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SMARTRING® SERVICE OC−N & STS−1
INTERFACE & PERFORMANCE
SPECIFICATIONS

**Technical
Reference**

NOTICE

This Technical Reference describes Synchronous Optical Network (SONET) Optical Carrier level (OC−N) and Synchronous Transport Signal level 1 (STS−1) SMARTRing® Service interfaces. It describes signals as they appear at the Network Interface (NI), between BellSouth Telecommunications, Inc. (BST) and Customer Installations or Carriers for SMARTRing SONET based services.

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SMARTRING® SERVICE OC−N & STS−1 INTERFACE & PERFORMANCE SPECIFICATIONS

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SMARTRING® SERVICE OC−N & STS−1
INTERFACE & PERFORMANCE SPECIFICATIONS

1. Scope

This Technical Reference (TR) describes Synchronous Optical Network (SONET) Optical Carrier and Synchronous Transport Signal level 1 (STS−1) interfaces, referred to as the Network Interface (NI), between BellSouth Telecommunications, Inc. (BST) and Customer Installation's (CI) or Carrier's. It establishes optical, electrical, physical, protocol and performance requirements at the NI necessary for compatible operation between BST and the CI or Carrier. At this time, it is recommended that optical interfaces be jointly engineered by BST and the Customer.

This Technical Reference does not cover SMARTRing® Service with DS3 or DS1 interfaces, as defined in the tariff. The technical specifications for DS3 interfaces are contained in Telcordia (formerly Bellcore) GR−342−CORE, *High−Capacity Digital Special Access Service Transmission Parameter Limits and Interface Combinations*, and BST TR 73501, *LightGate® Service Interface and Performance Specifications*. DS1 interfaces are described in Telcordia GR−54−CORE, *DS1 High−Capacity Digital Service End User Metallic Interface Specification,* TR 73501 and GR−342−CORE for Carriers.

1.1 Purpose

The requirements in this document were developed to establish a functional and practical interface. Compliance with them should provide a satisfactory interface in a high percentage of installations. If cases arise that have not been adequately addressed in this document, any resulting problems should be resolved through the cooperation of the user, BST and equipment suppliers. BST encourages customer participation to ensure an orderly, functional and mutually trouble−free interface at all locations.

1.2 Use of this Document

Network Interface (NI) specifications have been established based upon Industry Standards developed by the American National Standards Institute (ANSI) and Telcordia. This TR articulates BST variations from these standards and provides clarification of interface requirements as necessary.

1.3 Reason for Reissue

This Technical Reference is being reissued to generally update the previous issue and to specifically add the following:

- Asymmetrical channel interfaces
- OC−48 optical interface specifications
- OC−192+ SMARTRing System

2. Service Description

2.1 General

SMARTRing Service provides a dedicated network service capable of transporting DS1, DS3, STS−1, OC−3, OC−12 and/or OC−48 signals with exceptional performance and reliability. It provides a level of redundancy/diversity designed to limit a single event from interrupting service. SMARTRing Service is provided via a self−healing ring network architecture with capacities of OC−1, OC−3, OC−3+, OC−12, OC−24, OC−48, OC−48+, and OC−192+. Service can only be provided where facilities can be made available as determined by BST.

SMARTRing Service is provided between a designated customer premises node, where the ring network is accessed, and (1) another customer designated premises or (2) BST central office. At a central office, SMARTRing Service may be interconnected with other services such as: FlexServ® Service, LightGate® Service, SMARTPath® Service or Expanded Interconnection Services.

2.2 System Architecture

SMARTRing Service utilizes a self−healing ring network architecture between multiple customer designated locations and BST central offices. Its topology consists of fiber routed via primary and alternate protection facility paths between customer designated locations and BST local and alternate central offices. This ring topology will continually monitor service quality and detect any failure within the system. It will automatically self−heal itself around a point of failure to ensure the continuity of services between locations within the ring network.

2.3 Service Configurations

SMARTRing Service provides a multi−nodal ring topology which is specified jointly by BST and the customer. The minimum configuration must include at least three nodes. At least one node must in a BST central office. Additional nodes may be any combination thereof. The maximum number of nodes will be determined based on equipment capability. The nodes are connected by SMARTRing Service local channels, alternate central office channels, interoffice channels and internodal channels as applicable. SMARTRing Service may be connected to other services at central office locations.

SMARTRing Service can be utilized to provide end−to−end transport between CI End−User Point of Termination (EU−POT), Carrier Point of Termination (CXR−POT), EU−POT to CXR−POT, or between either an EU−POT or CXR−POT and a BST central office location. Further channelization is available in conjunction with SMARTRing Service to provide for network access to voice grade or digital data services that operate at 64 Kbit/s or below. At customer nodes, multiplexing to provide voice grade or digital data services must be implemented by customer−provided multiplexing equipment.

It is possible to utilize all or part of a SMARTRing Service to transport Switched Access Services. Specific provisions for order placement are outlined in the tariff.

2.4   Service Capacity

OC−1 SMARTRing Service is available only in overlay ring arrangements riding the customer's host OC−12, OC−48 or OC−48+ SMARTRing Service. The OC−1 shares the transport of its host SMARTRing Service. It provides an equivalent capacity of 1−STS−1 or 28−DS1s.

OC−3 SMARTRing Service is available as an individual service or in an overlay ring arrangement riding the customer's host OC−12, OC−48, OC−48+, or OC−192 SMARTRing Service. It provides an equivalent capacity of 3−STS−1s, 3−DS3s, 84−DS1s, or a combination thereof not to exceed the capacity of 3−STS−1s.

OC−3+ SMARTRing Service is available as an individual service, or in combination with OC−12 SMARTRing Service or in an overlay ring arrangement riding the customer's host OC−48, OC−48+, or OC−192+ SMARTRing Service. OC−3+ SMARTRing Service nodes provide an equivalent capacity of 3−STS−1s, 3−DS3s, 84−DS1s or a combination thereof not to exceed the capacity of 3−STS−1s at each node. The maximum ring capacity is 12−STS−1s, 12−DS3s, 336−DS1s or a combination thereof not to exceed the capacity of an OC−12 ring. When a customer orders OC−3+ SMARTRing Service in combination with OC−12 SMARTRing Service, capacity and channel interface availability at each node are determined by the size node ordered, i.e., OC−3+ or OC−12.

