SONET Graphical Overview

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Introduction

This document provides an overview of Synchronous Optical Network (SONET), represented in images.

Note: *Tables and diagrams courtesy of JDS Uniphase Corporation*

Prerequisites

Requirements

There are no specific requirements for this document.

Components Used

This document is not restricted to specific software and hardware versions.

Conventions

Refer to Cisco Technical Tips Conventions for more information on document conventions.

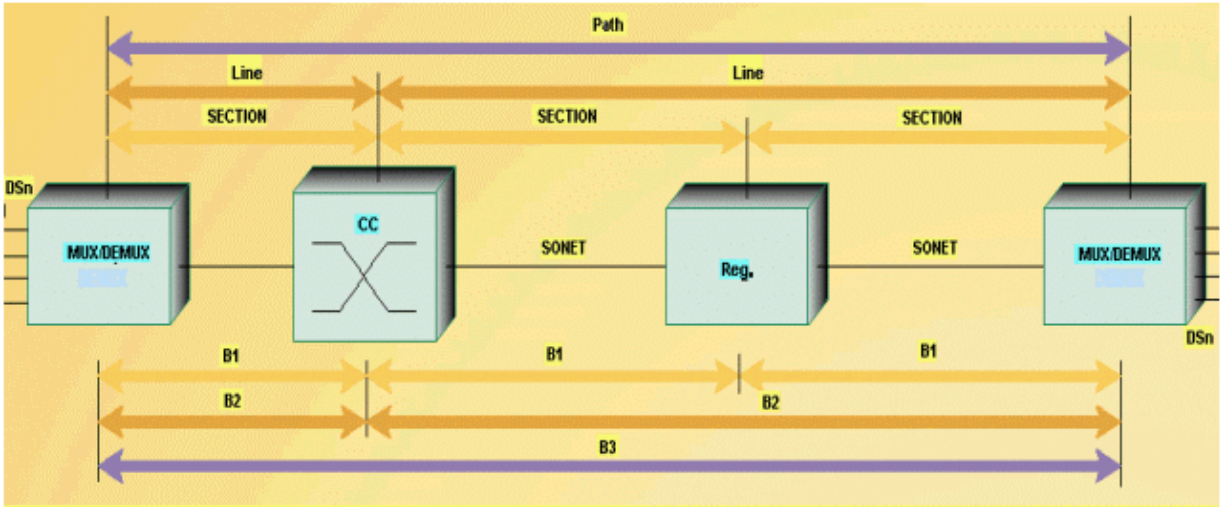
SONET Overview

This section provides an overview of SONET in a graphical format.

The SONET Link

Figure 1 shows what a SONET link looks like.

