SDH Overhead

The SDH standard was developed using a client/server layer approach (see Figure 4). The overhead and transport functions are divided into layers. They are:

- Regenerator Section
- Multiplex Section
- Path

The layers have a hierarchical relationship, with each layer building on the services provided by all the lower layers.

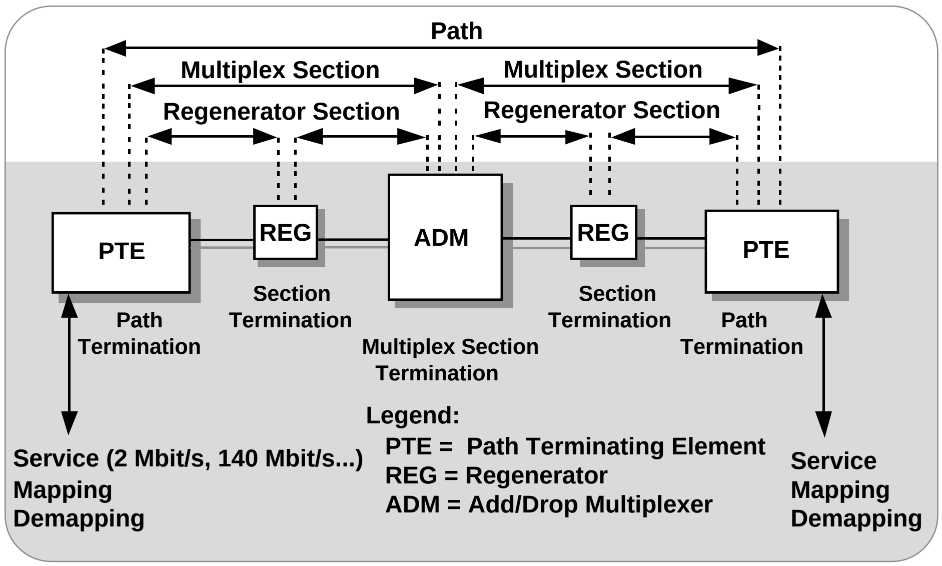
This section details the different SDH overhead information, specifically:

- Regenerator Section Overhead
- Multiplex Overhead
- Path Overhead

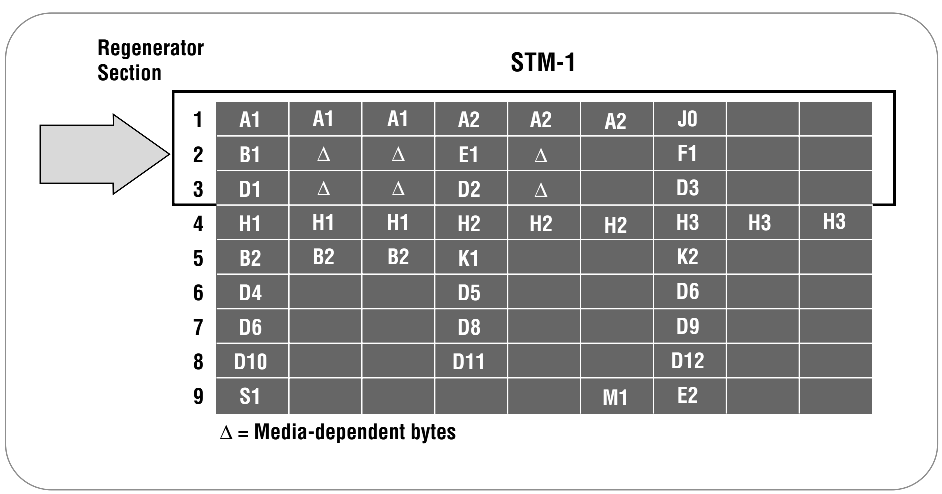
Regenerator Section Overhead

The Regenerator Section Overhead contains only the information required for the elements located at both ends of a section. This might be two regenerators, a piece of line terminating equipment and a regenerator, or two pieces of line terminating equipment.

The Regenerator Section Overhead is found in the first three rows of Columns 1 through 9 of the STM-1 frame (see Figure 5). Byte by byte, the Regenerator Section Overhead is shown in Table 4.