OC−12 SMARTRing Service is available as an individual service, or in combination with OC−3+ SMARTRing Service, or in an overlay ring arrangement riding the customer's host OC−48, OC−48+, or OC−192+ SMARTRing Service. It provides an equivalent capacity of 12−STS−1s, 12−DS3s, 4−OC−3s, or a combination thereof not to exceed the capacity of an OC−12 ring.

OC−24 SMARTRing Service is available to existing customers as an individual service with a capacity of 24−DS3s.

OC−48 SMARTRing Service is available as an individual service or with overlaying rings in capacities of OC−1, OC−3, OC−3+ and/or OC−12, or in an overlay ring arrangement riding the customer's host OC−192+ SMARTRing Service. It provides an equivalent capacity of 48−STS−1s, 48−DS3s, 4−OC−12s or 16−OC−3s.

OC−48+ SMARTRing Service is available as an individual bi−directional service, or with overlaying rings in capacities of OC−1, OC−3, OC−3+ and/or OC−12. It provides an equivalent capacity of 24−STS−1s, 24−DS3s or 8−OC−3s between adjacent node locations on the ring. The maximum capacity of an OC−48+ SMARTRing Service is determined by the number of customer and central office nodes on the ring.

OC−192+ SMARTRing Service is available as an individual bi−directional service, or with overlaying rings in capacities of OC−3, OC−3+, OC−12, and/or OC−48. It provides an equivalent capacity of 96−STS−1s, 96−DS3s, 8−OC−12s or 32−OC−3s. The maximum capacity of the OC−192+ SMARTRing Service is determined by the number of customer and central office nodes on the ring.

2.5   **Channel Interfaces**

SMARTRing Service channel interfaces provide DS1, DS3, STS−1, OC−3, OC−12, and/or OC−48 drop side interfaces at node locations. SMARTRing Service channel interfaces available with various SMARTRing Nodes are listed in Table 2−1.

Table 2−1. SMARTRing Service Channel Interfaces

Channel Interfaces	SMARTRing Nodes						
	OC−1	OC−3	OC−3+	OC−12	OC−48	OC−48+	OC−192+
DS1	X	X	X	1	1	1	
DS3		X	X	X	X	X	
STS−1	X	X	X	X	X	X	
OC−1[2]				X	X	X	
OC−3				X	X	X	X
OC−12					X	X	X
OC−48							X
28 DS1 Channel System − DS3		X	X	X	X	X	
28 DS1 Channel System − STS−1		X	X	X	X	X	
DS3 Asymmetrical with DS1		X	X				
DS1 Within an STS−1 Asymmetrical Arrangement		X	X				

Optical channel interfaces may be provisioned as concatenated. For concatenated interfaces, multiple STS−1s within the OC−N signal are provided as a single entity with a single overhead channel[3].

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[1] DS−1 interfaces are available via OC−1, OC−3 and OC−3+ overlay ring arrangements or 28 DS1 Channel Systems only.

[2] OC−1 interfaces are only available for use with OC−1 overlay ring arrangements.

[3] In more general terms, an STS−N signal may consist of an appropriate number of STS−M signals, where M<N. An STS−M signal in turn may consist of multiple STS−1 signals or it may be a concatenated STS−Mc or STS−Xc signal, where X<M, or a mixture thereof.

2.6   Asymmetrical Interfaces

SMARTRing Service interfaces may be ordered as asymmetrical (i.e. a circuit enters one node at a lower level interface and exits at another node at a higher level interface).

The allowable asymmetrical interface arrangements for various SMARTRing System sizes are shown in Table 2−2.

Table 2−2. SMARTRing Asymmetrical Channel Interfaces

Asymmetrical Channel Interfaces	SMARTRing Nodes					
	OC−3	OC−3+	OC−12	OC−48	OC−48+	OC−192+
DS1 − TDS3[4]	X	X				
DS1 − STS1	X	X				
DS1 − OC−3		X				
DS3 − STS1	X	X	X	X	X	
DS3 − OC−3		X	X	X	X	
DS3 − OC−12				X	X	
TDS3[4] − OC−3		X				
STS1 − OC−3		X	X	X	X	
STS1 − OC−12				X	X	
OC−3 − OC−12				X	X	X
OC−3 − OC−48						X
OC−12 − OC − 48						X

2.7   Ring Overlays

Overlay ring arrangements require a channel interface for each entry to or exit from the host ring. Optical overlay ring arrangements require the use of 2−fiber channel interfaces. The OC−1 channel interface is available as a 2−fiber interface for overlay ring arrangements only.

SMARTRing Service overlay ring arrangements are available as depicted in Table 2−3.

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[4] The DS3 Asymmetrical with DS1 transmux feature eliminates the need for a separate M13 multiplexer function. It translates the asynchronous DS1s contained within a DS3 to VT1.5s contained within an STS−1.

Table 2−3. SMATRing Overlay Ring Arrangements

Overlaying SMARTRing Service	Host SMARTRing Service			
	OC−12	OC−48	OC−48+	OC−192+
OC−1	X	X	X	
OC−3	X	X	X	X
OC−3+		X	X	X
OC−12		X	X	X
OC−48				X

2.8   Floor Space & Entrance Facilities

The customer must provide suitable floor space, including an environment controlled for humidity and temperature, and a source of non−switched AC power to support SMARTRing Service.

Where the customer provides two separate entrance facility cable routes for SMARTRing Service, the primary and alternate facilities will be separate and will enter the customer node over such different routes.

2.9   Limitations

With OC−12 SMARTRing Service installed on or after June 3, 1994, and with OC−48 and OC−48+ SMARTRing Service the customer may request a OC−1 and/or OC−3 overlay ring arrangement riding the customer's host OC−12, OC−48 or OC−48+ SMARTRing Service. With OC−48 SMARTRing Service the customer may request an OC−3+ and/or OC−12 overlay ring arrangement riding the customer's host OC−48 SMARTRing Service. In an overlay ring arrangement, node, channel, and performance monitoring configuration requirements apply to the host SMARTRing Service.

