	0.1
STM-4 (A)	5	500	5 000	0.1
STM-4 (B)	0.3	30	3 000	0.1
STM-16 (A)	20	2 000	20 000	0.1
STM-16 (B)	0.3	30	3 000	0.1
STM-64 (A)	10	1 000	80 000	0.1
STM-64 (B)	tbd	tbd	tbd	tbd
STM-256 (A)	tbd	tbd	tbd	tbd
STM-256 (B)	tbd	tbd	tbd	tbd

15.1.4 Pattern dependence testing

STM-N signals contain regions within the data stream where the possibility of bit errors being introduced is greater due to the structure of the data within these regions.

Three cases in particular may be identified:

1) errors resulting from eye-closure due to the tendency for the mean level of the signal within the equipment to vary with pattern-density due to alternative current couplings ("DC wander");
2) errors due to failure of the timing recovery circuit to bridge regions of data containing very little timing information in the form of data transitions;

3) errors due to failure of the timing recovery circuit as in 2) above but compounded by the occurrence of the first row of the STM-N section overhead bytes preceding a period of low timing content (these bytes have low data content, particularly for large N).

A possible method to verify the CID immunity of SDH equipment is described in Appendix V.

15.2 PDH interfaces

15.2.1 Input jitter and wander tolerance

Input jitter and wander tolerance for 2048 kbit/s hierarchy based signals are defined in ITU-T Rec. G.823. Input jitter and wander tolerance of 1544 kbit/s hierarchy based signals are defined in ITU-T Recs G.824, G.743, and G.752. The PDH signal may be used as a synchronization reference source by the synchronization functions (refer to ITU-T Rec. G.781). In this case, additional parameters and limits are defined in ITU-T Rec. G.813.

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

15.2.2 Jitter and wander transfer

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

NOTE 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.

NOTE 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.

15.2.3 Jitter and wander generation

15.2.3.1 Jitter and wander from tributary mapping

Specifications for jitter arising from mapping G.703 (PDH) tributaries into containers, described in ITU-T Rec. G.707/Y.1322, should be specified in terms of peak-to-peak amplitude over a given frequency band over a given measurement interval. The limits for each G.703 (PDH) tributary interface and the corresponding filter characteristics for mapping jitter are given in Table 15-3.

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 requirements shall be met when the input frequency of the PDH interface is constant within the limits –a ppm to +a ppm from the nominal frequency. The value of "a" is defined in the appropriate clauses of ITU-T Rec. G.703.

15.2.3.2 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.

15.2.3.3 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 (PDH) interfaces is the demarcation between jitter and wander. Thus, a critical feature is the high-pass filter characteristics which for measurement purposes are specified in 9.3.2/O.172. The limits for each G.703 (PDH) tributary interface and the corresponding filter characteristics for combined jitter are given in Table 15-4, based on the pointer test sequences shown in Figure 15-3.

In order to prime the pointer processor and to prepare the equipment for the test sequence, it is necessary to apply initialization and cool-down sequences. In the case of single and burst sequences, the pointer processor must not absorb the pointer movements and stop them affecting the jitter on the demultiplexed tributary signal. In the case of periodic sequences, the pointer processor must be in the steady-state condition that it would be in if continual pointer movements had always been present. For single and burst test sequences, the initialization period should consist of pointer adjustments applied at a rate exceeding that of the test sequence, but less than 3 pointer adjustments per second, in the same direction as the subsequent test sequence. The initialization period should last at least until a response is detected in the jitter measured on the demultiplexed tributary signal. After the initialization period, it is recommended that a 30-second cool-down period is allowed when no pointer activity is present in the test signal. For periodic test sequences (both continuous and gapped), it is recommended that a minimum 60-second initialization period be used. A 30-second cool-down period is recommended during which the periodic sequence is applied so that a steady state condition is maintained. If necessary, the period must be extended to include an integral number of complete sequences.

For the 1544 kbit/s wander requirements of 15.2.3.3.1, MTIE is measured using a 100 Hz first-order low-pass filter. The reason a 100 Hz low-pass filter is used is that the minimum observation interval for the MTIE measurements is 1 ms. For the 44 736 kbit/s wander requirements of 15.2.3.3.2, MTIE is measured using a 10 Hz first-order low-pass filter with a sampling rate of 30 samples/s or greater.

The values in Tables 15-3 and 15-4 are only valid if all network elements providing the path are maintained in synchronization. The above requirements do not apply under SDH network synchronization loss conditions.

The frequency of the PDH tributary is independent of the SDH synchronization frequency.

The requirements shall be met when the input frequency of the PDH interface is constant within the limits –a ppm to +a ppm from the nominal frequency. The value of "a" is defined in the appropriate clauses of ITU-T Rec. G.703.

The high-pass measurement filters of Tables 15-3 and 15-4 have a first-order characteristic and a roll-off of 20 dB/decade. The low-pass measurement filters have a maximally-flat, Butterworth characteristic and a roll-off of –60 dB/decade (for STM-N bit-rates and PDH bit rates based on the 2048 kbit/s hierarchy) or –20 dB/decade (for PDH bit rates based on the 1544 kbit/s hierarchy). Further specifications for the frequency response of the jitter measurement function such as measurement filter accuracy and additional allowed filter poles are given in ITU-T Rec. O.172 [23].

Table 15-3/G.783 – Mapping jitter generation specification

G.703 (PDH) interface	Filter characteristics (Notes 2)			Maximum pk-pk jitter	
				Mapping	
	f1 high pass	f3 high pass	f4 low pass	f1-f4	f3-f4
1544 kbit/s	10 Hz 20 dB/dec	8 kHz	40 kHz –20 dB/dec	0.7 (Note 3) (A_0)	(Note 1)
2048 kbit/s	20 Hz 20 dB/dec	18 kHz (700 Hz) 20 dB/dec	100 kHz –60 dB/dec	(Note 1)	0.075 UI
6312 kbit/s	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)
34 368 kbit/s	100 Hz 20 dB/dec	10 kHz 20 dB/dec	800 kHz –60 dB/dec	(Note 1)	0.075 UI
44 736 kbit/s	10 Hz	30 kHz	400 kHz –20 dB/dec	0.40 UI (A_0) (Note 3)	(Note 1)
139 264 kbit/s	200 Hz 20 dB/dec	10 kHz 20 dB/dec	3500 kHz –60 dB/dec	(Note 1)	0.075 UI

NOTE 1 – These values are for further study.

NOTE 2 – The frequency value shown in parenthesis only applies to certain national interfaces. For more information on filter characteristics, refer to ITU-T Rec. O.172 [23].

NOTE 3 – To ensure synchronizer/desynchronizer interoperability, the mapping mechanism shall meet the following requirement. The stuffing mechanism that generates the C bits (justification control bits) shall be implemented such that, given a 40 Hz single pole low pass filter desynchronizer with gain peaking not exceeding 0.1 dB, the mapping jitter shall meet the respective requirement in this table.

Table 15-4/G.783 – Combined jitter generation specification

G.703 (PDH) interface	Filter characteristics (Notes 4 and 8)			Maximum pk-pk jitter	
				Combined	
	f1 high pass	f3 high pass	f4 low pass	f1-f4	f3-f4
1544 kbit/s	10 Hz 20 dB/dec	8 kHz	40 kHz –20 dB/dec	(Note 9) (Note 5)	(Note 1)
2048 kbit/s	20 Hz 20 dB/dec	18 kHz (700 Hz) 20 dB/dec	100 kHz –60 dB/dec	0.4 UI (Note 2)	0.075 UI (Note 2)
6312 kbit/s	(Note 1)	(Note 1)	(Note 1)	(Note 1)	(Note 1)
34 368 kbit/s	100 Hz 20 dB/dec	10 kHz 20 dB/dec	800 kHz –60 dB/dec	0.4 UI 0.75 UI (Note 3)	0.075 UI (Note 3)

Table 15-4/G.783 – Combined jitter generation specification

G.703 (PDH) interface	Filter characteristics (Notes 4 and 8)			Maximum pk-pk jitter	
				Combined	
	f1 high pass	f3 high pass	f4 low pass	f1-f4	f3-f4
44 736 kbit/s	10 Hz	30 kHz	400 kHz –20 dB/dec	(Note 9) (Note 6)	(Note 1)
139 264 kbit/s	200 Hz 20 dB/dec	10 kHz 20 dB/dec	3500 kHz –60 dB/dec	0.4 UI 0.75 UI (Notes 3 and 7)	0.075 UI (Notes 3 and 7)

NOTE 1 – These values are for further study.

NOTE 2 – The limit corresponds to pointer sequences in Figure 15-3 a), b), c). T2 > 0.75 s T3 = 2 ms.

NOTE 3 – The 0.4 UI and 0.075 UI limits correspond to pointer sequences in Figure 15-3 a), b), c). The 0.75 UI limit corresponds to the pointer sequence in Figure 15-3 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.

NOTE 4 – The frequency value shown in parenthesis only applies to certain national interfaces.

NOTE 5 – The requirement for a single pointer adjustment (Figure 15-3 e)) is A0 + 0.6 UI. The requirement for periodic (both continuous and 26/1) without added or cancelled pointers (Figures 15-3 h), j)) is 1.3 UI. The requirement for periodic (both continuous and 26/1) with added or cancelled pointers (Figures 15-3 h), j)) is 1.9 UI. In Figures 15-3 h) and 15-3 j), T4 = 2 ms and 1 s ≤ T5 < 10 s.

NOTE 6 – The requirement for a single pointer adjustment (Figure 15-3 e)) is A0 + 0.3 UI. The requirement for periodic (both continuous and 87/3) without added or cancelled pointers (Figure 15-3 g), h)) is 1.0 UI. The requirement for periodic (both continuous and 87/3) with added or cancelled pointers (Figure 15-3 g), h)) is 1.3 UI. The requirement for a burst of pointer adjustments (Figure 15-3 f)) is 1.3 UI. The requirement for a phase transient pointer adjustment burst (Figure 15-3 i)) is 1.2 UI. In Figure 15-3 f), g) and h), T4 = 0.5 ms and 34 ms ≤ T5 < 10 s.

NOTE 7 – The pointer sequence in Figure 15-3 g) applies at AU-3 and AU-4 levels only. Jitter and wander values are for further study.

NOTE 8 – For more information on filter characteristics, refer to ITU-T Rec. O.172.

NOTE 9 – A_0 is the combined jitter when there is no pointer sequence applied.