▶ ***Figure 4.*** *SDH network layers.*



▶ ***Figure 5.*** *STM-1 Regenerator section overhead.*

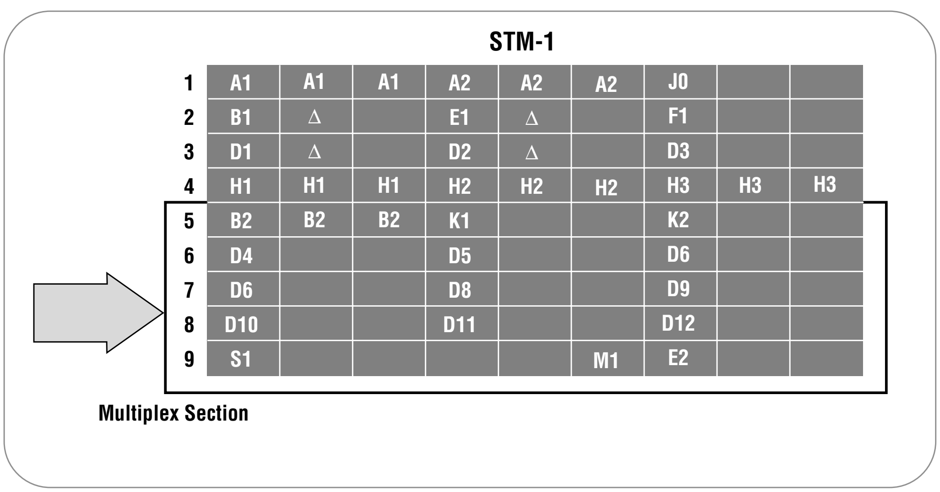
Multiplex Section Overhead

The Multiplex Section Overhead contains the information required between the multiplex section termination equipment at each end of the Multiplex section (that is, between consecutive network elements excluding the regenerators).

The Multiplex Section Overhead is found in Rows 5 to 9 of Columns 1 through 9 of the STM-1 frame (see Figure 6). Byte by byte, the Multiplex Section Overhead is shown in Table 5.

Table 4. Regenerator Section Overhead

Byte	Description
A1 and A2	**Framing bytes –** These two bytes indicate the beginning of the STM-N frame. The A1, A2 bytes are unscrambled. A1 has the binary value 11110110, and A2 has the binary value 00101000. The frame alignment word of an STM-N frame is composed of (3 x N) A1 bytes followed by (3 x N) A2 bytes.
J0	**Regenerator Section (RS) Trace message –** It's used to transmit a Section Access Point Identifier so that a section receiver can verify its continued connection to the intended transmitter. The coding of the J0 byte is the same as for J1 and J2 bytes. This byte is defined only for STM-1 number 1 of an STM-N signal.
Z0	These bytes, which are located at positions S[1,6N+2] to S[1,7N] of an STM-N signal (N > 1), are reserved for future international standardisation.
B1	**RS bit interleaved parity code (BIP-8) byte –** This is a parity code (even parity), used to check for transmission errors over a regenerator section. Its value is calculated over all bits of the previous STM-N frame after scrambling, then placed in the B1 byte of STM-1 before scrambling. Therefore, this byte is defined only for STM-1 number 1 of an STM-N signal.
E1	**RS orderwire byte –** This byte is allocated to be used as a local orderwire channel for voice communication between regenerators.
F1	**RS user channel byte –** This byte is set aside for the user's purposes; it can be read and/or written to at each section terminating equipment in that line.
D1, D2, D3	**RS Data Communications Channel (DCC) bytes –** These three bytes form a 192 kbit/s message channel providing a message-based channel for Operations, Administration and Maintenance (OAM) between pieces of section terminating equipment. The channel can be used from a central location for control, monitoring, administration, and other communication needs.