SMARTRing Service can only be provided where suitable facilities can be made available.

Shared Network Arrangements will not be provided with SMARTRing Service at the ring level.

With 24−DS3 SMARTRing Service, only the DS3 customer channel interface is available at a customer node. DS3 and/or DS1 interfaces (via a 28 channel system) are available at a central office node.

3. **SONET Hierarchy & Interface Considerations**

This section reviews the SONET hierarchy, rates and signal format as well as key SONET interface considerations. Interface compatibility is discussed in terms of BST supported SONET optical and electrical interface rates, overhead bits active across the interface and termination of overhead bits.

3.1 **SONET Rates**

SONET defines a progressive hierarchy of optical signal and line rates. The basic building block is the STS−1 (Synchronous Transport Signal at level 1), operating at 51.840 Mb/s. All higher rate signals (STS−N) are multiples (N) of the basic STS−1 signal rate. One example of forming a STS−N signal is by synchronously byte−interleaving N STS−1 signals[5]. The values of N currently recognized in Industry Standards are 1, 3, 12, 24, 48, and 192. The optical counterpart of a STS−N is the OC−N, operating at the same rate as the corresponding STS−N.

SONET takes a layered approach, starting with the lowest layer called the Physical Media Dependent (PMD) layer, followed by the logical layers called the Section, Line and Path[6] layers in ascending order. These layers together constitute the lowest layer, the Physical layer, in the 7−layer Open Systems Interconnection (OSI) Reference Model. The layers are largely independent. Each NE (Network Element) terminates at least the Physical layer[7], which provides for the optical or electrical transmission of bits. Each logical layer has an associated overhead which is generated and terminated by NEs operating at the respective level. These NEs are called Section Terminating Equipment (STE), Line Terminating Equipment (LTE[8]) and Path Terminating Equipment (PTE) in ascending order. A NE may terminate one or more than one layer; for example, STE and LTE functions may be combined in one piece of equipment.

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[5] In more general terms, an STS−N signal may consist of an appropriate number of STS−M signals, where M < N. An STS−M signal in turn may consist of multiple STS−1 signals or it may be a concatenated STS−Mc or STS−Xc signal, where X < M, or a mixture there of.

[6] The Path layer is subdivided into the STS (Synchronous Transport Signal) Path layer and depending on multiplexing arrangements, VT (Virtual Tributary) Path layer.

[7] Except the Physical layer regenerator.

[8] Line Terminating Equipment (LTE) from two different vendors is only compatible if transmission as well as Physical layer overhead and operational characteristics match.

3.2   SONET Signal Format

The signal format at the SONET interface is based on the SONET frame structure as specified in Telcordia GR−253−CORE, *Synchronous Optical Network (SONET) Transport Systems: Common Generic Criteria Physical Layer*, and ANSI T1.105, *Digital Hierarchy − Optical Interface Rates and Formats Specifications (SONET)*. The STS−1 frame structure, as shown in Figure 1, consists of the Transport Overhead with Section and Line Overhead portions, the Path Overhead, and the payload. The payload and the Path Overhead together are also referred to as the STS SPE (Synchronous Payload Envelope).

For BST applications the Transport and Path Overhead bytes listed in Table 3−1 are the ones that are active or potentially active across the interface.

Table 3−1. SONET Overhead Bytes Active Across the Interface

Level	Overhead Bytes	Function
Section	A1	Frame Alignment (11110110) all STS–1s within STS–N
	A2	Frame Alignment (00101000) all STS–1s within STS–N
	J0/Z0	Trace/Growth in each of N STS–1s in STS–N
	B1	Section BIP–8 using even parity first STS–1 of STS–N, calculated over all bits of previous STS–N frame after scrambling
Line	H1 (bits 1–4)	New Data Flag
	H1 (bits 5 & 6)	Undefined
	H1 & H2 (bits 7–16)	Pointer Value also indicate concatenation & detect STS Path Alarm Indication Signals (AIS–P)
	H3	Pointer action byte is allocated for SPE frequency justification purposes
	B2	Line BIP–8 using even parity in all STS–1s of STS–N, calculated over all bits of the Line Overhead and the Envelope Capacity of previous STS–1 before scrambling
	K1 & K2	Automatic Protection Switching first STS–1 of STS–N
	K2 (bits 6,7&8)	Line Alarm Indication Signal (AIS) 111 Line Remote Defect Indication (RDI–L) (formerly FERF) 110
	S1/Z1	Synchronization Status (S1) first STS–1 of STS–N bits 5 through 8, Growth (Z1) second through Nth STS–1s of STS–N (3≤N≤48)
	(M0) STS–1 REI–L	M0 byte only in STS–1 in an OC–1 or STS–1 electrical signal, bits 5 through 8 allocated for Line Remote Error Indication (REI) function (formerly FEBE)
	(M1) STS–N REI–L	M1 in third STS–1 (in order of appearance in the byte–interleaved STS–N electrical or OC–N signal) in an STS–N(N≥3) and is used as a REI–L function
STS–Path	J1	STS–Path Trace
	B3	STS–Path BIP–8 using even parity, calculated over all bits of previous STS SPE before scrambling
	C2	STS–Path Signal Label
	G1	STS–Path Status, bits 1–4 count of interleaved–bit block errors detected in B3 byte, bits 5, 6 & 7 allocated for STS Path RDI (RDI–P)
	H4	Indicator
VT–Path	V5 (bits 1 & 2)	VT–Path BIP–2
	V5 (bit 3)	VT–Path Remote Equipment Indicator (REI–V)
	V5 (bit 4)	VT–Path Remote Failure Indication (RFI–V)
	V5 (bits 5 – 7)	VT–Path Signal Label
	V5 (bit 8)	VT–Path Remote Defect Indicator (RDI–V)RFI (formerly Yellow)

3.2.1 Framing Information

Framing information is contained in the A1 and A2 bytes. Equipment on either side of the NI shall meet the requirements for going from an in−frame condition to an out−of−frame condition and for going from an out−of−frame condition to an in−frame condition, as well as for entering and exiting the loss of frame state, as specified in GR−253−CORE.