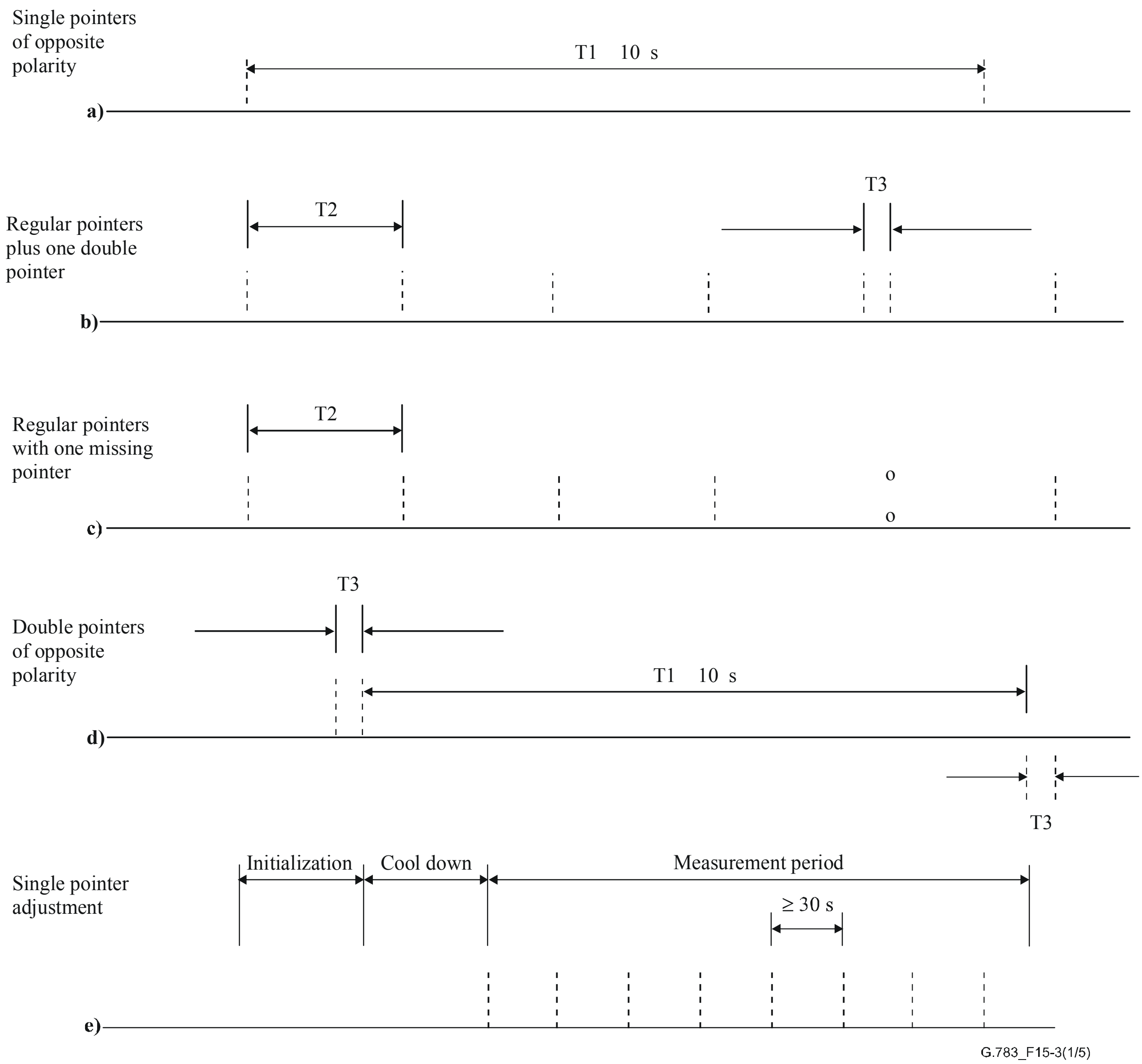


Figure 15-3/G.783 – Pointer test sequences *(sheet 1 of 5)*

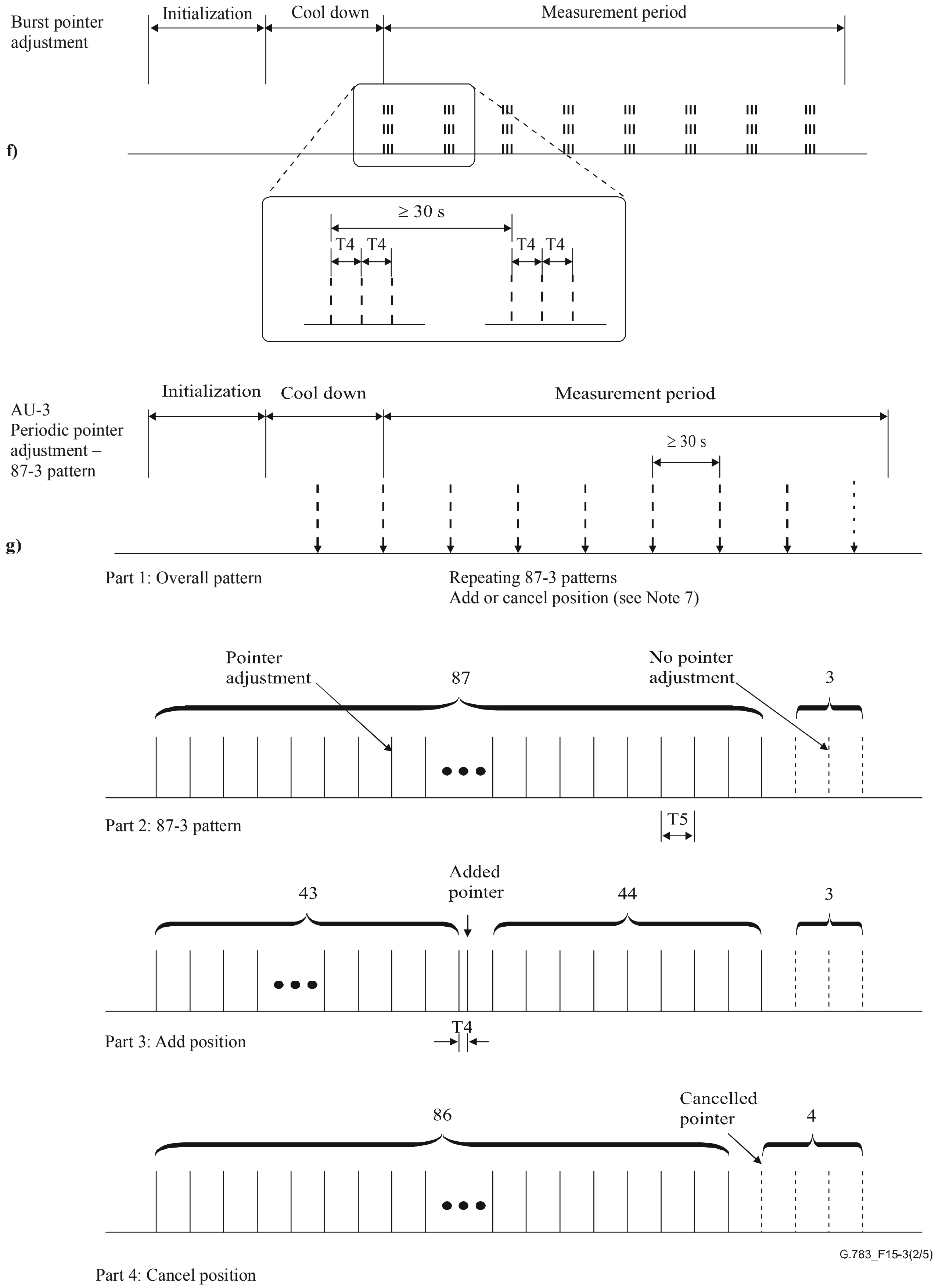
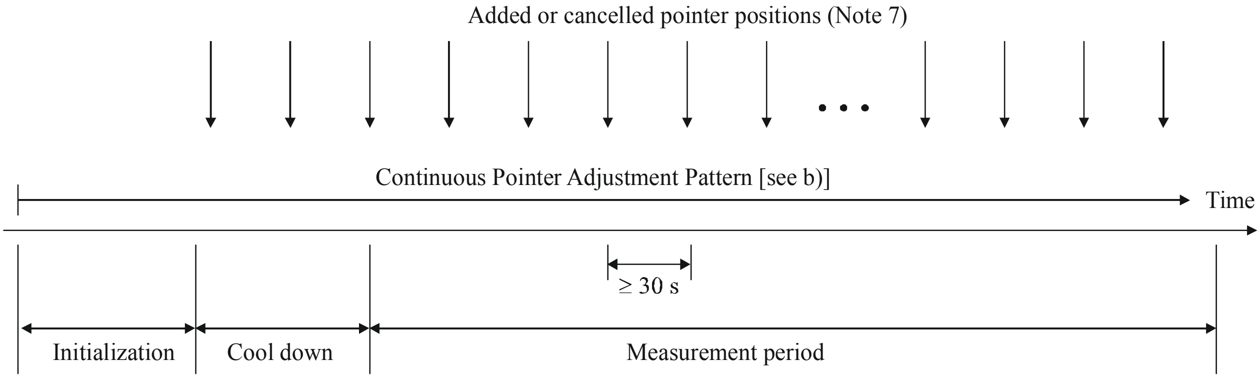
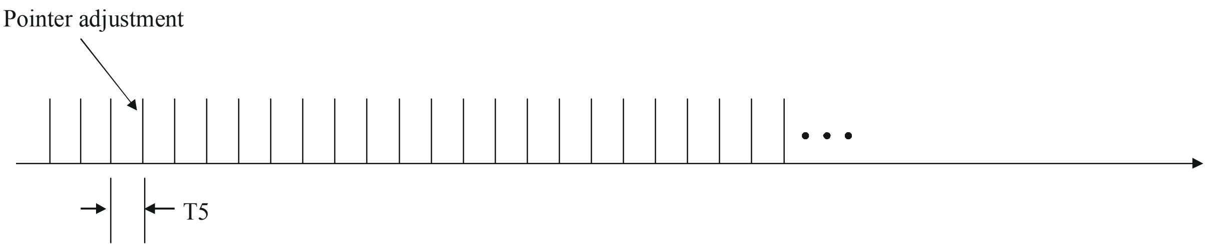


Figure 15-3/G.783 – Pointer test sequences *(sheet 2 of 5)*

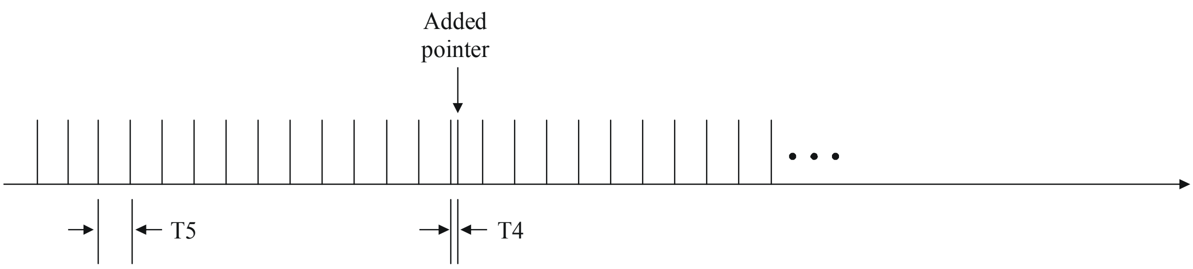
h) Periodic pointer adjustment – continuous (VC-11 and AU-3)