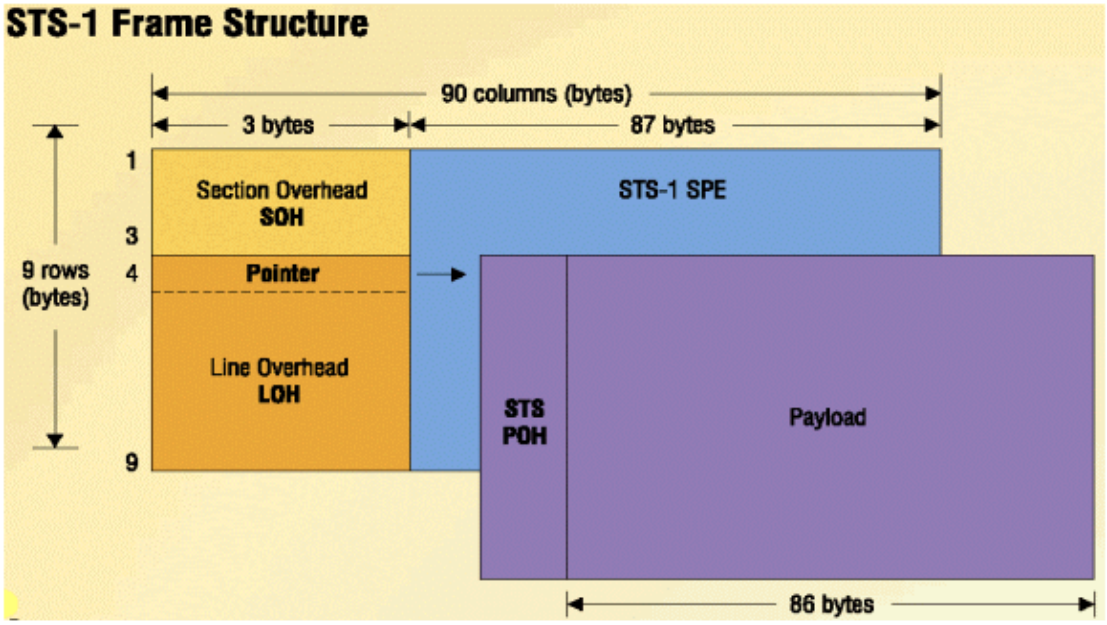
Figure 1 A SONET Link



STS−1 Frames

Figure 2 shows the Synchronous Transport Signal level 1 (STS−1) frame structure.

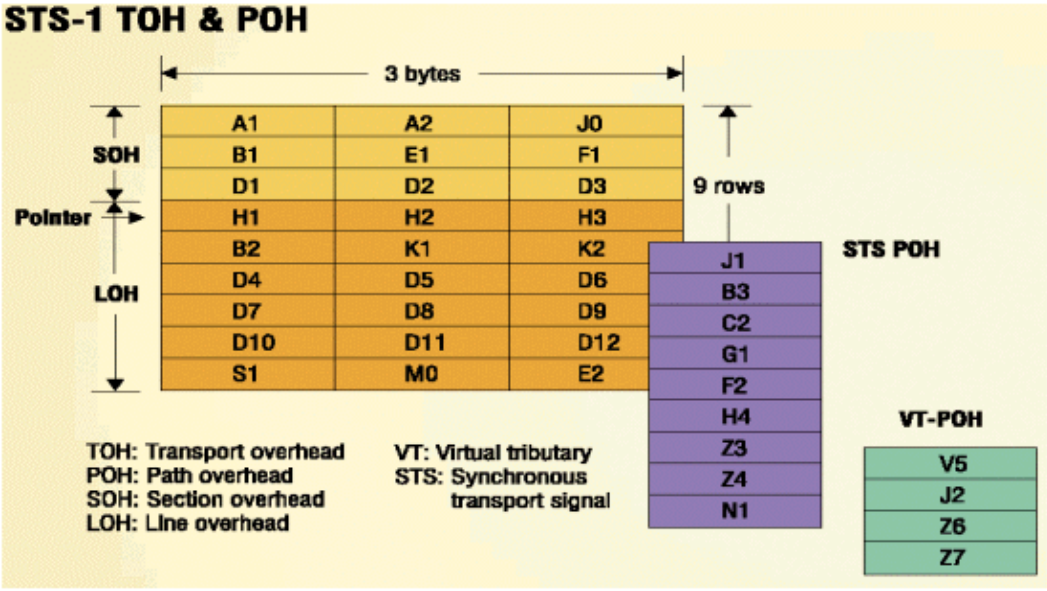
Figure 2　STS−1 Frame Structure



STS−1 SONET Overhead

Figure 3 shows the STS−1 Transport and Path Overhead (SONET Overhead).