3.2.2 Data Communications Channel

The Section Data Communications Channel (DCC) consists of 192 kbps located in bytes D1, D2 and D3, and the Line DCC consists of 576 kbps located in bytes D4−D12. The Section DCC and Line DCC will not be active across the SONET interface − receiving equipment must be capable of ignoring their content.

3.2.3 Automatic Protection Switching

Automatic Protection Switching (APS) is controlled by the K1 and K2 bytes. For 4 fiber optical interfaces unidirectional 1+1 non−revertive APS will be provided across the interface. Use of the K1 and K2 bytes is specified in GR−253−CORE.

3.3 Overhead Bytes Active Across the Network Interface

The function of overhead bytes active across the NI shall be consistent with the specifications contained in GR−253−CORE and ANSI T1.105. Transport and Path Overhead bytes active across the interface are summarized in Table 3−2. The Data Communications Channel (DCC) will not be active across the interface at this time. Therefore, receiving equipment must be capable of ignoring DCC content and other inactive bytes. Any future utilization of overhead bytes is expected to be consistent with SONET Industry Standards.

Table 3−2. Overhead Bytes Active across NI

	Transport Overhead				Path Overhead
Section Overhead	Framing A1	Framing A2	Trace/Growth J0/Z0		Trace J1
	Section BIP−8 B1				Path BIP−8 B3
					Signal Label C2
Line Overhead	Pointer H1	Pointer H2	Pointer Action H3		Path Status G1
	Line BIP−8 B2	APS K1	APS K2		
					Indicator H4*
	Synch Status/ Growth S1*/Z1*	STS−N REI−L/ Growth M0* or M1*			

* These bytes could be active across the interface for specific applications.

4.   STS−1 Electrical Interface

This section defines the Network Interface (NI) requirements for the Synchronous Transport Signal level 1 (STS−1) signal. It denotes existing documentation which details electrical and signal specifications and provides BST variations and clarifications. The physical layer of the STS−1 NI is defined in the following specifications.

GR−253−CORE   *Synchronous Optical Network (SONET) Transport Systems: Common Criteria Physical Layer*

ANSI T1.102   *Digital Hierarchy − Electrical Interfaces*

ANSI T1.105   *Synchronous Optical Network (SONET) − Basic Description including Multiplex Structure, Rates and Formats*

The specifications in this section, together with the SONET hierarchy specifications in Section 3 and payload mapping requirements in Section 6 comprise the complete set of interface characteristics.

4.1   Frame Format

To assure proper operation of transmission facilities and higher order multiplex equipment, all STS−1 sources shall use the frame structure and scrambler specification in GR−253−CORE and ANSI T1.105.

4.1.1   Overhead Bytes Active Across NI

The function of overhead bytes active across the NI shall be consistent with the specifications contained in GR−253−CORE and ANSI T1.105. Transport and Path Overhead bytes active across the interface are summarized in Table 3−2. The Data Communications Channel (DCC) will not be active across the interface at this time. Therefore, receiving equipment must be capable of ignoring DCC content and other inactive bytes. Any future utilization of overhead bytes is expected to be consistent with SONET Industry Standards.

4.2   Payload Compatibility

For payloads terminated within the BST network, payload compatibility must be assured. Payload mappings for Synchronous Payload Envelopes (SPEs) terminated in the BST network are defined in ANSI T1.105 and currently limited to the following for STS−1 interfaces.

- Asynchronous mapping for DS1 signals into floating VT1.5 SPE
- Asynchronous mapping for DS3 signals with DS3 framing structure into STS−1 SPE

4.3   Mechanical Interface

One coaxial cable is provided for each direction of transmission. The referenced cable for interconnections at the NI is 75−ohm coaxial cable with tinned copper meeting the requirements specified in ANSI T1.102, *Digital Hierarchy − Electrical Interfaces.* Interconnection at the NI is through Universal Service Order Code (USOC) connector, SJA 44 as shown in ANSI T1.404. The SJA 44 was originally defined as a 75−ohm plug and jack coaxial connector meeting the requirements in MIL−C−39012 and MIL−STD−202 for TNC connectors. Currently, the preferred method of interconnection is via two BNC connectors.

4.4   Customer Responsibility

The customer is required to provide network protection, signal recovery, Line Buildout and test access functionality. These functions are normally included in a device called a Channel Service Unit (CSU).

4.5   Maintenance Responsibility

Customer Premises Equipment (CPE) shall provide the capability of generating and interpreting standard STS−1 signals, alarm/defect indication signals and performance monitoring as defined in GR−253−CORE and ANSI T1.105. Section 10 contains additional SONET operations and maintenance considerations.

5.   **OC−N Optical Interface**

This section defines the Network Interface (NI) requirements for Synchronous Optical Network (SONET) OC−3, OC−12 and OC−48 signals. SMARTRing SONET interfaces are highlighted and specific information is provided concerning the optical system reference diagram, optical parameter definitions, joint engineering and the system budget.

Where feasible, BST will support interconnection with Short Reach (SR), Intermediate Reach (IR), and Long Reach (LR) interface options. The establishment of optical interfaces will require joint engineering between BST and the customer, to establish the application category and to define the transmitter type used. The broad application categories in current standards are:

Short Reach: typically used for intra−office connections with interconnection distances from 0 to 2 km.

Intermediate Reach: typically used for short−haul applications with interconnection distances from 0 to 15 km.

Long Reach: typically used for applications with interconnection distances from 10 to 40 km.

5.1   Signal Format

The optical signal shall utilize the frame structure in GR−253−CORE and ANSI T1−105. Section 3 of this Technical Reference contains additional details regarding the SONET signal format.