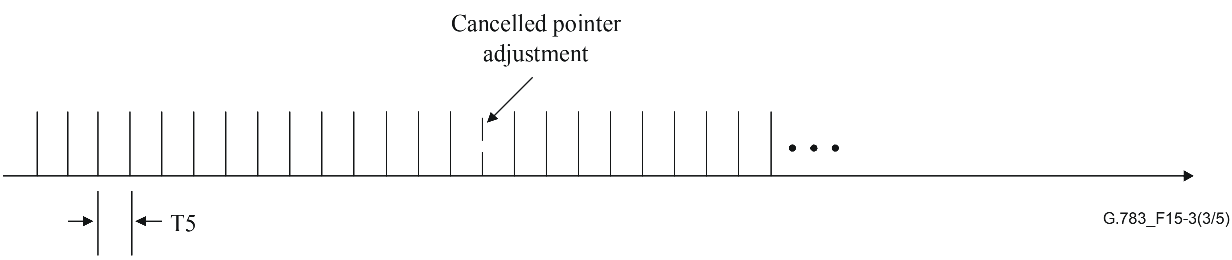
a) Overall pattern



b) Continuous pattern



c) Add position



d) Cancel position

Figure 15-3/G.783 – Pointer test sequences *(sheet 3 of 5)*

i) Phase transient pointer adjustment test sequence

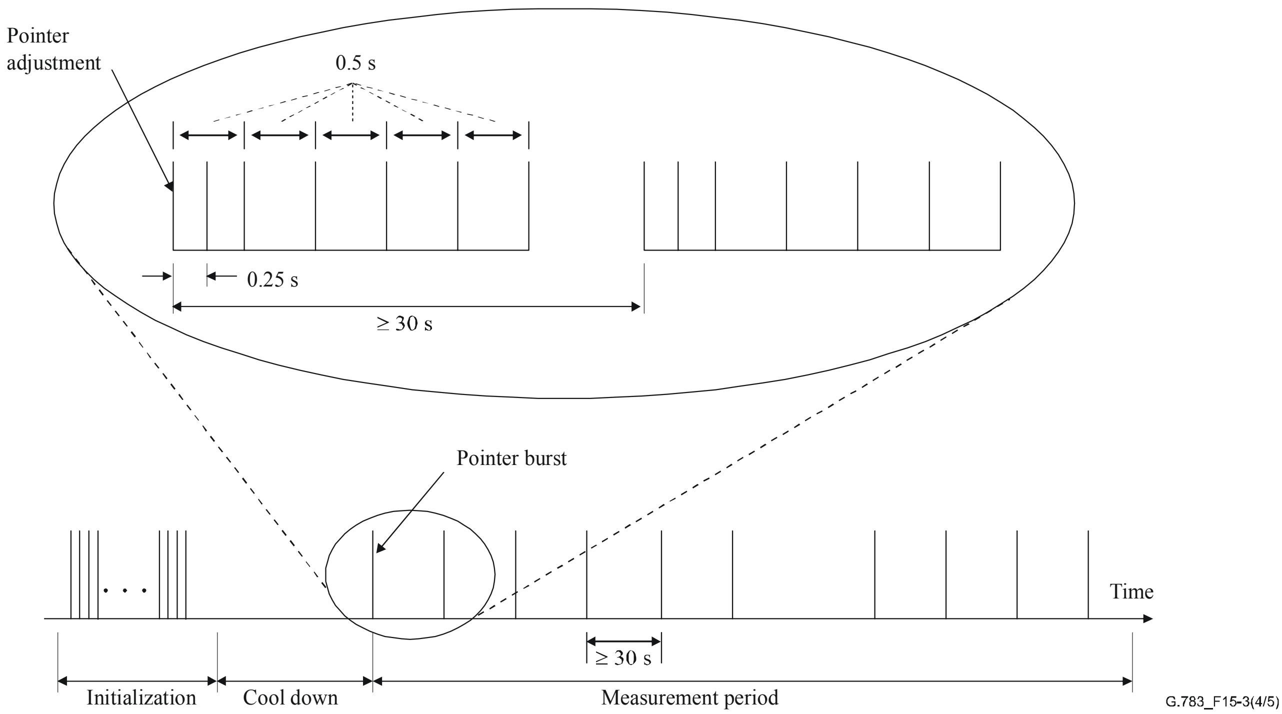
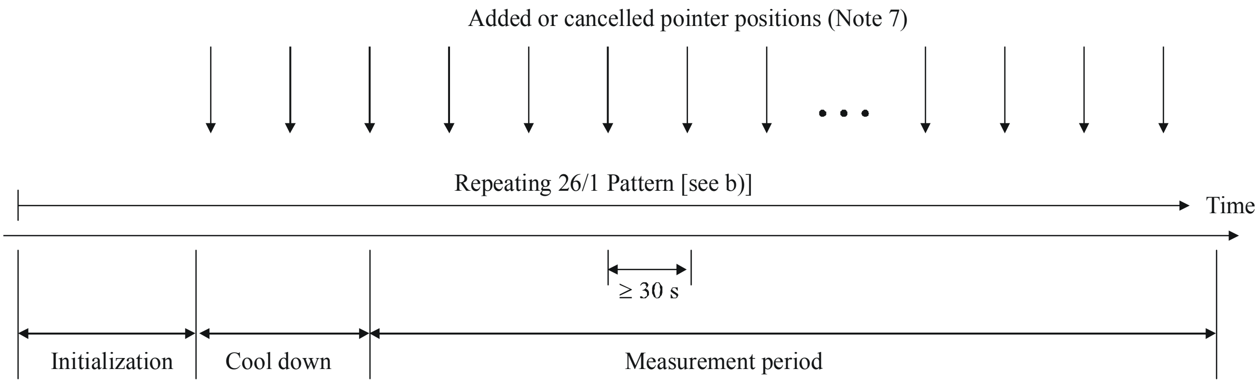
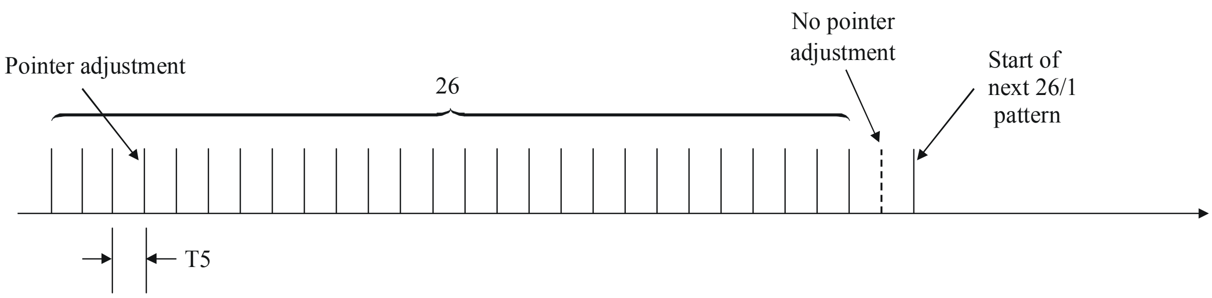


Figure 15-3/G.783 – Pointer test sequences *(sheet 4 of 5)*

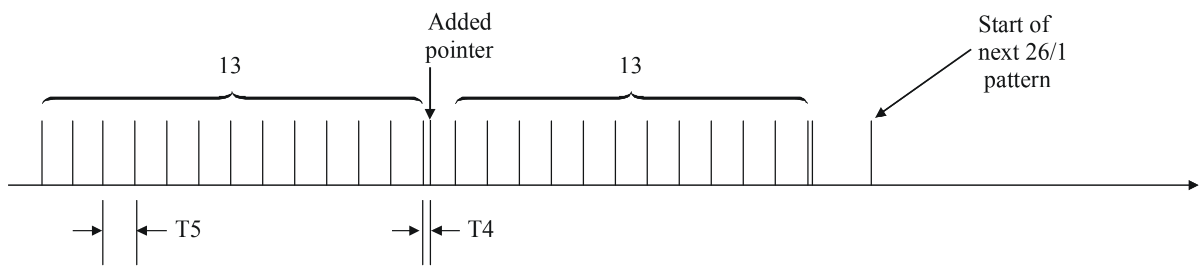
j) Periodic VC-11 pointer adjustment test sequence – 26/1 pattern



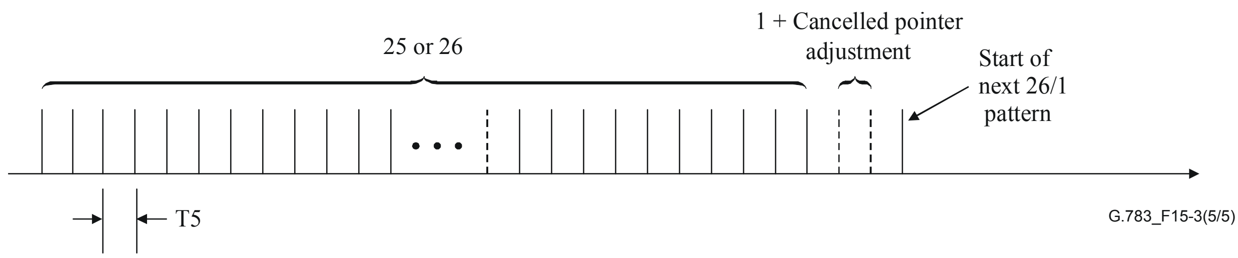
a) Overall pattern



b) 26/1 pattern



c) Add position



d) Cancel position

Figure 15-3/G.783 – Pointer test sequences *(sheet 5 of 5)*

Notes to Figure 15-3 e) through j)

NOTE 1 – The payload output jitter is defined as the maximum jitter over the entire measurement period.

NOTE 2 – For AU-3 level payloads, the adjustments shall be applied to the STM-N level pointers. For VC level payloads, the adjustments shall be applied to the TU level pointers.

NOTE 3 – Complete payload data integrity shall be maintained through the SDH network.

NOTE 4 – For both single and burst sequences, separate tests shall be run first with all positive pointer adjustments and then with all negative pointer adjustments.

NOTE 5 – For periodic sequences, T5 is constant for each measurement and determined by the amount of frequency offset between the VC and its carrier (higher order path for lower order VCs and STM-N for higher order VCs). T5 shall be varied over the range given in Notes 6 and 7 of Table 15-4.

NOTE 6 – All periodic tests must be done with positive frequency offsets and negative frequency offsets.

NOTE 7 – For periodic sequences, separate tests shall be run first with only added pointer adjustments and then with only cancelled pointer adjustments.

15.2.3.3.1 1544 kbit/s wander

15.2.3.3.1.1 1544 kbit/s wander caused by mapping

The wander on a 1544 kbit/s payload signal out of an SDH island due to the asynchronous mapping process and wander generation of the clocks shall be less than the values contained in Table 15-5 and illustrated in the mask of Figure 15-4 given no pointer adjustments, no wander on synchronizing signals and no jitter or wander on the 1544 kbit/s payload input to the SDH island.

Table 15-5/G.783 – 1544 kbit/s mapping MTIE (includes mapping and desynchronizer NE clock effects)

Time in seconds	MTIE in nanoseconds
0.001326 < S < 0.0115	MTIE < 61 000 * S
S > 0.0115	MTIE < 700

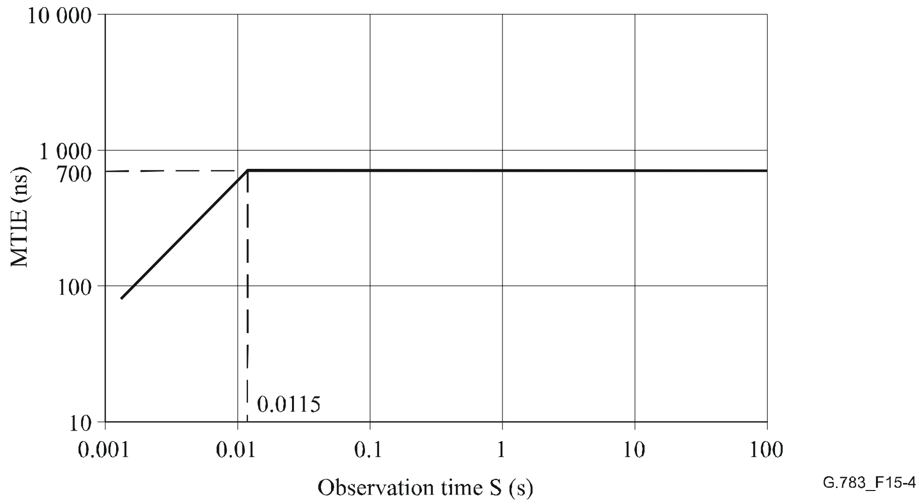


Figure 15-4/G.783 – 1544 kbit/s mapping MTIE

15.2.3.3.1.2 Wander caused by pointer adjustments

SDH pointer adjustment activity within a network is a function of the synchronization characteristics of that network. Clock noise causes a variation of the pointer processor buffer fill which results in wander of the payload signal. Because pointer adjustment statistics can vary widely, a set of test sequences was developed to adequately simulate the effect of network pointer adjustment activity on wander at the output of desynchronizers.

15.2.3.3.1.2.1 Single pointer adjustments

The MTIE on 1544 kbit/s payload signals out of an SDH island shall be less than the values contained in Table 15-6 and illustrated in the mask of Figure 15-5 when the pointer adjustment test sequence described in Figure 15-3 e) is applied to the final PTE and no jitter or wander is on the 1544 kbit/s input to the SDH island. These MTIE values do not include the effects of mapping wander, nor wander on synchronizing signals for the network elements.