▶ ***Figure 6.*** *STM-1 Multiplex section overhead.*

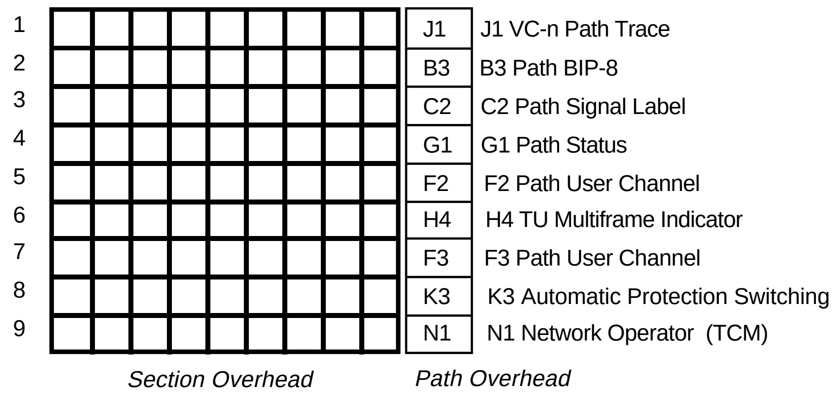
Table 5. Multiplex Section Overhead

Byte	Description
B2	**Multiplex Section (MS) bit interleaved parity code (MS BIP-24) byte –** This bit interleaved parity N x 24 code is used to determine if a transmission error has occurred over a multiplex section. It's even parity, and is calculated overall bits of the MS Overhead and the STM-N frame of the previous STM-N frame before scrambling. The value is placed in the three B2 bytes of the MS Overhead before scrambling. These bytes are provided for all STM-1 signals in an STM-N signal.
K1 and K2	**Automatic Protection Switching (APS channel) bytes –** These two bytes are used for MSP (Multiplex Section Protection) signaling between multiplex level entities for bi-directional automatic protection switching and for communicating Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) conditions. The Multiplex Section Remote Defect Indication (MS-RDI) is used to return an indication to the transmit end that the received end has detected an incoming section defect or is receiving MS-AIS. MS-RDI is generated by inserting a "110" code in positions 6, 7, and 8 of the K2 byte before scrambling. K1 Byte Bits 1-4 Type of request 1111 Lock out 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 (not used) 1000 Manual Switch 0111 (not used) 0110 Wait-to-Restore 0101 (not used) 0100 Exercise 0011 (not used) 0010 Reverse Request 0001 Do Not Revert 0000 No Request Bits 5-8 Indicate the number of the channel requested K2 Byte Bits 1-4 Selects channel number Bit 5 Indication of architecture 0 1+1 1 1:n Bits 6-8 Indicate mode of operation 111 MS-AIS 110 MS-RDI 101 Provisioned mode is bi-directional 100 Provisioned mode is unidirectional 011 Future use 010 Future use 001 Future use 000 Future use
D4 to D12	**MS Data Communications Channel (DCC) bytes –** These nine bytes form a 576 kbit/s message channel from a central location for OAM information (control, maintenance, remote provisioning, monitoring, administration and other communication needs).
S1	**Synchronisation status message byte (SSMB) –** Bits 5 to 8 of this S1 byte are used to carry the synchronisation messages. Following is the assignment of bit patterns to the four synchronisation levels agreed to within ITU-T (other values are reserved): Bits 5-8 0000 Quality unknown (existing sync. network) 0010 G.811 PRC 0100 SSU-A (G.812 transit) 1000 SSU-B (G.812 local) 1011 G.813 Option 1 Synchronous Equipment Timing Clock (SEC) 1111 Do not use for synchronisation. This message may be emulated by equipment failures and will be emulated by a Multiplex Section AIS signal.
M1	**MS remote error indication –** The M1 byte of an STM-1 or the first STM-1 of an STM-N is used for a MS layer remote error indication (MS-REI). Bits 2 to 8 of the M1 byte are used to carry the error count of the interleaved bit blocks that the MS BIP-24xN has detected to be in error at the far end of the section. This value is truncated at 255 for STM-N >4.
E2	**MS orderwire byte –** This orderwire byte provides a 64 kbit/s channel between multiplex entities for an express orderwire. It's a voice channel for use by craftspersons and can be accessed at multiplex section terminations.

Higher-Order Path Overhead (VC-4/VC-3)

The Path Overhead is assigned to, and transported with the Virtual Container from the time it's created by path terminating equipment until the payload is demultiplexed at the termination point in a piece of path terminating equipment.

The Path Overhead is found in Rows 1 to 9 of the first column of the VC-4 or VC-3 (see Figure 7). Byte by byte, the Higher Order Path Overhead is shown in Table 6.