5.2   Overhead Bytes Active Across NI

The function of overhead bytes active across the NI shall be consistent with the specifications contained in GR−253−CORE and ANSI T1.105. Transport and Path Overhead bytes active across the interface are summarized in Table 3−2. The Data Communications Channel (DCC) will not be active across the interface at this time. Therefore, receiving equipment must be capable of ignoring DCC content and other inactive bytes. Any future utilization of overhead bytes is expected to be consistent with SONET Industry Standards.

5.3   Payload Compatibility

For payloads terminated within the BST network, payload compatibility must be assured. Payload mappings for Synchronous Payload Envelopes (SPEs) terminated in the BST network are defined in ANSI T1.105.02, *Synchronous Optical Network (SONET) − Payload Mappings* and currently limited to the following:

- Asynchronous mapping for DS1 signals into floating VT1.5 SPE.

- Asynchronous mapping for DS3 signals with DS3 framing structure into STS−1 SPE.

- STS−1 signals mapping into STS−3, STS−12 or STS−48 SPE

OC−3, OC−12 and OC−48 interfaces support transport of properly mapped STS−1, STS−3, STS−3c (concatenated[9]), STS−12, STS−12c, STS−48, and STS−48c signals. Payloads that are transported, but not terminated in the BST network, must be contained in one of the supported frame structures.

Additional information concerning payload mapping is contained in Section 6.

5.4   Physical Media Characteristics

The interface shall be established based upon SONET terminal equipment which meets the physical media characteristics defined in GR−253−CORE for either the Short Reach (SR), Intermediate Reach−1 (IR−1) or Long Reach (LR−1) applications as established by BST. Transmitter, optical path and receiver parameters for OC−3, OC−12, and OC−48 interfaces are summarized in Table 5−1 through Table 5−3, respectively. Appropriate attenuation may be necessary to achieve a satisfactory interface.

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[9] For concatenated interfaces, multiple STS−1s within the OC−N signal are provided as a single entity with a single overhead channel.

Table 5−1. OC−3 Optical Parameters

Parameter	SR	IR−1	LR−1	Units
Transmitter	MLM/LED	MLM	MLM	
$\lambda_{Tmin} - \lambda_{Tmax}$	1260−1360	1261−1360	1280−1335	nm
$\Delta\lambda_{rms}$	40/80	7.7	4	nm
$\Delta\lambda_{20}$	NA	NA	NA	nm
SSR_{min}	NA	NA	NA	dB
P_{Tmax}	−8	−8	0	dBm
P_{Tmin}	−15	−15	−5	dBm
r_{emin}	−8.2	8.2	10	dB
Optical Path				
System ORL_{min}*	NA	NA	NA	dB
D_{SRmax}	18/25	96	185	ps/nm
Attenuation	0−7	0−12	10−28	dB
Maximum Reflection between S and R	NA	NA	NA	dB
Receiver				
P_{Rmax}	−8	−8	−10	dBm
P_{Rmin}	−23	−28	−34	dBm
P_O	1	1	1	dB
Maximum Receiver Reflectance	NA	NA	NA	dB

* For all applications, it is an objective that the optical system suffer a power penalty less than 1 dB in the presence of −8.5 dB reflectance.

NA – Not Applicable

Table 5−2. OC−12 Optical Parameters

Parameter	SR	IR−1	LR−1		Units
Transmitter	MLM/LED	MLM	MLM	SLM	
$\lambda_{Tmin} - \lambda_{Tmax}$	1261−1360	1293−1334 $(1274-1356)^2$	1300−1325 $(1296-1330)^2$	1280−1335	nm
$\Delta\lambda_{rms}$	14.5/35	4.0 $(2.5)^2$	2.0 $(1.7)^2$	NA	nm
$\Delta\lambda_{20}$	NA	NA	NA	1	nm
SSR_{min}	NA	NA	NA	30	dB
P_{Tmax}	−8	−8	+2	+2	dBm
P_{Tmin}	−15	−15	−3	−3	dBm
r_{emin}	8.2	8.2	10	10	dB
Optical Path					
System ORL_{min}[1]	NA	NA	20	20	dB
D_{SRmax}	13/14	46 $(74)^2$	92 $(109)^2$	NA	ps/nm
Attenuation	0−7	0−12	10−24	10−24	dB
Maximum Reflection between S and R	NA	NA	−25	−25	dB
Receiver					
P_{Rmax}	−8	−8	−8	−8	dBm
P_{Rmin}	−23	−28	−28	−28	dBm
P_O	1	1	1	1	dB
Maximum Receiver Reflectance	NA	NA	−14	−14	dB

[1]   For all applications, it is an objective that the optical system suffer a power penalty less than 1 dB in the presence of −8.5 dB reflectance.

[2]   Transmitters meeting the narrower spectral width objective are allowed a wider central wavelength range ($\lambda_{Tmin} - \lambda_{Tmax}$).

NA – Not Applicable

Table 5−3. OC−48 Optical Parameters

Parameter	SR	IR−1	LR−1	Units
Transmitter	MLM	SLM	SLM	
$\lambda_{Tmin} - \lambda_{Tmax}$	1266−1360	1260−1360	1280−1335	nm
$\Delta\lambda_{rms}$	4	NA	NA	nm
$\Delta\lambda_{20}$	NA	1	1	nm
SSR_{min}	NA	30	30	dB
P_{Tmax}	−3	0	+3	dBm
P_{Tmin}	−10	−5	−2	dBm
r_{emin}	8.2	8.2	8.2	dB
Optical Path				
System ORL_{min}[1]	24	24	24	dB
D_{SRmax}	12	NA	NA	ps/nm
Attenuation	0−7	0−12	10−24	dB
Maximum Reflectance Between S and R	−27	−27	−27	dB
Receiver				
P_{Rmax}	−3	0	−9	dBm
P_{Rmin}	−18	−18	−27	dBm
P_O	1	1	1	dB
Maximum Receiver Reflectance	−27[2]	−27[2]	−27[2]	dB

[1] For all applications, it is an objective that the optical system suffer a power penalty less than 1 dB in the presence of −8.5 dB reflectance.

[2] This value is intended to ensure acceptable penalties due to multiple reflections for all likely system configurations. For systems employing few or higher−performance optical components (e.g., a system with only two connectors), a −14 dB receiver reflectance may be considered acceptable.