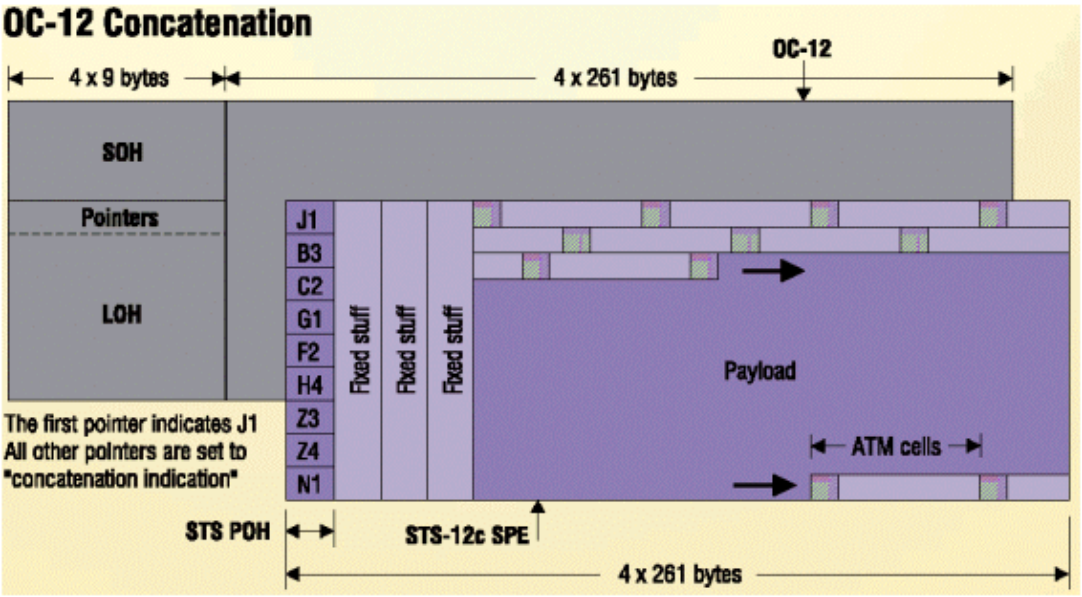
Figure 3　STS−1 Transport and Path Overhead



OC−12 Concatenation

Figure 4 looks at OC−12 concatenation.

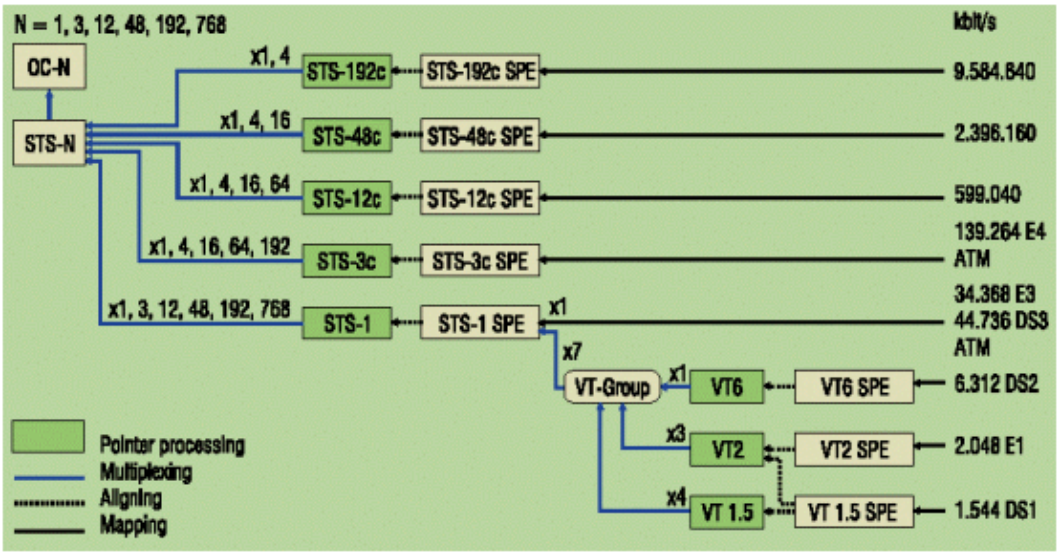
Figure 4 OC−12 Concatenation



SONET Hierarchy

Figure 5 displays the SONET hierarchy.