▶ ***Figure 7.*** *Higher-order path overhead (VC-4/VC-3).*

Table 6. Higher-Order Path Overhead

Byte	Description			
J1	**Higher-Order VC-N path trace byte –** This user-programmable byte repetitively transmits a 15-byte, E.64 format string plus 1-byte CRC-7. A 64-byte free-format string is also permitted for this Access Point Identifier. This allows the receiving terminal in a path to verify its continued connection to the intended transmitting terminal.			
B3	**Path bit interleaved parity code (Path BIP-8) byte –** This is a parity code (even), used to determine if a transmission error has occurred over a path. Its value is calculated over all the bits of the previous virtual container before scrambling and placed in the B3 byte of the current frame.			
C2	**Path signal label byte –** This byte specifies the mapping type in the VC-N. Standard binary values for C2 are:			
	MSB	LSB	Hex Code	Interpretation
	Bits 1-4	Bits	5-8	
	0000	0000	00	Unequipped or supervisory-unequipped
	0000	0001	01	Equipped – non-specific
	0000	0010	02	TUG structure
	0000	0011	03	Locked TU-n
	0000	0100	04	Asynchronous mapping of 34,368 kbit/s or 44,736 kbit/s into the Container-3
	0001	0010	12	Asynchronous mapping of 139,264 kbit/s into the Container-4
	0001	0011	13	ATM mapping
	0001	0100	14	MAN DQDB (IEEE Standard 802.6) mapping
	0001	0101	15	FDDI (ISO Standard 9314) mapping
	0001	0110	16	Mapping of HDLC/PPP (Internet Standard 51) framed signal
	0001	0111	17	Mapping of Simple Data Link (SDL) with SDH self synchronising scrambler
	0001	1000	18	Mapping of HDLC/LAP-S framed signals
	0001	1001	19	Mapping of Simple Data Link (SDL) with set-reset scrambler
	0001	1010	1A	Mapping of 10 Gbit/s Ethernet frames (IEEE 802.3)
	1100	1111	CF	Obsolete mapping of HDLC/PPP framed signal
	1110	0001	E1	Reserved for national use
	:	:	:	:
	1111	1100	FC	Reserved for national use
	1111	1110	FE	Test signal, 0.181 specific mapping
	1111	1111	FF	VC-AIS

Table 6 (contd)

Byte	Description

G1

Path status byte – This byte is used to convey the path terminating status and performance back to the originating path terminating equipment. Therefore the bi-directional path in its entirety can be monitored, from either end of the path.

REI				RDI	Reserved		Spare
1	2	3	4	5	6	7	8

Byte G1 is allocated to convey back to a VC-4-Xc/VC-4/VC-3 trail termination source the status and performance of the complete trail. Bits 5 to 7 may be used to provide an enhanced remote defect indication with additional differentiation between the payload defect (PLM), server defects (AIS, LOP) and connectivity defects (TIM, UNEQ). The following codes are used:

Bits 5-7	Meaning	Triggers
001	No remote defect	No remote defect
010	E-RDI Payload defect	PLM
101	E-RDI Server defect	AIS, LOP
110	E-RDI Connectivity defect	TIM, UNEQ

The E-RDI G1 (bits 5-7) code interpretation provides for interworking with equipment which supports RDI. It is not necessary for the interpretation to identify if the equipment supports RDI or E-RDI. For the E-RDI codes, bit 7 is set to the inverse of bit 6. Following is the E-RDI G1 (bits 5-7) code interpretation:

Bits 5-7	E-RDI Interpretation
000	No remote defect (Note 1)
001	No remote defect
010	E-RDI Payload defect (Note 2)
011	No remote defect (Note 1)
100	E-RDI Server defect (Note 1)
101	Remote E-RDI Server defect
110	Remote E-RDI Connectivity defect
111	Remote E-RDI Server Defect (Note 1)

NOTE 1: These codes are generated by RDI supporting equipment and are interpreted by E-RDI supporting equipment as shown. For equipment supporting RDI, clause 9.3.1.4/G.707, this code is triggered by the presence or absence of one of the following defects: AIS, LOP, TIM, or UNEQ. Equipment conforming to an earlier version of this standard may include PLM as a trigger condition. ATM equipment complying with the 1993 version of ITU-T Recommendation I.432 may include LCD as a trigger condition. Note that for some national networks, this code was triggered only by an AIS or LOP defect.