NA − Not Applicable

5.4.1 Optical Parameter Definitions

The following definitions apply to the parameter values listed for each optical interface.

LED	Light Emitting Diode
MLM	Multi$-$Longitudinal Mode laser
SLM	Single Longitudinal Mode laser
$\lambda_{Tmin}, \lambda_{Tmax}$	The range of central operating wavelengths $-$ minimum and maximum central operating wavelengths, under worst$-$case variations due to manufacturing, temperature, aging, and reflections.
$\Delta\lambda_{rms}$	Root$-$Mean$-$Square (RMS) spectral width under worst$-$case reflection conditions, $\Delta\lambda_{rms}$ does not apply to SLM transmitters.
$\Delta\lambda_{20}$	Full spectral width measured 20 dB down from the maximum of the central wavelength peak of a single longitudinal mode (SLM) transmitter operating fully modulated in the presence of worst$-$case reflections.
P_{Tmax}, P_{Tmin}	The maximum and minimum coupled transmitter power at point S in Figure 2, with a pseudo$-$random data sequence. These are worst$-$case values to account for manufacturing variances, drifts due to temperature variations and aging effects, and operation with minimum value of the extinction ratio.
r_{emin}	The minimum value of the extinction ratio $-$ ratio of the average optical energy in a logic one level to a logic zero level, under fully modulated conditions in the presence of worst$-$case reflections.
ORL_{min}	The minimum ratio in dB of optical power arriving downstream at a system interface to the optical power reflected back upstream to the same interface.
D_{SRmax}	The maximum dispersion between points S & R in Figure 2.
P_{Rmax}, P_{Rmin}	The maximum and minimum receiver power at point R in Figure 2 for 1×10^{-10} BER. These values take into account power penalties caused by use of a transmitter with worst$-$case spectral width, extinction ratio, pulse shape characteristics, and operating wavelength. They include the effect of drifts due to temperature variations and aging.
P_O	Optical path power penalty between points S and R in Figure 2. P_O accounts for the total degradation along the optical path (reflections, jitter, intersymbol interference, mode$-$partition noise, and laser chirp).

5.5   Optical System Reference Diagram

For the purpose of optical parameter specifications, optical interfaces are referred to a optical system reference diagram as shown in Figure 2. Point S is a reference point on the optical fiber just after the transmitter (Tx) optical connector (C_{Tx}). Point R is a reference point on the optical fiber just before the receiver (Rx) optical connector (C_{Rx}). Points S and R provide a convenient separation of the optical link into a transmitter subsection, a receiver subsection, and an optical path subsection. Optical parameters are specified for the transmitter at point S, for the receiver at point R, and for the optical path between points S and R. All parameter values specified are worst−case values and are to be met over the ranges of standard operating conditions (i.e., temperature and humidity ranges); they include aging effects. The parameters are specified relative to an optical section design objective of a bit error ratio (BER) better than $1x10^{-10}$. Optical parameters are addressed in the following subsections based upon the values given in GR−253−CORE.

5.5.1   Fiber Transmission Media

The optical interface shall use single−mode fiber with a nominal zero dispersion wavelength at 1310 nanometers. The conventional dispersion−unshifted single−mode fiber (also known as EIA/TIA Class IVa fiber) shall meet the requirements detailed in Telcordia GR−20−CORE, *Generic Requirements for Optical Fiber and Optical Fiber Cables*, and ITU Recommendation G.652, *Characteristics of a Single−Mode Optical Fiber Cable*.

For optical interfaces 2 fiber or 4 fiber interfaces are available. The 2 fiber interface provides a working fiber pair which uses one fiber for each direction of transmission. The 4 fiber interface supports unidirectional 1+1 non−revertive Automatic Protection Switching (APS) using two fiber pairs (4 individual fibers), one pair for working service and one pair for protection. Each pair will utilize a single fiber for each direction of transmission as shown in Figure 3.

5.5.2   Transmitter

The transmitter requirements include the operating wavelength range, spectral width, range of transmit power, and extinction ratio. In addition, the transmitter pulse shapes are specified by the mask of the eye diagram at point S as defined in GR−253−CORE.

5.5.3   Receiver

Receiver characteristics as defined in GR−253−CORE are specified in terms of receiver sensitivity, receiver overload, and the allowable power penalty from the combined effects of dispersion, reflection, and jitter.

5.6   System Budget − Joint Engineering

It is recommended that the interface be jointly engineered by BST and the customer or Carrier using commonly accepted engineering practices. The design approach should be based on ANSI/EIA/TIA−559, *Single−Mode Fiber Optic System Transmission Design,* or GR−253−CORE procedures. Appropriate attenuation may be necessary to achieve a satisfactory design.

To ensure proper system performance it is necessary to specify attenuation and dispersion characteristics of the optical path. Attenuation shall be in the range of $0-7$ dB for Short Reach (SR) applications, $0-12$ dB for Intermediate Reach (IR) applications, and $10-24/28$ dB for Long Reach (LR) applications. This specification is assumed to represent worst−case values including losses due to splices, connectors, optical attenuators (if used), or other passive optical devices, and any additional cable margin to cover allowances for the following:

(1)   future modifications to the cable configuration (additional splices, increased cable lengths, etc.),

(2)   fiber cable performance variations due to environmental factors, and

(3)   degradation of any connector, optical attenuator (if used), or other passive optical device when provided.

5.7   Optical Connector at NI

At the NI, duplexable SC type (EIA/TIA SCFOC/2.5) plug and jack type connectors will be used to support transmission over single−mode fiber with a nominal zero dispersion wavelength at 1310 nanometers. BST will install the connector jack at the NI. BST and the customer must each provide connector plugs to terminate their fibers at the NI. Each connector plug will contain 2 fibers, one for each direction of transmission. The connector is the demarcation point between BST and the CI.

For 2 fiber interfaces, the working fiber pair (2 individual fibers − one for each direction of transmission) must be provided at the NI. For 4 fiber interfaces, 2 fiber pairs (4 individual fibers − 2 working and 2 protection) must be provided at the NI, as shown in Figure 3.