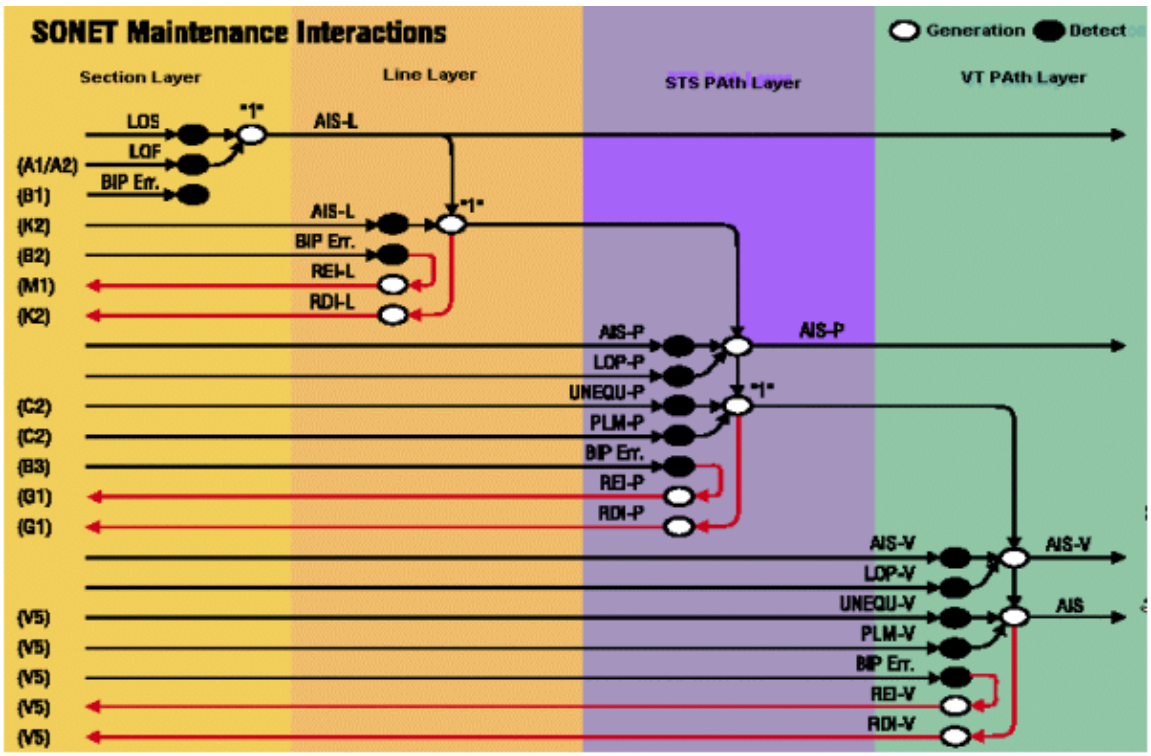
Figure 5 SONET Hierarchy



SONET Maintenance Interactions

Figure 6 shows how SONET maintenance interactions appear.

Figure 6 SONET Maintenance Interactions



Alarms and Detection Criteria

Table 1 lists what the alarms mean, and their detection criteria.