NOTE 2: ATM equipment complying with the 08/96 version of ITU-T Recommendation I.432.2 may include LCD as a trigger condition.

F2

Path user channel byte – This byte is used for user communication between path elements.

H4

Position and Sequence Indicator byte – This byte provides a multi frame and sequence indicator for virtual VC-3/4 concatenation and a generalized position indicator for payloads. In the latter case, the content is payload specific (e.g., H4 can be used as a multiframe indicator for VC-2/1 payload). For mapping of DQDB in VC-4, the H4 byte carries the slot boundary information and the Link Status Signal (LSS). Bits 1-2 are used for the LSS code as described in IEEE Standard 802.6. Bits 3-8 form the slot offset indicator. The slot offset indicator contains a binary number indicating the offset in octets between the H4 octet and the first slot boundary following the H4 octet. The valid range of the slot offset indicator value is 0 to 52. A received value of 53 to 63 corresponds to an error condition.

F3

Path user channel byte – This byte is allocated for communication purposes between path elements and is payload dependent.

K3

APS signalling is provided in K3 bits 1-4, allocated for protection at the VC-4/3 path levels. K3 bits 5-8 are allocated for future use. These bits have no defined value. The receiver is required to ignore their content.

Table 6 (contd)

Byte | **Description**

N1 **Network operator byte –** This byte is allocated to provide a Higher-Order Tandem Connection Monitoring (HO-TCM) function. N1 is allocated for Tandem Connection Monitoring for contiguous concatenated VC-4, the VC-4 and VC-3 levels.

IEC				TC-REI	OEI	TC-APId, TC-RDI, ODI, reserved	
1	2	3	4	5	6	7	8

Bits 1-4	Incoming Error Count (IEC).
1001	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1110	Incoming AIS

NOTE: To guarantee a non all-zeroes N1 byte independent of the incoming signal status, it is required that the IEC code field contains at least one “1”. When zero errors in the BIP-8 of the incoming signal are detected, an IEC code is inserted with “1”s in it. In this manner, it is possible for the Tandem Connection sink at the tail end of the Tandem Connection link to use the IEC code field to distinguish between unequipped conditions started within or before the Tandem Connection.

Bit 5 Operates as the TC-REI of the Tandem Connection to indicate errored blocks caused within the Tandem Connection.

Bit 6 Operates as the OEI to indicate errored blocks of the egressing VC-n.

Bits 7-8 Operate in a 76 multiframe as:

- Access point identifier of the Tandem Connection (TC-APId); it complies with the generic 16-byte string format given in 9.2.2.2.
- TC-RDI, indicating to the far end that defects have been detected within the Tandem Connection at the near end Tandem Connection sink.
- ODI, indicating to the far end that AU/TU-AIS has been inserted into the egressing AU-n/TU-n at the TC-sink due to defects before or within the Tandem Connection.
- Reserved capacity (for future standardization).

Frame #	Bits 7-8 definition
1-8	Frame Alignment Signal: 1111 1111 1111 1110
9-12	TC-APId byte #1 [1 $C_1C_2C_3C_4C_5C_6C_7$]
13-16	TC-APId byte #2 [0 X X X X X X X]
17-20	TC-APId byte #3 [0 X X X X X X X]
:	:
65-68	TC-APId byte #15 [0 X X X X X X X]
69-72	TC-APId byte #16 [0 X X X X X X X]
73-76	TC-RDI, ODI and Reserved (see following)

Frame #	Bit 7 definition	Bit 8 definition
73	Reserved (default = “0”)	TC-RDI
74	ODI	Reserved (default = “0”)
75	Reserved (default = “0”)	Reserved (default = “0”)
76	Reserved (default = “0”)	Reserved (default = “0”)

Lower-Order Path Overhead (VC-2/VC-1)

The bytes V5, J2, N2, and K4 are allocated to the VC-2/VC-1 POH. The V5 byte is the first byte of the multiframe and its position is indicated by the TU-2/TU-1 pointer. The V5 byte provides the functions of error checking, signal label, and path status of the VC-2/VC-1 paths. The bit assignments for the V5 byte and the byte-by-byte Lower Order Path Overhead is shown in Table 7.