5.8   Powering Arrangement

Powering shall not be provisioned across the Network Interface (NI) by either BST or the customer or Carrier.

6. Payload Mapping

This section provides information concerning the mapping of network services into Synchronous Transport Signal (STS) Synchronous Payload Envelopes (SPEs). This includes STS−1 level services and sub−STS−1 level services.

6.1 Payload Mapping − Terminated

SMARTRing Service currently will support termination of the following payload mappings within the BST network.

  − Asynchronous mapping for DS1 signals into floating mode VT1.5 SPE.

  − Asynchronous mapping for DS3 signals with DS3 framing structure into STS−1 SPE.

  − STS−1 signals mapping into STS−3, STS−12 or STS−48 SPE.

It is anticipated that additional mappings will be supported under this and other service offerings. Contact a BST Account Team Representative for additional details.

For any payload terminated within the BST network, payload compatibility of the SONET signals exchanged at the Network Interface (NI) must be assured, i.e., the Path layer payload composition and mapping must be well defined. This information should be established at the time service is initially ordered and accurately reflected on subsequent orders. The Path layer is subdivided into STS Path layer and Virtual Tributary (VT) Path layer.

A customer that terminates the STS Path layer must know the payload composition of the OC−N signal. The latter may consist of N basic rate STS−1 signals or an appropriate number of STS−M signals, where M<N. An STS−M signal in turn may consist of multiple STS−1 signals or it may be a concatenated STS−Mc signal, or a mixture thereof.

A customer that terminates the VT Path layer must know the payload composition and mappings employed in the individual STS−1 signals. An STS−1 signal, in its SPE, may contain a single DS3 signal or DS1 signals. The sub−DS3 level signals are mapped into individual VTs. Floating mode VTs are grouped such that seven VT Groups make up one STS−1 signal. Each VT Group can accommodate only one type of tributary, e.g., four VT1.5.

6.2 Sub−STS−1 Level Mapping

This section describes the BST supported payload mappings that use the VT structured STS−1.

6.2.1 Asynchronous Mapping for DS1

All services below the DS3 rate are transported in a VT structure. DS1 payloads are mapped into a floating mode VT1.5 Synchronous Payload Envelope (SPE) as defined in GR−253−CORE and ANSI T1.105.02. The asynchronous mapping for DS1 is depicted in Figure 4. In addition to the VT Path Overhead, the DS1 mapping consists of 771 data bits, 6 stuff control bits, 2 stuff opportunity bits and 8 overhead communication channel bits. The remaining bits are Fixed Stuff (R) bits. The 8 O−bits are reserved for future communication purposes.

DS1 payloads contained within a DS3 must be mapped using the asynchronous M13 multiplex format (combination of M12 and M23 formats) for terminal equipment that multiplexes 28 DS1s into a DS3, as defined in ANSI T1.107, *Digital Hierarchy Formats Specifications*. The DS3 signal must be framed utilizing the framing structure in ANSI T1.107 and use the asynchronous mapping for a DS3 into an STS−1 SPE.

6.3   **STS−1 Level Mapping**

This section describes the BST supported payload mappings that occupy an entire STS−1 SPE.

6.3.1   **Asynchronous Mapping for DS3**

DS3 Services are mapped into an STS−1 SPE as defined in GR−253−CORE and ANSI T1.105.02. The asynchronous mapping for DS3 is depicted in Figure 5. The mapping consists of 9 subframes every 125 ms. Each subframe consists of 621 data bits, a set of 5 stuff control bits, 1 stuff opportunity bit, and 2 overhead communication channel bits. The remaining bits are Fixed Stuff (R) bits. The O−bits are reserved for future overhead communication purposes.

6.4   **Payload Mapping − Transported**

The OC−N and STS−1 Network Interfaces (NIs) support transport of properly mapped DS3, STS−1, STS−N and STS−Nc (concatenated) signals. Payloads which are transported, but not terminated in the BST network, must be contained in one of the supported frame structures. Industry Standard mappings have been defined for Asynchronous Transfer Mode (ATM), Fiber Distributed Data Interface (FDDI), and Distributed Queue Dual Bus (DQDB). In addition to these standard mappings, proprietary mappings may also be acceptable for transport; provided they comply with standard frame, format and overhead structure.

A pure transit Carrier that only transports OC−N signals without terminating any STS Paths or VT Paths may not need to know the payload composition for its own operation, but may need to pass the information between its connecting points at both ends.

7.   **Synchronization**

To insure proper operation when connected to the BST digital network, channelized DS1 circuits should follow the guidelines of Telcordia GR−436−CORE, *Digital Network Synchronization Plan*. Timing information may be transmitted as part of the DS1 signal. Improper timing will result in transmission impairing slips which can cause loss of data information.

End−User synchronization may be achieved by deriving timing from a BST channelized DS1, by deriving timing from a different DS1 traceable to a Primary Reference Source (PRS) and timing all other facilities from it, or by providing timing traceable to a PRS. For BST services with central office channelization, it has been recommended that the customer equipment be loop−timed (slaved) to the incoming bit stream from the network.

It is important to note that Synchronous Optical Network (SONET) facilities may be used to transport SMARTRing Service. SONET facilities may introduce DS1 phase transients as a result of pointer adjustments. Characteristics of the phase transients at the network interface have been addressed in the latest version of ANSI T1.403. Customer equipment must be capable of accommodating these phase transients. Further information about phase transients due to SONET pointer adjustments is contained in ANSI T1.403.

8.   **Performance**

Performance objectives for SMARTRing Service have been established based on on ANSI T1.510, *Network Performance Parameters for Dedicated Digital Services for Rates Up to and Including DS3 − Specifications*, and T1.514, *Network Performance Parameters and Objectives for Dedicated Digital Services − SONET Bit Rates*. Performance objectives are stated in terms of Error Free Seconds (EFS), Severely Errored Seconds (SES), Service Availability, and Service Continuity.