Table 15-6/G.783 – 1544 kbit/s MTIE specification for single pointer adjustments

Time in seconds	MTIE in nanoseconds
0.001326 < S < 0.0164	MTIE < 61 000 * S
0.0164 > S > 0.93	MTIE < 925 + 4600 * S
S > 0.93	MTIE < 5200

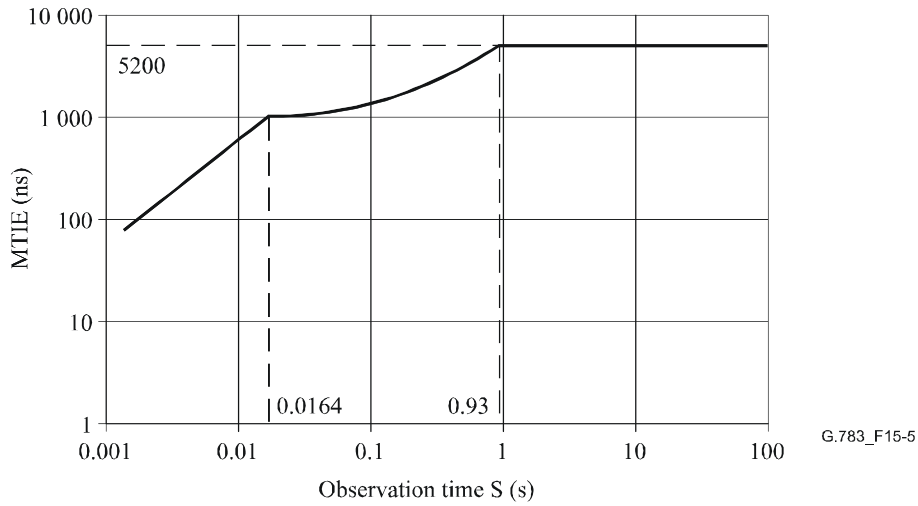


Figure 15-5/G.783 – Single 1544 kbit/s pointer adjustment MTIE

15.2.3.3.1.2.2 Periodic pointer adjustments

The MTIE on 1544 kbit/s payload signals out of SDH islands shall be less than the values contained in Table 15-7 and illustrated in the mask of Figure 15-6 when the pointer adjustment test sequence described in Figure 15-3 h) b) and Figure 15-3 j) b) are applied to the final PTE and no jitter or wander is applied at the input to the SDH island. These MTIE values do not include the effects of mapping wander, nor wander on synchronizing signals for network elements.

Table 15-7/G.783 – 1544 kbit/s MTIE specification for periodic pointer adjustments

Time in seconds	MTIE in nanoseconds
0.001326 < S < 0.0164	MTIE < 61 000 * S
0.0164 > S > 1.97	MTIE < 925 + 4600 * S
S > 1.97	MTIE < 10 000

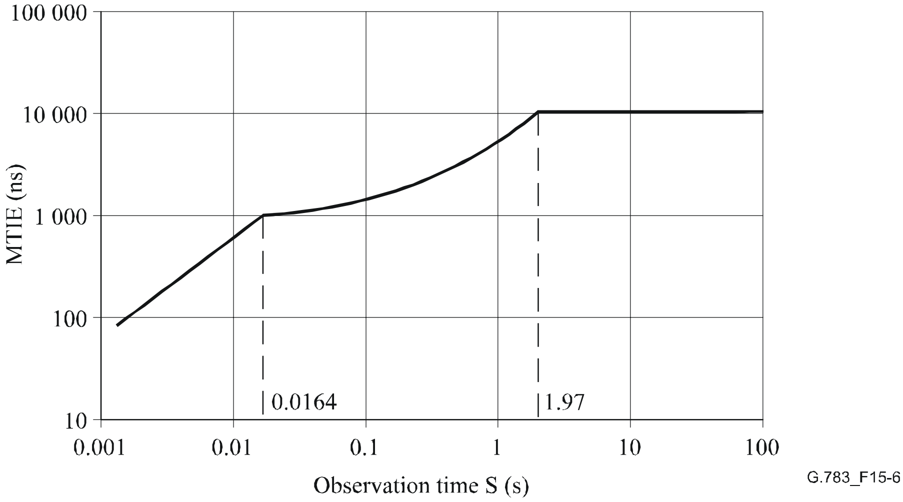


Figure 15-6/G.783 – Periodic 1544 kbit/s pointer adjustment MTIE

15.2.3.3.2 44 736 kbit/s wander

15.2.3.3.2.1 44 736 kbit/s wander caused by mapping

The wander on a 44 736 kbit/s payload signal out of an SDH island due to the asynchronous mapping process and wander generation of the clocks shall be less than the values contained in Table 15-8 and illustrated in the mask of Figure 15-7 given no pointer adjustments, no wander on synchronizing signals and no jitter or wander on the 44 736 kbit/s payload input to the SDH island.

Table 15-8/G.783 – 44 736 kbit/s mapping MTIE (includes mapping and desynchronizer NE clock effects)

Time in seconds	MTIE in nanoseconds
S < 0.1	N/A (jitter region)
0.1 < S < 0.25	20
0.25 < S < 1	53 * S + 7
1 < S < 10	37 * S^1/2 + 23
10 < S < 100	140

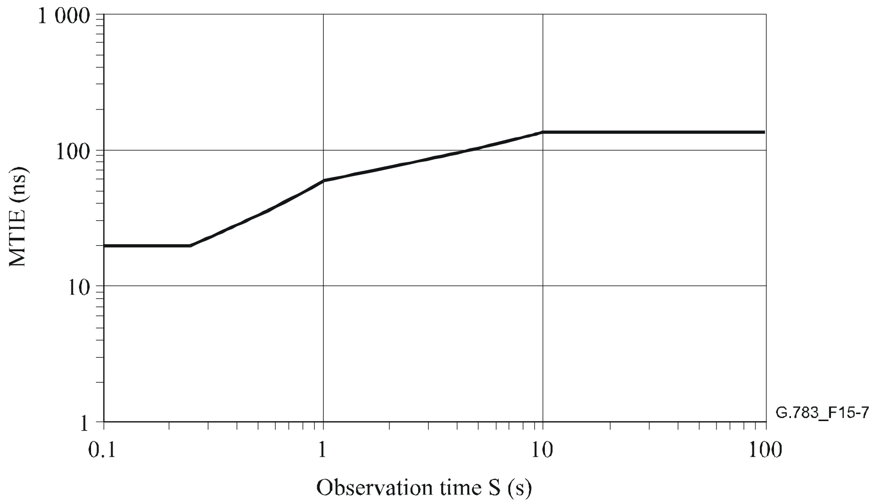


Figure 15-7/G.783 – 44 736 kbit/s mapping MTIE (includes mapping and desynchronizer NE clock effects)

15.2.3.3.2.2 44 736 kbit/s wander caused by pointer adjustments

SDH pointer adjustment activity within a network is a function of the synchronization characteristics of that network. Clock noise causes a variation of the pointer processor buffer fill which results in wander of the payload signal. Because pointer adjustment statistics can vary widely, a set of test sequences was developed to adequately simulate the effect of network pointer adjustment activity on wander at the output of desynchronizers.

15.2.3.3.2.2.1 Single pointer adjustments

The MTIE on 44 736 kbit/s payload signals out of an SDH island shall be less than the values contained in Table 15-9 and illustrated in the mask of Figure 15-8 when the pointer adjustment test sequence described in Figure 15-3 e) is applied to the final PTE and no jitter or wander is on the 44 736 kbit/s input to the SDH island. These MTIE values do not include the effects of mapping wander, nor wander on synchronizing signals for the network elements.

Table 15-9/G.783 – 44 736 kbit/s MTIE specification for single AU-3 pointer adjustments

Time in seconds	MTIE in nanoseconds
S < 0.1	N/A (jitter region)
0.1 < S < 0.18	945 * S
0.18 < S < 100	170 (Note)
NOTE – The MTIE values allocated for the non-continuous pointer sequences allow MTIE levels of 170 ns/pointer. The MTIE level is higher than the theoretical MTIE/pointer of 160 ns to allow for desynchronizer overshoot, phase leaking errors, and other desynchronizer pointer movement effects.	

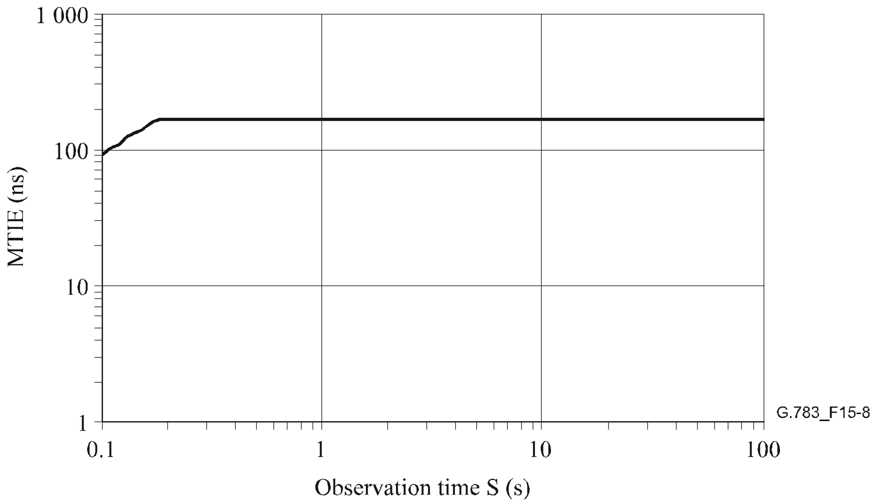


Figure 15-8/G.783 – Single AU-3 pointer adjustment MTIE mask

15.2.3.3.2.2.2 Pointer adjustment bursts

The MTIE on 44 736 kbit/s payload signals out of SDH islands shall be less than the values contained in Table 15-10 and illustrated in the mask of Figure 15-9 when the pointer adjustment test sequence described in Figure 15-3 f) is applied to the final PTE and no jitter or wander is on the 44 736 kbit/s input to the SDH island. These MTIE values do not include the effects of mapping wander, nor wander on synchronizing signals for the network elements.

Table 15-10/G.783 – 44 736 kbit/s MTIE specification for burst of three AU-3 pointer adjustments

Time in seconds	MTIE in nanoseconds
S < 0.1	N/A (jitter region)
0.1 < S < 0.28	1820 * S
0.28 < S < 100	510 (Note)
NOTE – The MTIE values allocated for non-continuous pointer sequences allow MTIE levels of 170 ns/pointer, or 510 ns for the burst of three AU-3 pointer adjustments. The MTIE level is higher than the theoretical MTIE/pointer of 160 ns to allow for desynchronizer overshoot, phase leaking errors, and other desynchronizer pointer movement effects.	

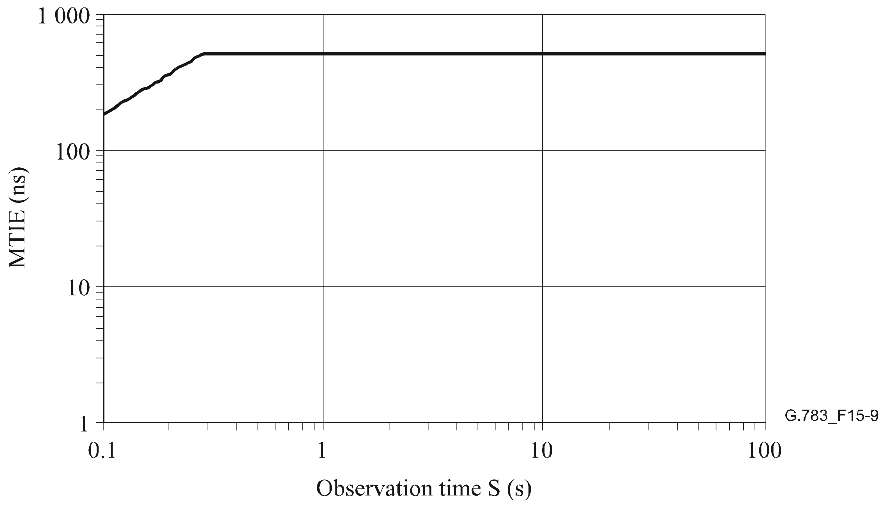


Figure 15-9/G.783 – Burst of three pointer adjustments MTIE mask

15.2.3.3.2.2.3 Phase transient pointer adjustment bursts

The MTIE on 44 736 kbit/s payload signals out of SDH islands shall be less than the values contained in Table 15-11 and illustrated in the mask of Figure 15-10 when the pointer adjustment test sequence described in Figure 15-3 i) is applied to the final PTE and no jitter or wander is on the 44 736 kbit/s input to the SDH island. These MTIE values do not include the effects of mapping wander, nor wander on synchronizing signals for the network elements.