Table 1 Meaning of Alarms and their Detection Criteria

	Anomalies / Defects	Detection criteria	Bellcore ANSI
LOS	Loss of Signal	All-zero pattern for 2.3 μs ≤ T ≤ 100 μs	GR-253 T1.231
SEF	Severely Error Framing	A1, A2 errored for ≥ 625 μs	GR-253 T1.231
LOF	Loss of Frame	If SEF persists for ≥ 3 ms	GR-253 T1.231
S-BIP Error	Section BIP Error (B1)	Mismatch of the recovered and computed BIP-8 covers the whole STS-N frame	GR-253 T1.105
L-BIP Error	Line BIP Error (B2)	Mismatch of the recovered and computed N x BIP-8 covers the whole frame, except section overhead	GR-253 T1.105
AIS-L	Line-AIS	K2 (bits 6, 7, 8) = 111 for ≥ 5 frames	GR-253 T1.231
REI-L	Line Remote Error Indication	Number of detected B2 errors in the sink side encoded in byte M0 or M1 of the source side	GR-253 T1.105
RDI-L	Line Remote Defect Indication	K2 (bits 6, 7, 8) = 110 for ≥ z frames (z = 5 - 10)	GR-253 T1.231
AIS-P	STS Path AIS	All "1" in the STS pointer bytes H1, H2 for ≥ 3 frames	GR-253 T1.231
LOP-P	STS Path Loss of Pointer	8 - 10 NDF enable 8 - 10 invalid pointers	GR-253 T1.231
P-BIP Error	STS Path BIP Error (B3)	Mismatch of the recovered and computed BIP-8 covers entire STS-SPE	GR-253 T1.105
UNEQ-P	STS Path Unequipped	C2 = "0" for ≥ 5 (≥ 3 as per T1.231) frames	GR-253 T1.231
TIM-P	STS Path Trace Identifier Mismatch	Mismatch of the accepted and expected Trace Identifier in byte J1 (64 bytes sequence)	GR-253 T1.105
REI-P	STS Path Remote Error Indication	Number of detected B3 errors in the sink side encoded in byte G1 (bits 1, 2, 3, 4) of the source side	GR-253 T1.105
RDI-P	STS Path Remote Defect Indication	G1 (bit 5) = 1 for ≥ 10 frames	GR-253 T1.231
PLM-P	STS Path Payload Label Mismatch	Mismatch of the accepted and expected Payload Label in byte C2 for ≥ 5 (≥ 3 as per T1.231) frames	GR-253 T1.231
LOM	Loss of Multiframe	Loss of synchronization on H4 (bits 7, 8) superframe sequence	GR-253 T1.105
AIS-V	VT Path AIS	All "1" in the VT pointer bytes V1, V2 for ≥ 3 superframes	GR-253 T1.231
LOP-V	VT Loss of Pointer	8 - 10 NDF enable 8 - 10 invalid pointers	GR-253 T1.231
V-BIP Error	VT Path BIP Error (BIP-2)	Mismatch of the recovered and computed BIP-2 (V5 bits 1, 2) covers entire VT	GR-253 T1.105
UNEQ-P	VT Path Unequipped	V5 (bits 5, 6, 7) = 000 for ≥ 5 (≥ 3 as per T1.231) superframes	GR-253 T1.231
TIM-V	VT Path Trace Identifier Mismatch	Mismatch of the accepted and expected Trace Identifier in byte J2	for further study
REI-V	VT Path Remote Error Indication	If one or more BIP-2 errors detected in the sink side, byte V5 (bits 3) = 1 on the source side	GR-253 T1.105
RDI-V	VT Path Remote Defect Indication	V5 (bit 8) = 1 for ≥ 10 superframes	GR-253 T1.231
PLM-V	VT Path Payload Label Mismatch	Mismatch of the accepted and expected Payload Label in byte V5 (bits 5, 6, 7) for ≥ 5 (≥ 3 as per T1.231) superframes	GR-253 T1.231

STS−1 SOH, LOH, POH and VT POH Bytes

Figure 7 and Figure 8 provide a description of all the bytes from STS−1 SOH, Line OverHead (LOH), Path OverHead (POH) and Virtual Tributary Path OverHead (VT POH).