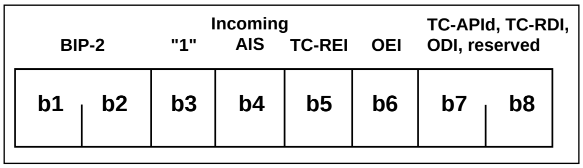
Table 7. Lower-Order Path Overhead

<table>
<tr><th>Byte</th><th>Description</th></tr>
<tr><td>V5</td><td>VT path overhead byte.
<table>
<tr><td colspan="2">BIP-2</td><td>REI</td><td>RFI</td><td colspan="3">Signal Label</td><td>RDI</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr>
</table>
Bits 1-2 Allocated for error performance monitoring. A Bit Interleaved Parity (BIP-2) scheme is specified. Includes POH bytes, but excludes V1, V2, V3, and V4.
Bit 3 A VC-2/VC-1 path Remote Error Indication (LP-REI) that is set to one and sent back towards a VC-2/VC-1 path originator if one or more errors were detected by the BIP-2; otherwise set to zero.
Bit 4 A VC-2/VC-1 path Remote Failure Indication (LP-RFI). This bit is set to one if a failure is declared, otherwise it is set to zero. A failure is a defect that persists beyond the maximum time allocated to the transmission system protection mechanisms.
Bits 5-7 Provide a VC-2/VC-1 signal label. The Virtual Container path Signal Label coding is:
000 Unequipped or supervisory-unequipped
001 Equipped – non-specific
010 Asynchronous
011 Bit synchronous
100 Byte synchronous
101 Reserved for future use
110 Test signal, O.181 specific mapping
111 VC-AIS
Bit 8 Set to 1 to indicate a VC-2/VC-1 path Remote Defect Indication (LP-RDI); otherwise set to zero.</td></tr>
<tr><td>J2</td><td>Used to repetitively transmit a Lower-Order Access Path Identifier so that a path receiving terminal can verify its continued connection to the intended transmitter. A 16-byte frame is defined for the transmission of Path Access Point Identifiers. This 16-byte frame is identical to the 16-byte frame of the J1 and J0 bytes.</td></tr>
</table>

Table 7 (contd)

Byte	Description

N2 Allocated for Tandem Connection Monitoring for the VC2, VC-12, and VC-11 level.



Bits 1-2	Used as an even BIP-2 for the Tandem Connection.
Bit 3	Fixed to “1”. This guarantees that the contents of N2 is not all zeroes at the TC-source. This enables the detection of an unequipped or supervisory unequipped signal at the Tandem Connection sink without the need of monitoring further OH-bytes.
Bit 4	Operates as an “incoming AIS” indicator.
Bit 5	Operates as the TC-REI of the Tandem Connection to indicate errored blocks caused within the Tandem Connection.
Bit 6	Operates as the OEI to indicate errored blocks of the egressing VC-n.
Bits 7-8	Operate in a 76 multiframe as:

– The access point identifier of the Tandem Connection (TC-APId); it complies with the generic 16-byte string format given in 9.2.2.2.

– The TC-RDI, indicating to the far end that defects have been detected within the Tandem Connection at the near end Tandem Connection sink.

– The ODI, indicating to the far end that TU-AIS has been inserted at the TC-sink into the egressing TU-n due to defects before or within the Tandem Connection.

– Reserved capacity (for future standardization).

Frame #	Bits 7-8 definition
1-8	Frame Alignment Signal: 1111 1111 1111 1110
9-12	TC-APId byte #1 [1 $C_1C_2C_3C_4C_5C_6C_7$]
13-16	TC-APId byte #2 [0 X X X X X X X]
17-20	TC-APId byte #3 [0 X X X X X X X]
:	:
65-68	TC-APId byte #15 [0 X X X X X X X]
69-72	TC-APId byte #16 [0 X X X X X X X]
73-76	TC-RDI, ODI and Reserved (see following)

Frame #	Bit 7 definition	Bit 8 definition
73	Reserved (default = “0”)	TC-RDI
74	ODI	Reserved (default = “0”)
75	Reserved (default = “0”)	Reserved (default = “0”)
76	Reserved (default = “0”)	Reserved (default = “0”)

K4 Bits 1-4 are allocated for APS signalling for protection at the Lower-Order path level. Bits 5-7 are reserved for optional use.
Bit 8 is reserved for future use and has no defined value.