Table 15-11/G.783 – 44 736 kbit/s MTIE specification for phase transient burst of AU-3 pointer adjustments

Time in seconds	MTIE in nanoseconds
S < 0.1	N/A (jitter region)
0.1 < S < 0.70	1650 * S
0.70 < S < 100	1155 (Note)
NOTE – The MTIE values allocated for non-continuous pointer sequences allow MTIE levels of 165 ns/pointer for the phase transient pointer adjustment burst. The MTIE level is higher than the theoretical MTIE/pointer of 160 ns to allow for desynchronizer overshoot, phase leaking errors, and other desynchronizer effects. Less margin per pointer is allowed here than for the single pointer or burst of 3 since there are seven pointers in this pattern and the cumulative phase errors are expected to be less.	

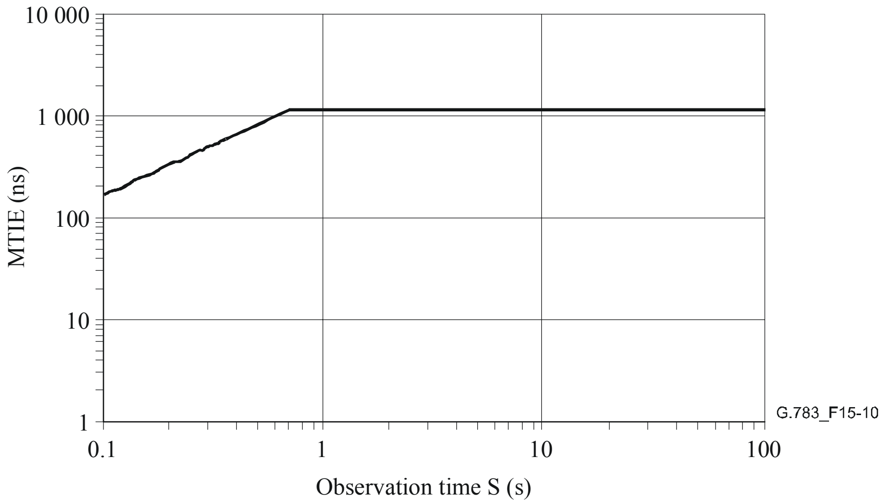


Figure 15-10/G.783 – Phase transient pointer adjustment burst MTIE mask

15.2.3.3.2.2.4 Periodic pointer adjustments

The MTIE on 44 736 kbit/s payload signals out of SDH islands shall be less than the values contained in Table 15-12 and illustrated in the mask of Figure 15-11 when the pointer adjustment test sequence described in Figure 15-3 g) and Figure 15-3 h) (a-b) are applied to the final PTE and no jitter or wander is applied at the input to the SDH island. The added and cancelled pointer adjustments referred to in Figure 15-3 g) and Figure 15-3 h) (c-d) are not applied. These MTIE values do not include the effects of mapping wander, nor wander on synchronizing signals for network elements.

Table 15-12/G.783 – 44 736 kbit/s MTIE specification for periodic AU-3 pointer adjustments

Time in seconds	MTIE in nanoseconds
S < 0.1	N/A (jitter region)
0.1 < S < 0.44	1830 * S
0.44 < S < 100	800

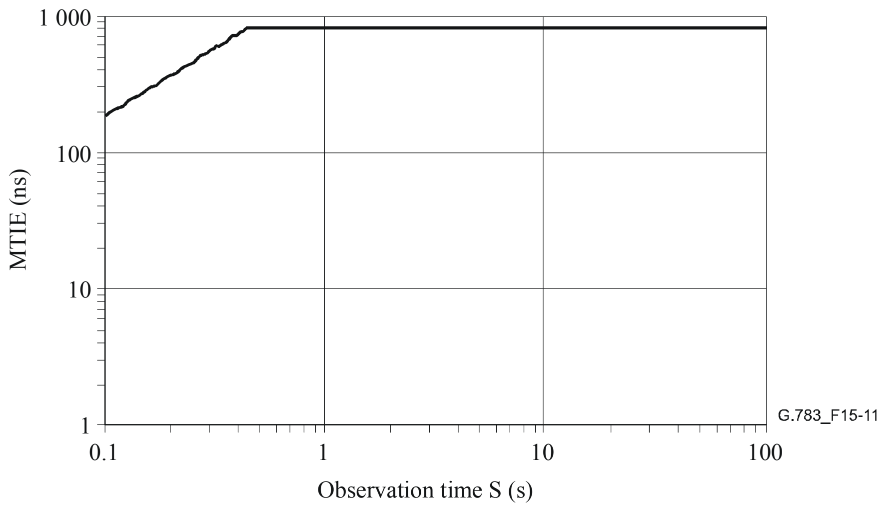


Figure 15-11/G.783 – Periodic pointer adjustments MTIE mask

15.3 Jitter and wander measurement

Instrumentation in accordance with ITU-T Rec. O.172 [23] is appropriate for measurement of jitter and wander in SDH systems.

NOTE – ITU-T Rec. O.172 includes test set specifications for the measurement of SDH tributaries operating at PDH bit rates, where the test set requirements are more stringent than those relating only to PDH systems. Therefore, instrumentation in accordance with ITU-T Rec. O.172 shall be used at PDH interfaces in SDH systems.

The functional description for measuring output jitter at a digital interface is provided in ITU-T Rec. O.172. When measuring combined mapping and pointer jitter, the test procedure using initialization and cool-down periods is described in 15.2.3.3. Appendix III/O.172 provides further information regarding the test set configuration and capability for testing using pointer sequences.

The limits given in the preceding clauses represent the maximum permissible levels of jitter at the equipment interfaces under the defined conditions and when measured for a certain time period. In general, jitter is measured over a 60-second period. However, when measuring combined mapping and pointer jitter using the test sequences defined in 15.2.3.3, the measurement period depends on the test sequence used. If necessary, the period must be extended to include an integral number of complete sequences.

16 Overhead access function (OHA)

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.

A particular overhead access function which may be included in SDH NEs is the orderwire 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 RSn/OW_A and MSn/OW_A functions and present them as data channels at one or more external interfaces as described in Table 16-1.

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

Table 16-1/G.783 – Orderwire interface

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

Annex A

Algorithm for pointer detection

A.1 Pointer interpretation

A.1.1 AU-n/AU-4-Xc

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 A.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 offset value in range.

– NDF_enable: NDF enabled AND offset value in range.

– AIS_ind: 11111111 11111111.

– Incr_ind: Normal NDF 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 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 × norm_point: Three consecutive equal norm_point indications.

– NDF_enable: Single NDF_enable indication.

– 3 × AIS_ind: Three consecutive AIS indications.

– N × inv_point: N consecutive inv_point ($8 \leq N \leq 10$).

– N × NDF_enable: N consecutive NDF_enable ($8 \leq N \leq 10$).

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

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

NOTE 6 – Earlier versions of this Recommendation required the match of the ss bits in defining Norm_point, NDF_enable, Incr_ind, and Decr_ind as part of the algorithm for pointer detection. It was considered that these ss bits are not necessary for the pointer detection algorithm.

A.1.2 TU-n

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 A.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 behavior 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 × norm_point: Three consecutive equal norm_point indications.

– NDF_enable: Single NDF_enable indication.

– 3 × AIS_ind: Three consecutive AIS indications.

– N × inv_point: N consecutive inv_point ($8 \leq N \leq 10$).

– N × NDF_enable: N consecutive NDF_enable ($8 \leq N \leq 10$).

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

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

A.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 A.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 ITU-T Rec. G.707/Y.1322 and therefore do not care for the algorithm.

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

– 3 × AIS_ind: Three consecutive AIS indications.

– N × inv_point: N consecutive inv_point ($8 \le N \le 10$).

– 3 × conc_ind: Three consecutive conc_ind.

A defect in one or more of the AUs and TUs of a concatenated payload results in the detection of a defect in the concatenated payload. Two types of defects can be reported:

– Loss of pointer;

– Path AIS.

A Loss of pointer defect 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 defect will be reported.