Figure 7 SOH Section Overhead

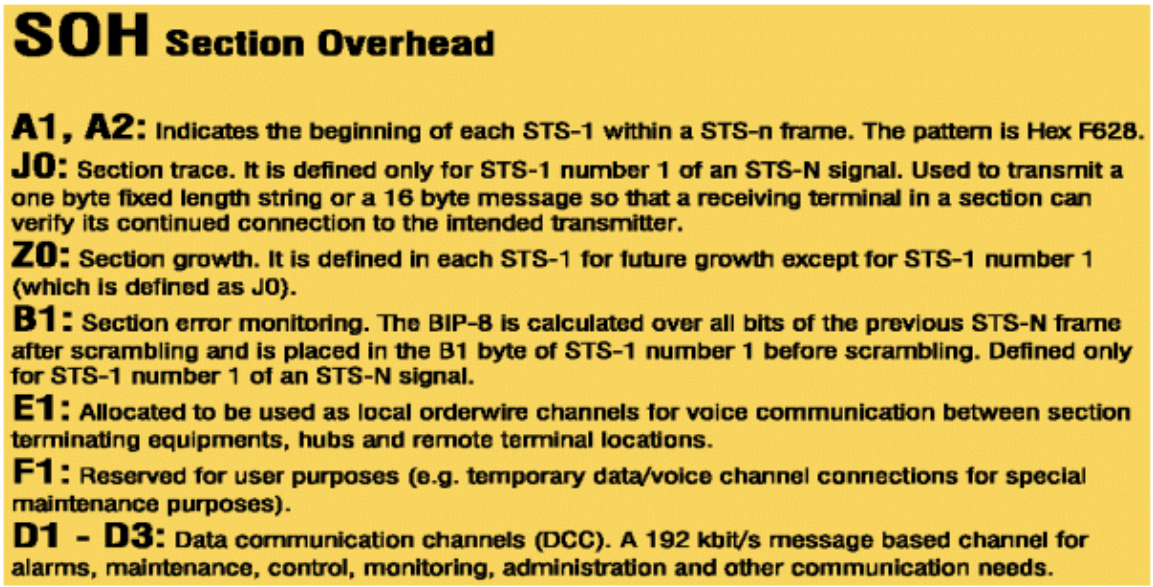


Figure 8 LOH Line Overhead

LOH Line Overhead

H1, H2: Pointer bytes. Allocated to a pointer that indicates the offset in bytes between pointer and the first byte of the STS SPE. It is used to align the STS-1 transport overheads in an STS-N signal as well as perform frequency justification.

H3: Pointer action byte. It is used for frequency justification. Depending on the pointer value, this byte is used to adjust the fill input buffers. It only carries valid information in the event of negative justification, otherwise it's not defined.

B2: Line error monitoring. The BIP-8 is used to determine if a transmission error has occurred over a line. It is calculated over all bits of the previous STS-1 frame before scrambling and is placed in the B2 byte of the current frame before scrambling.

K1, K2: Allocated for APS (Automatic Protection Switching) signaling for the protection of the multiplex section.

Linear APS messages

ANSI T1.105.01 protection switching protocol

K1 byte	Condition
b1 - b4	
1111	Lockout of protection
1110	Forced switch
1101	Signal fail high priority
1100	Signal fail low priority
1011	Signal degrade high priority
1010	Signal degrade low priority
1001	Unused
1000	Manual switch
0111	Unused
0110	Wait-to-restore
0101	Unused
0100	Exercise
0011	Unused
0010	Reserve request
0001	Do not revert
0000	No request
b5 - b8	Selects channel used by APS messages

K2 byte	Condition
b1 - b4	Selects bridged channel used
b5	Determines automatic protection switch architecture
b6 - b8	000 = Reserved for future use 001 = Reserved for future use 010 = Reserved for future use 011 = Reserved for future use 100 = Reserved for future use 101 = Reserved for future use 110 = MS-RDI 111 = MS-AIS

Ring APS messages

ANSI T1.105.01 protection switching protocol

K1 byte	Condition
b1 - b4	
1111	Lockout of protection (span) or signal fail (protection)
1110	Forced switch (span)
1101	Forced switch (ring)
1100	Signal fail (span)
1011	Signal fail (ring)
1010	Signal degrade (protection)
1001	Signal degrade (span)
1000	Signal degrade (ring)
0111	Manual switch (span)
0110	Manual switch (ring)
0101	Wait-to-restore
0100	Exerciser (span)
0011	Exerciser (ring)
0010	Reserve request (span)
0001	Reserve request (ring)
0000	No request
b5 - b8	Destination node ID

K2 byte	Condition
b1 - b4	Source node ID
b5	Path code: 0 = short path; 1 = long path
b6 - b8	000 = Idle 001 = Bridged 010 = Bridged and switched 011 = Reserved for future use 100 = Reserved for future use 101 = Reserved for future use 110 = MS-RDI

D4 - D12: Data Communication Channels (DCC). These 9 bytes form a 576 kbit/s message channel for alarms, maintenance, control, monitor, administration and other communication needs between line-terminating entities.

S1: Synchronization messaging. Bits 5 - 8 are used to carry the synchronization status messages which provide an indication of the quality level of the synchronization source of the SONET signal. Bits 1 - 4 are reserved for future use.