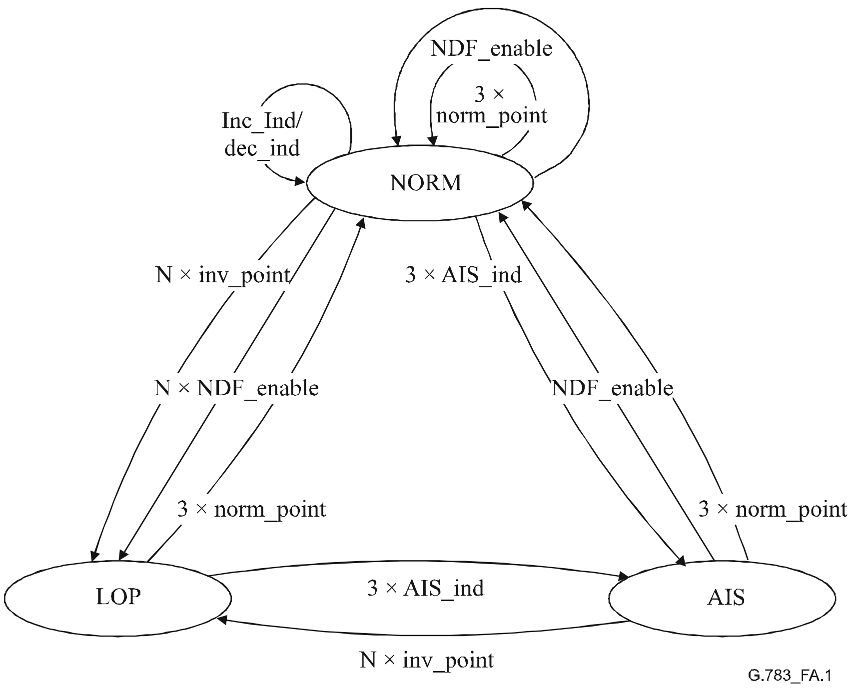


Figure A.1/G.783 – Pointer interpretation state diagram

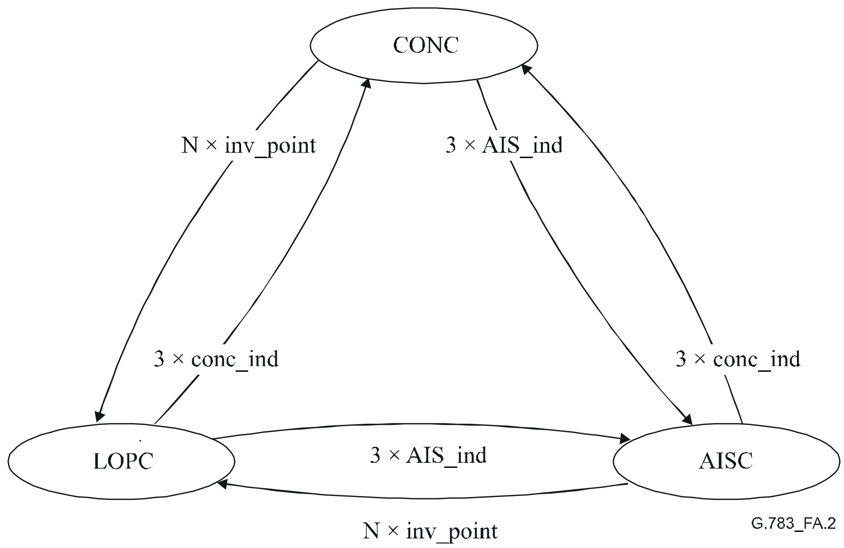
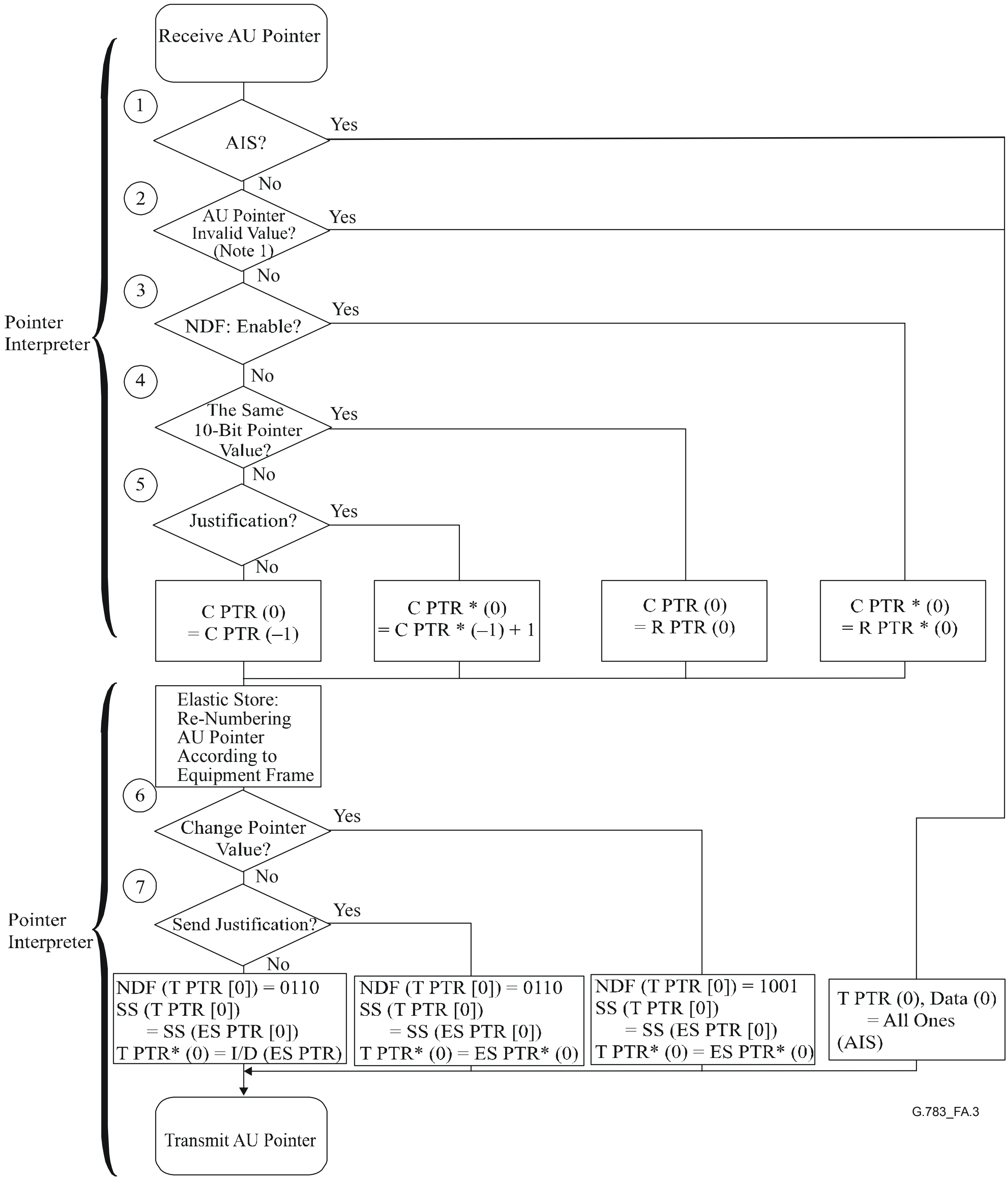


Figure A.2/G.783 – Concatenation indicator state diagram

A.3 Pointer processing flow chart

The mechanism of pointer processing is illustrated as a flow chart in Figure A.3.



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 Bit 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 of an elastic store
*	10-Bit Pointer
n	The n-th Frame Preceding the Present One

NOTE 1 – Concatenation Indication (CI) should be interpreted at this point. From the rules in ITU-T Rec. G.707/Y.1322, 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.

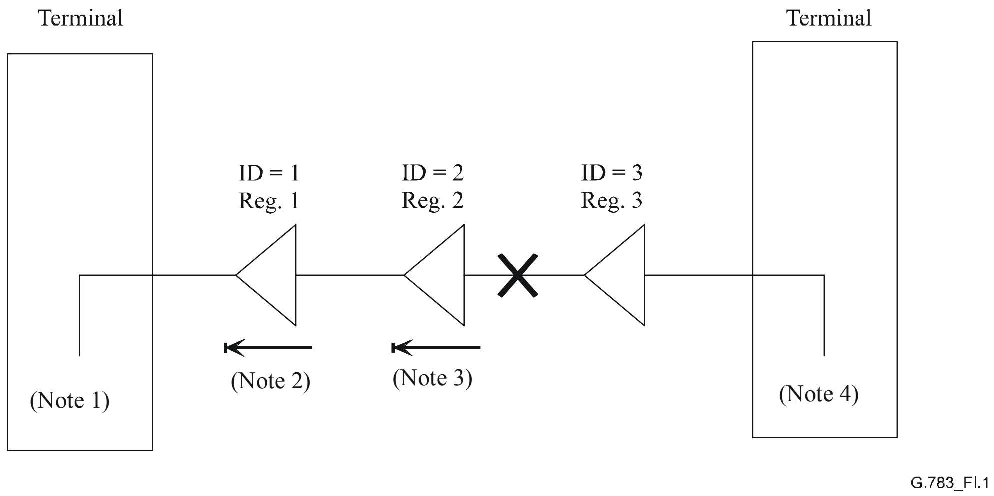
NOTE 2 – AU Pointer: NDF, SS, 10-bit pointer.

Figure A.3/G.783 – Pointer processing flow chart

Appendix I

Example of F1 byte usage

ITU-T Rec. G.784 [10] describes usage of DCCs for maintenance of the SDH network including regenerators. To introduce cost-effective regenerators, this appendix shows an example of F1 byte usage to identify a failed section in a chain of regenerator sections. When a regenerator detects a failure in its section, it inserts its regenerator number and the status of its failure into the F1 byte. Figure I.1 illustrates the procedure while the definition of F1 byte is shown in Figure I.2.



NOTE 1 – The terminal receives the regenerator's alarms and reports them.

NOTE 2 – If the regenerator status is normal, it should transfer received F1 byte to the downstream without any change.

NOTE 3 – If Reg. 2 detects LOS, LOF, SD(B1) or ERR MON on the upstream side, then it sends the regenerator number and status information to the downstream side using the F1 byte. These alarms are defined as follows:

– LOF or LOS Loss of frame or loss of signal.

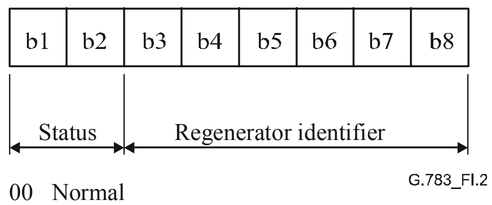
– SD(B1) Signal degrade calculated by B1 byte.

Note that if this procedure is used, it is necessary that the RSn_TT function regarding B1 calculation be enhanced.

– ERR MON * Error detection by monitoring B1 byte.

NOTE 4 – Normal is inserted into F1 byte by the terminal.

Figure I.1/G.783 – Chain of regenerator sections



00 Normal
01 SD(B1)
10 LOS or LOF
11 ERR MON

Figure I.2/G.783 – Definition of F1 byte

Appendix II

Data communications channel (DCC)

The use of the DCC is dependent on the network operator's maintenance strategy and the specific situation. It may not always be required as it is possible to carry out the required functions by other means.

There are two ways of using the DCC:

i) use of the D1 to D3 bytes located in the RSOH (DCC_R) and accessible at regenerators and other network elements;

ii) use of the D4 to D12 (and D13 to D156 in the case of STM-256) bytes located in the MSOH (DCC_M) and not accessible at regenerators. These bytes are provided alternatively across either a MCF function, or an OHA function. The specific use of these bytes is for further study.

These channels are message based and provide communications between network elements. They can be used to support communications between sites and the TMN. Two examples are given in Figures II.1 and II.2.

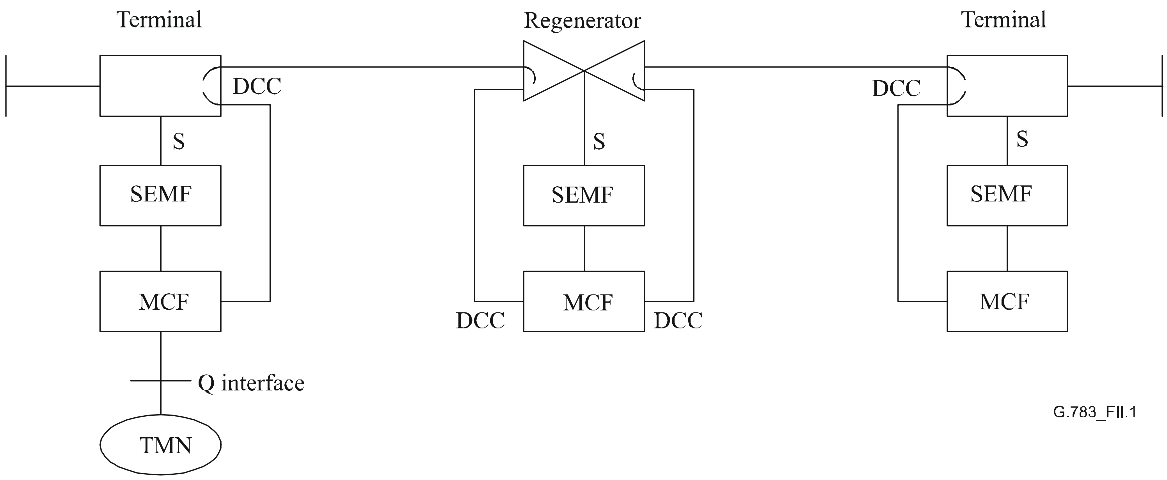


Figure II.1/G.783 – SDH linear system configuration

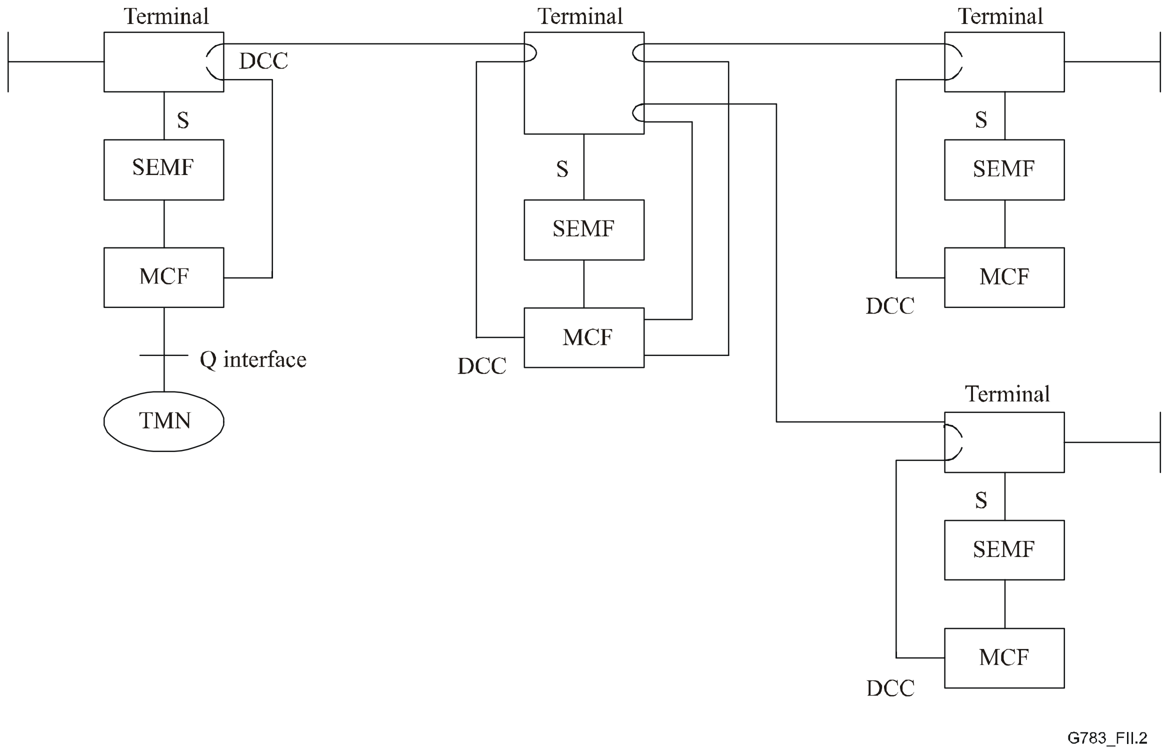


Figure II.2/G.783 – SDH tree configuration

Appendix III

STM-16 regenerator functional model (example)

Figure III.1 presents the combination of atomic functions that represent the transport part of a STM-16 regenerator network element. In this example, a DCC, orderwire and user channel are supported; the physical section atomic functions of the orderwire (E0) and user channel (E0 or V11) are not shown.

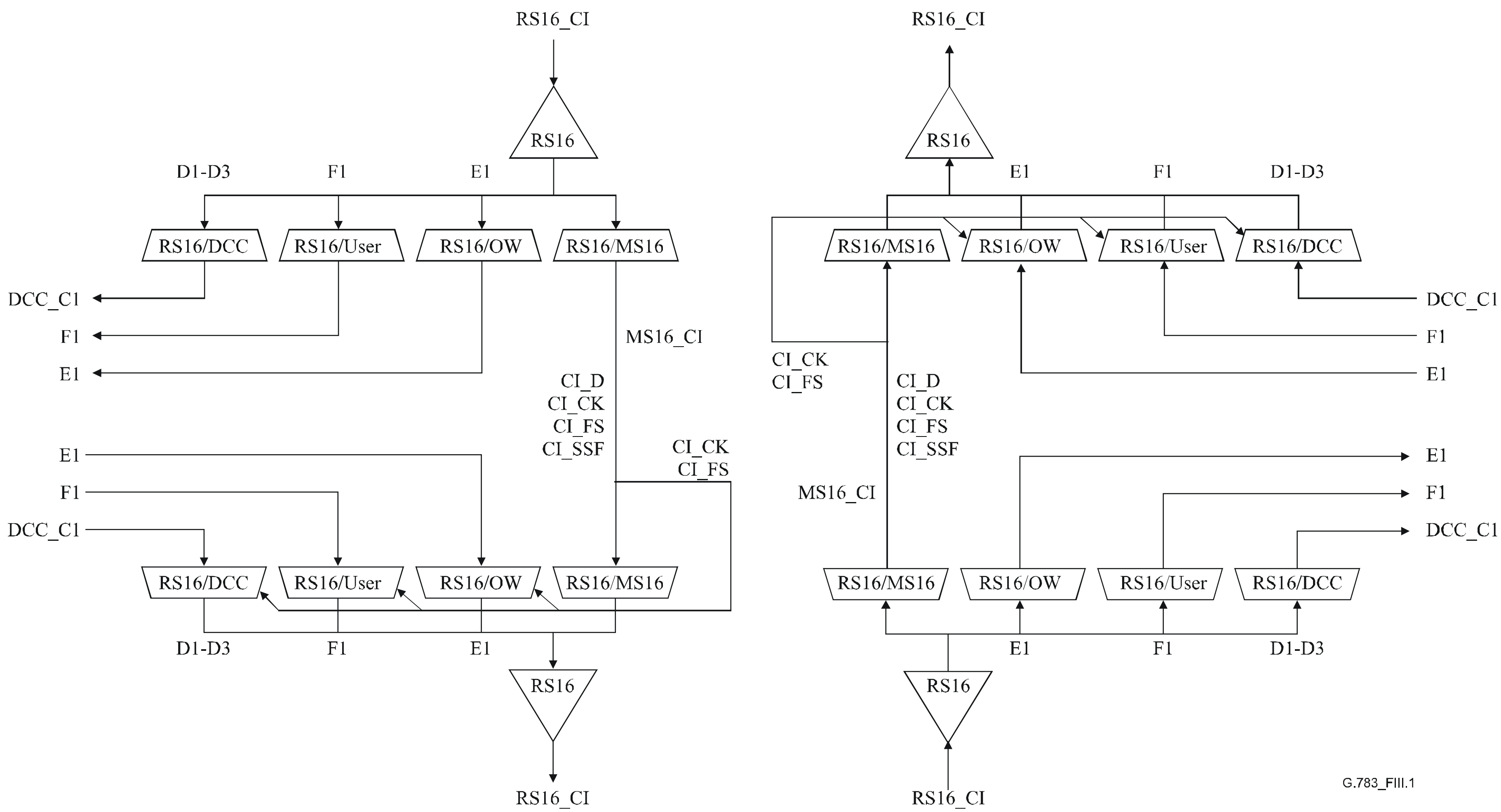


Figure III.1/G.783 – STM-16 regenerator model (supporting DCC, OW, USR)

Appendix IV

STM-N transparent regenerator

In regenerators, the A1, A2 and J0 bytes may be relayed (i.e., passed transparently through the regenerator) instead of being terminated and generated.

Under normal operation when RSn_CI_SSF is inactive (i.e., in-frame condition):

– A1, A2, J0 and Z0 bytes are either generated or relayed. Relaying the received framing bytes reduces the delay in the detection of OOF and recovery from failure in a chain of regenerators. Fault sectionalization capability is not affected because B1 is recalculated for each regenerator section. From a management viewpoint, it is preferable that all the regenerators in a line system conform to either one or other approach.
– E1 and F1 are taken from the OHA; optionally they may be relayed.
– D1-D3 are taken from the MCF.
– Bytes for national use and bytes reserved for future international standardization in the RSOH are either relayed or generated.

When RSn_CI_SSF is active (i.e., frame alignment is lost):

– A1, A2, J0 and Z0 are generated;
– B1 is generated as described in this Recommendation;
– E1 and F1 are taken from the OHA;
– D1-D3 are taken from the MCF;
– Bytes for national use and bytes reserved for future international standardization in the RSOH are generated.

When OSn/RSn_A_Sk is in OOF condition (but not in a failure state), all RSOH bytes may be relayed.

Appendix V

Verification of SDH equipment CID immunity

V.1 Background

Appendix II/G.957 [20] contains a test for CID. That is intended for test of the optical receiver and clock recovery components and is optimized for that. It can however not be used on SDH systems.

This appendix gives an alternative test that can be used on SDH systems. It is not as stringent as the above but it has the advantage of using a valid STM-N frame and can thus be used on an SDH system.

V.2 Method

V.2.1 Generation of CID

A method that may be used to verify the Consecutive Identical Digit (CID) immunity of SDH equipment is to provide the all-1s or all-0s test signal using a higher order path with a payload set to the inverse pattern of the scrambler for a specified number of bits. 72 bits is provisionally proposed as the limit for SDH equipment. AU pointers should be fixed so that the POH is placed directly after the SOH. Table V.1 indicates the type of payload and the maximum CID signal that can be generated for each interface type (see also Figures V.1 to V.3).

The part of the STM-N frame not containing the CID pattern should contain a pattern that (after scrambling) has equal occurrences of 1s and 0s. The bits before and after the CID should be the opposite of the CID. For STM-0 the CID pattern should only be applied every second frame in order to get the clock recovery cool-down period sufficiently long. For STM-N, N ≥ 1, the 0s CID pattern can be applied in one frame and the 1s CID can be applied in the following frame.

Table V.1/G.783 – VC inverse scrambler payloads for CID test

Interface	Payload for CID test	Maximum CID
STM-0	VC-3	224
STM-1	VC-4	2080
STM-4	VC-4-4c	8320
STM-16	VC-4-16c	33 280
STM-64	VC-4-64c	133 120
STM-256	VC-4-256c	532 480

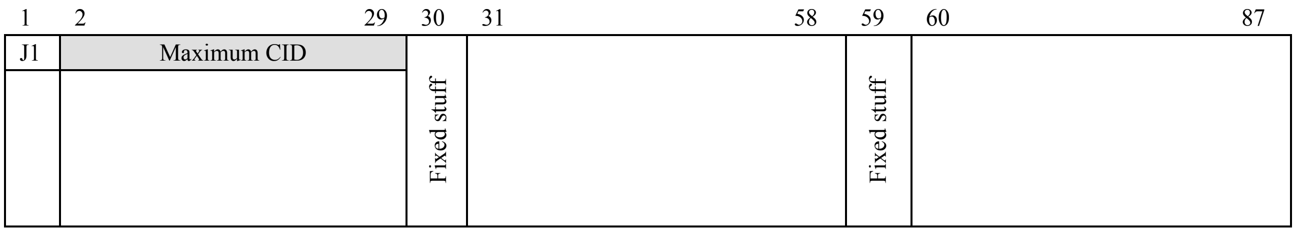


Figure V.1/G.783 – Maximum CID for VC-3 in STM-0

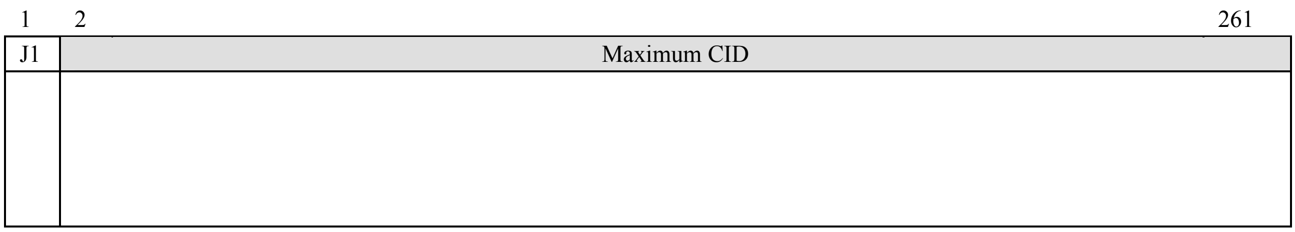


Figure V.2/G.783 – Maximum CID for VC-4 in STM-1

1	2 … n	n+1 … 261n
J1	Fixed stuff	Maximum CID

Figure V.3/G.783 – Maximum CID for VC-4-Nc in STM-N

V.2.2 Interpretation

The SDH system under test should have generation of the MS REI enabled, the HO path configured as bidirectional and TIM disabled. Optionally the SDH system could have the VC-n cross-connected back to the port the test is performed on but that is not necessary.

The test set monitors the STM-N signal for MS-REI, MS-RDI, HO-REI and HO-RDI. The occurrence of any of these anomalies or defects is an indication that the SDH system under test has not coped with the CID of the length generated.

Optionally the test set may compare the received VC-n/VC-4-Nc with transmitted.

NOTE – If the test set has a problem to frame align on the STM-N signal it may be necessary to remove the VC-n cross-connection back to the port.

Appendix VI

Enhanced Remote Defect Indication operation

As an option, equipment may provide additional differentiation between the payload defect (PLM), server defects (AIS, LOP) and connectivity defects (TIM, UNEQ). This appendix provides the detail for that option.

VI.1 VC-4-Xc/VC-4/VC-3 paths

For the VC-n Layer Trail Termination Source Sn_TT_So, byte G1 is allocated to convey back to a VC-4-Xc/VC-4/VC-3 termination source the status and performance of the complete trail. As described in Appendix VII/G.707/Y.1322, bits 5 to 7 of byte G1 may be used to provide an enhanced remote defect indication (E-RDI). If this E-RDI option is used, the codes from Table VII.1/G.707/Y.1322 [6] will be used for G1[5-7].