SONET Synchronization Status Messages

S1 byte b5 - b8	SONET synchronization quality level description
0000	Synchronized-traceability unknown
0001	Stratum 1 traceable
0111	Stratum 2 traceable
1010	Stratum 3 traceable
1100	±20 ppm clock traceable
1110	Reserved for network synchronization
1111	Don't use for synchronization

M0: Only defined for STS-1 signal. Bits 5 - 8 are used as a line REI function. They convey the count of errors detected by B2. Bits 1 - 4 are reserved for future use.

M1: This byte is located in the third STS-1 in order of appearance in the byte interleaved STS-N frame and is used as a line REI function. It conveys the count of errors detected by B2.

Z1: In SONET signals and at rates above STS-1 and below STS-192, this byte is defined in each STS-1 number 1 for future growth.

Z2: In SONET signals and at rates above STS-1 and below STS-192, this byte is defined in each STS-1 except the third STS-1 for future growth.

E2: Allocated for an express orderwire between line entities. It is defined only for STS-1 number 1 of an STS-N signal and its use is optional.

STS POH STS Path Overhead

J1: STS path trace. It is used to transmit a 64-byte, fixed-length string so that a receiving terminal can verify its continued connection to the intended transmitter.

B3: Path error monitoring. The BIP-8 is calculated over all bits of the previous STS SPE before scrambling. Computed value is placed in the B3 byte.

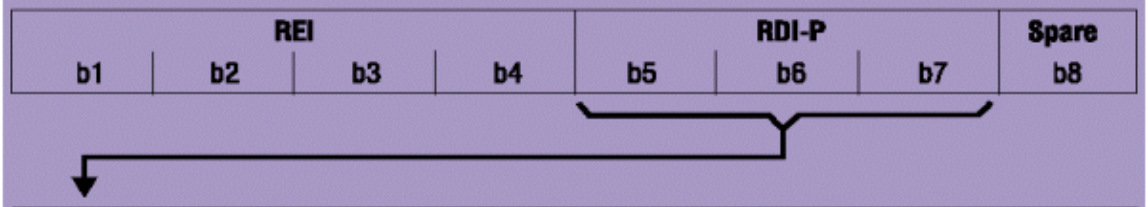
C2: Signal label. Allocated to identify the construction and content of the STS-level SPE and for PDI-P.

C2 byte coding

Code [hex]	Payload type
00	Unequipped
01	Equipped – nonspecific
02	Floating VT mode
03	Locked VT mode
04	Asynchronous mapping for DS3
12	Asynchronous mapping for 139.264 Mbit/s
13	Mapping for ATM
14	Mapping for DQDB
15	Asynchronous mapping for FDDI
16	Mapping for HDLC over SONET
E1	STS-1 payload with 1 VT-x payload defect
E2	STS-1 payload with 2 VT-x payload defects
E3	STS-1 payload with 3 VT-x payload defects
E4	STS-1 payload with 4 VT-x payload defects
E5	STS-1 payload with 5 VT-x payload defects
E6	STS-1 payload with 6 VT-x payload defects
E7	STS-1 payload with 7 VT-x payload defects
E8	STS-1 payload with 8 VT-x payload defects
E9	STS-1 payload with 9 VT-x payload defects
EA	STS-1 payload with 10 VT-x payload defects
EB	STS-1 payload with 11 VT-x payload defects
EC	STS-1 payload with 12 VT-x payload defects
ED	STS-1 payload with 13 VT-x payload defects
EE	STS-1 payload with 14 VT-x payload defects
EF	STS-1 payload with 15 VT-x payload defects
F0	STS-1 payload with 16 VT-x payload defects
F1	STS-1 payload with 17 VT-x payload defects
F2	STS-1 payload with 18 VT-x payload defects
F3	STS-1 payload with 19 VT-x payload defects
F4	STS-1 payload with 20 VT-x payload defects
F5	STS-1 payload with 21 VT-x payload defects
F6	STS-1 payload with 22 VT-x payload defects
F7	STS-1 payload with 23 VT-x payload defects
F8	STS-1 payload with 24 VT-x payload defects
F9	STS-1 payload with 25 VT-x payload defects
FA	STS-1 payload with 26 VT-x payload defects
FB	STS-1 payload with 27 VT-x payload defects
FC	STS-1 payload with 28 VT-x payload defects, or STS-1, STS-3c, etc. with a non-VT payload defect (DS3, FDDI, etc.)