For the VC-n Layer Trail Termination Sink Sn_TT_Sk, if the E-RDI option is used, byte G1[5-7] will be interpreted as described in Table VII.2/G.707/Y.1322.

VI.2 VC-2/VC-1 paths

For the VC-m Layer Trail Termination Source Sm_TT_So, bits 5-7 of byte K4 may be used to provide an enhanced remote defect indication (E-RDI). If this E-RDI option is used, the codes from Table VII.3/G.707/Y.1322 will be used for K4[5-7].

For the VC-m Layer Trail Termination Sink Sm_TT_Sk, if the E-RDI option is used, byte K4[5-7] will be interpreted as described in Table VII.4/G.707/Y.1322.

VI.3 Interworking functions

VI.3.1 VC-4-Xc to VC-4-Xv

If the E-RDI option is used:

G1[5-7]: Bits 5 to 7 (enhanced RDI) of the VC-4-Xc shall be inserted to Bits 5 to 7 of all VC-4s of the VC-4-Xv.

VI.3.2 VC-4-Xv to VC-4-Xc

G1[5-7]: Bits 5 to 7 (enhanced RDI) of all VC-4s of the VC-4-Xv shall be compared against the priority list defined in Table VI.1. The value with the highest priority is inserted into bits 5 to 7 of the VC-4-Xc.

Table VI.1/G.783 – E-RDI priorities

Priority	G1[5..7]	E-RDI
8 (lowest)	000	no remote defect
7	001	no remote defect
6	011	no remote defect
5	010	E-RDI payload defect
4	110	E-RDI connectivity defect
3	100	E-RDI server defect
2	111	E-RDI server defect
1 (highest)	101	E-RDI server defect

Appendix VII

STM-64 regenerator jitter accumulation analyses and hypothetical reference model (HRM)

VII.1 Introduction

This appendix describes the details of the Hypothetical Reference Model (HRM) and jitter accumulation analyses that led to the STM-64 (Type A) jitter generation requirements in Tables 9-6 and 9-7 and to the STM-64 (Type A) jitter transfer requirements in Table 15-2. The analyses show that these jitter generation and transfer requirements and this HRM are consistent with the STM-64 output jitter (i.e., network interface jitter) specifications in Table 1/G.825.

The jitter accumulation analyses were actually performed for chains of OTU2 3R regenerators of the OTN (see ITU-T Rec. G.8251). The simulation models and jitter accumulation analyses are documented extensively in Appendix IV/G.8251. The results for chains of OTU2 3R regenerators can be applied to chains of STM-64 regenerators because:

1) the OTU2 and STM-64 rates are very similar, i.e., they differ by approximately 7.6%; and

2) the relevant jitter measurement filter bandwidths, jitter transfer bandwidth and gain peaking, other frequency breakpoints in the simulation model, and jitter limits are the same for the two cases.

In view of this, it is not necessary to repeat the details of the simulation model and analyses in Appendix IV/G.8251 here. Instead, the simulation model is summarized and the relevant results of Appendix IV/G.8251 are referenced; the focus here is on the application of the results to the STM-64 case.

The STM-64 regenerator HRM is described in VII.2, and the simulation model, analyses, and results are described in VII.3.

VII.2 STM-64 regenerator hypothetical reference model

The Hypothetical Reference Model (HRM) for STM-64 (Type A) regenerator jitter accumulation is given in Figure VII.1. The HRM consists of 50 cascaded regenerators, each assumed to meet the STM-64 (Type A) jitter generation requirements of Tables 9-6 and 9-7 (the jitter generation requirements for STM-64 (Type A) are the same in both tables) and the STM-64 (Type A) jitter transfer requirements of Table 15-2. The 50 regenerators are preceded by an SDH Equipment Clock (SEC; see ITU-T Rec. G.813), which is also assumed to meet the jitter generation requirements of Tables 9-6 and 9-7 (note that SEC jitter generation requirements for STM-64 are not specified in ITU-T Rec. G.813; the highest rate for which SEC jitter generation requirements are specified in ITU-T Rec. G.813 is STM-16). Under these conditions, the output jitter at the end of the chain of 50 regenerators is expected to be within the STM-64 output jitter limits (i.e., jitter network limits) of Table 1/G.825.

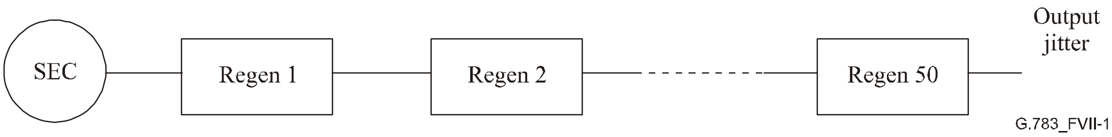


Figure VII.1/G.783 – Hypothetical Reference Model for STM-64 (Type A) regenerator jitter accumulation

VII.3 STM-64 (Type A) regenerator jitter accumulation simulation model, analyses, and results

The jitter generation requirement for STM-64 (Type A) is (see Tables 9-6 and 9-7):

1) 0.3 UIpp measured from 20 kHz to 80 MHz (wideband); and

2) 0.1 UIpp measured from 4 MHz to 80 MHz (high-band) (see Table 9-6).

This is identical to the jitter generation requirement for OTU2 3R regenerators for OTN in ITU-T Rec. G.8251 (see Table A.2/G.8251). The network interface output jitter requirement for STM-64 in ITU-T Rec. G.825 is (see Table 1/G.825):

1) 1.5 UIpp measured from 20 kHz to 80 MHz (wideband); and

2) 0.15 UIpp measured from 4 MHz to 80 MHz (high-band). This is identical to the network interface output jitter requirement for OTU2 for OTN in ITU-T Rec. G.8251 (see Table 1/G.8251).

The STM-64 and OTU2 line rates are very similar (the latter exceeds the former by a factor of 255/237 = 1.076 (see Table 7-1/G.709/Y.1331). Therefore, the jitter accumulation over chains of STM-64 regenerators and OTU2 3R regenerators that have the same jitter transfer bandwidth and gain peaking should be the same (because all the other relevant parameters are the same).

Jitter accumulation analyses for chains of 3R regenerators in OTN have been performed, and are documented in Appendix IV/G.8251. The analyses were done using two independent (but consistent) models, which gave similar results and which are also documented in Appendix IV/G.8251. Both models are based on a chain of phase-locked loops (PLLs). The first of the two models (see IV.2/G.8251), for which more detail is provided, considers noise generation in the phase-detector (PD), voltage-controlled oscillator (VCO), and optical receiver just prior to the PLL input. The VCO noise is modelled as a combination of white phase modulation (WPM) and white frequency modulation (WFM) using the Leeson model (see reference [5] of Appendix IV/G.8251). The other noise sources are modelled as WPM. Models were developed for both systematic and random jitter accumulation; however, the jitter accumulation for the OTUk 3R regenerators in ITU-T Rec. G.8251 (and also for STM-64 regenerators) is random because the buffer fills in the successive regenerators are uncorrelated with each other (each regenerator is assumed to include a wideband clock recovery circuit, followed by a narrower band filter, and there is some data buffering for overhead processing). The models are implemented in the frequency domain, and therefore produce rms jitter rather than peak-to-peak jitter; however, it is assumed that the ratio of peak-to-peak to rms jitter is a constant. While the model assumes a constant ratio, it is not necessary to know the value of this constant to assess the jitter accumulation. Since the requirements provide the ratio of output jitter to jitter generation (1.5/0.3 = 5 for wideband and 0.15/0.1 = 1.5 for high-band), it is only necessary to verify that the jitter accumulation does not exceed this.

Define the normalized jitter accumulation as the ratio of the output peak-to-peak (or rms, since we assume a constant ratio of peak-to-peak to rms jitter) jitter after N regenerators to the output peak-to-peak jitter after one regenerator (the latter is the jitter generation, and the former is the network limit). The results in ITU-T Rec. G.8251 show that the normalized jitter accumulation is largest for the cases of:

1) VCO noise with low oscillator Q, and therefore large WFM noise component; and
2) optical receiver WPM noise.

The reason these two cases are similar is that the VCO noise sees a high-pass filter transfer function with corner frequency equal to the PLL bandwidth. If the noise input is WFM, this is equivalent to having WPM with an integrator; the integrator converts the high-pass transfer function to a low-pass transfer function. The result resembles the optical receiver noise case, namely WPM that sees a low-pass transfer function. The noise accumulation for these cases is greater than for the other cases because in the other cases the noise generation is more nearly WPM with a high-pass transfer function; noise generated in one regenerator is effectively filtered by the low-pass transfer functions of subsequent regenerators.

Jitter accumulation results for VCO noise, for Q equal to 30, 100, and 535, are given in Figure IV.2-4b/G.8251 for a regenerator bandwidth of 8 MHz and Figure IV.2-6b/G.8251 for a regenerator bandwidth of 1 MHz. For a regenerator bandwidth of 8 MHz, Figure IV.2-4b indicates that the normalized jitter accumulation of 1.5 is reached after approximately 10 regenerators for Q = 30 and after approximately 15 regenerators for Q = 100. The OTN hypothetical reference model (HRM) for regenerator jitter accumulation consists of 50 3R regenerators (see Appendix III/G.8251). The jitter accumulation for 8 MHz bandwidth and Q = 30 or 100 is between 1.5 and 2 after 50 regenerators. Therefore, the high-band jitter network limit for OTU2 is not met for the OTN HRM and regenerator bandwidth of 8 MHz. It was found for OTN that choosing the OTU2 bandwidth to be 1 MHz would provide for acceptable jitter accumulation. These results are shown in Figure IV.2-6b/G.8251; for regenerator bandwidth of 1 MHz the normalized jitter accumulation is very close to 1.0 after 50 regenerators (in fact, the normalized jitter accumulation is approximately 1.2 after 200 regenerators for Q = 30, and less for the higher values of Q). In addition, Figure IV.2-6b shows that the normalized wideband jitter accumulation is approximately 3.2 after 50 3R regenerators for Q = 30 and 100, and approximately 4.8 after 100 3R regenerators for Q = 30 and 100. This means that the wideband jitter network limit requirements are also met for the 50 regenerator HRM. The actual wideband jitter will be somewhat lower, because the results in Appendix IV/G.8251 show that if the high-band jitter generation requirement is just met, the worst-case ratio of wideband to high-band jitter generation (worst-case among all the noise models considered here) is approximately 1.25. The actual wideband jitter generation is allowed to be 3 times the high-band jitter generation (0.3 versus 0.1); therefore, the wideband jitter accumulation will be below the network limit by an additional factor of 1.25/3.0.

The above results indicated that, while a jitter transfer bandwidth of 8 MHz for OTU2 regenerators would not provide for acceptable jitter accumulation, a bandwidth of 1 MHz would provide for acceptable accumulation. On this basis, the OTU2 jitter transfer bandwidth (specifically, the ODCr bandwidth for OTU2) was specified as 1 MHz in Table A.5/G.8251.

The rate for STM-64 is very close to the OTU2 rate (the latter exceeds the former by approximately 7.6%; see above). Also, the jitter generation requirements for STM-64 (Type A), Options 1 and 2, and OTU2 regenerators are the same. In addition, the jitter network limits for STM-64 and OTU2 are the same. Then, if the jitter transfer bandwidth and gain peaking for STM-64 (Type A) regenerators are chosen to be the same as for OTU2 3R regenerators (i.e., 1 MHz and 0.1 dB, respectively), the jitter accumulation over respective HRMs consisting of the same number of regenerators should be approximately the same in both cases. Since the OTU2 jitter accumulation over an HRM of 50 regenerators is acceptable with the above parameters, the STM-64 (Type A) jitter accumulation over an HRM of 50 regenerators will also be acceptable with the above parameters.

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