G1: Path status. Allocated to convey back to an originating STS SPE the path-terminating status and performance. Bits 1 - 4 convey the count of interleaved bit blocks that have been detected in error by B3. Bits 5 - 7 provide codes to indicate both an old version and an enhanced version of the STS RDI-P.

G1, RDI-P defects



b5	b6	b7	Interpretation	Triggers
0	0	0	No remote defect	No defects
0	0	1	No remote defect	No defects
0	1	0	Remote payload defect	PLM-P
0	1	1	No remote defect	No defects
1	0	0	Remote defect	AIS-P, LOP-P
1	0	1	Remote server defect	AIS-P, LOP-P
1	1	0	Remote connectivity defect	TIM-P, UNEQ-P
1	1	1	Remote defect	AIS-P, LOP-P

F2: Path user channel. Allocated for user communication purposes between path elements.

H4: Multiframe indicator. Provides a generalized multiframe indicator for payloads. Currently, it is only used for VT-structured payloads.

Z3, Z4: Allocated for future use. Have no defined value. The receiver is required to ignore their content.

N1: Allocated to support tandem connection maintenance and the tandem connection link. Bits 1 - 4 are used to provide the tandem connection Incoming Error Count (IEC). In option 1, bits 5 - 8 are used to provide the tandem connection data link which is an optional 32 kbit/s data channel available to applications or services that span more than one LTE-LTE connection, but may be shorter than a PTE-PTE connection. In option 2, bits 5 - 8 are used to provide maintenance information including REI, outgoing error indication, RDI, outgoing defect information and TC access point identifier.

VT-POH VT Path Overhead

(for VT-1.5, VT-2, VT-3, VT-6)

V5: The first byte of a VT SPE, provides the functions of error checking, signal label and path status. Bits 1 and 2 are allocated for error performance monitoring. Bit 3 is a REI-V that is sent back towards an originating VT PTE if errors were detected by the BIP-2. Bit 4 is reserved for mapping-specific functions. Bits 5 - 7 provide a VT signal label. Bit 8 provides codes to indicate both an old version and an enhanced version of the RDI-V.

b5 - b7	Assigned VT Identification
000	Unequipped VT1.5
001	Equipped – nonspecific VT1.5
010	Asynchronous mapping for DS1
011	Bit-synchronous mapping for DS1
100	Byte synchronous mapping for DS1
101	Unassigned VT1.5
110	Unassigned VT1.5
111	Unassigned VT1.5
000	Unequipped VT2
001	Equipped – nonspecific VT2
010	Asynchronous mapping for 2.048 Mbit/s
011	Bit-synchronous mapping for 2.048 Mbit/s
100	Byte synchronous mapping for 2.048 Mbit/s
101	Unassigned VT2
110	Unassigned VT2
111	Unassigned VT2
000	Unequipped VT3
001	Equipped – nonspecific VT2
010	Asynchronous mapping for 2.048 Mbit/s
011	Bit-synchronous mapping for 2.048 Mbit/s
100	Byte synchronous mapping for 2.048 Mbit/s
101	Unassigned VT2
110	Unassigned VT2
111	Unassigned VT2
000	Unequipped VT3
001	Equipped – nonspecific VT3
010	Asynchronous mapping for DS1C
011	Unassigned VT3
100	Unassigned VT3
101	Unassigned VT3
110	Unassigned VT3
111	Unassigned VT3
000	Unequipped VT6
001	Equipped – nonspecific VT6
010	Asynchronous mapping for DS2
011	Unassigned VT6
100	Unassigned VT6
101	Unassigned VT6
110	Unassigned VT6
111	Unassigned VT6

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