8.1   **General**

The performance objective for SMARTRing Service pertains to the BST provided bit stream on the network side of the NI. The performance of DS1 or DS1 subrate services transport via SMARTRing is covered in documents that pertain to those services. Verification of circuit performance up to the NI may be performed by BST using a variety of testing techniques.

8.2   **Quality Objectives**

The performance quality objectives of a SMARTRing Service circuit on the network side of the NI are stated in terms of four parameters: Error Free Seconds (EFS), Severely Errored Seconds (SES), Service Availability and Service Continuity. SMARTRing performance objectives, stated in terms of the DS3/STS−1 level, are summarized in Table 8−1.

Table 8−1. SMARTRing Service DS3/STS−1 Quality Performance Objectives

Performance Parameter	Objective (Long Term)
%Error Free Seconds (%EFS)	EFS > 99.5%
%Severely Errored Seconds (%SES)	SES < 0.009%
%Annual Service Availability	Availability > 99.99%
Service Continuity	Single Event Restoration < 2.5 seconds

Optical interfaces that are jointly engineered by BST and the customer should be designed to have a bit error ratio (BER) better than $1x10^{-10}$. DS3/STS−1 service transported over these optical interfaces should meet or exceed the above service quality performance objectives. The performance of transported DS1 service should exceed 99.95% EFS.

8.2.1   **Error Free Seconds**

The long term (i.e., 30 or more days) EFS performance objective is better than 99.5% EFS when the circuit is available. An EFS is defined as any second in which there is no bit errors. Conversely, an Errored Second (ES) is one in which there is one or more bit errors. ES are typically transient in nature, arise from a variety of causes, and have a small probability of occurring at any given time.

8.2.2   **Severely Errored Seconds**

The long term Severely Errored Second (SES) performance objective is less than 0.009% SES when the circuit is available. A SES is defined as any second in which the Bit Error Ratio (BER)is $1x10^{-3}$ or worse.

8.2.3   **Annual Service Availability**

The long term availability performance objective is better than 99.99% availability over 12 consecutive months. Circuit availability is a measure of the amount of time that the service is "usable" by the customer. According to the American National Standards Institute (ANSI) a service is assumed to be in the available state unless a transition to the unavailable state is observed without a subsequent transition to the available state. The transitions between the available and unavailable states are:

- – Transition to the unavailable state occurs at the beginning of 10 consecutive SES.

- – Transition to the available state occurs at the beginning of 10 consecutive seconds none of which is a SES.

8.2.4   **Service Continuity**

The Service Continuity performance objective is that in the event of primary facility failure, service will switch to the alternate facility path in 2.5 seconds or less.

9.   **Network Codes**

The Network Channel (NC) Code identifies the service and provides an encoded representation of the SMARTRing Service channel. The electrical characteristics of the interface at the Network Interface (NI)/Point of Termination (POT) are identified by the Network Channel Interface (NCI) Code.

When ordering service, the customer must specify compatible codes. An overview and definitions of specific codes that apply to SMARTRing Service are covered in this Section. Descriptions of the component parts of the code are provided to aid the customer in understanding the relationship of these codes to the electrical characteristics of the interface.

The appropriate interface ordering procedures, which use these NC and NCI codes, are covered in other publications such as Telcordia SR−STS−000307 and the NC/NCI Decoder.

9.1   **Network Channel Code**

The Network Channel (NC) Code is a 4−character code that consists of two (2) data elements:

Channel Code   A two−character code in positions 1&2 that describes the channel service in an abbreviated form. Code HC identifies a High Capacity Channel Service HC1.

Optional Feature Code   A two−character code in positions 3&4 that identifies the option codes available for each Channel Code. The third character defines functions of the channel, i.e. protocols B8ZS, SF and ESF etc. The fourth character is used to further enhance the third character of the NC Code by defining features of the channel, i.e. multiplexing etc.

Codes for link connectable services such as: Asynchronous Transfer Mode, Frame Relay, Video etc. can be obtained from the BST Account Team.

9.2   **Network Channel Interface Code**

The Network Channel Interface (NCI) Code is a maximum twelve−character code that can consist of five data elements and two delimiters. The NCI describes the number of conductors, protocol, impedance, protocol options and transmission level point(s) reflecting characteristics at the Central Office or Network Interface (NI)/Point of Termination (POT). NCI code selection for SMARTRing Service should be coordinated between the customer and BST during the initial service order discussion.

The protocol code is the most significant component of the NCI code, since it is associated with the basic electrical function of the interface. The protocol code broadly describes the technical capabilities of the interface at the EU−POT, CXR−POT or serving wire center.

Number of Conductors	A two−character code in positions 1& 2 that identifies the total number of physical conductors, i.e. code **02** identifies two wires or two optical fibers.
Protocol	A two−character code in positions 3 & 4 that represents requirements for the interface regarding signaling/transmission and digital applications, i.e. code **SO** represents SONET optical.
Impedance	A one−character code in position 5 that identifies the nominal reference impedance that will terminate the channel for the purpose of evaluating the transmission performance at the POT; i.e. **F** represents a fiber interface, **6** represents 75 ohms − DS3 or STS−1 interface, and **9** represents 100 ohms − DS1 interface.
Delimiter	A "." is used as a delimiter in position 6
Protocol Options	A one− to three−character code in positions 7,8 and 9 that broadly describes the technical capabilities of the interface, i.e. **B** indicates LR1−SLM.
TLP	Transmission Level Point (TLP) can be contained in positions 8 through 12. A one− or two−character code corresponding to a value for the TLP(s) with a delimiter. This code will not be used for SMARTRing.

Additional information about Network Channel Interface Codes may be found in Telcordia SR−STS−000307, *Industry Support Interface (ISI): NC/NCI Dictionary*.

9.3 Ring Level and Service Activation NC and NCI Codes

NC and NCI code selection for SMARTRing Service should be coordinated between the customer and BST during the initial service order discussion.

NC and NCI codes are used to support the Marketing Service Request (MSR) mechanized order process for access service. Exhibit 1 provides Ring Level Network Channel NC and NCI code combinations for OC−1, OC−3, OC−3+, OC−12, OC−48, OC−48+ and OC−192+ SMARTRing OC−N (Ring Level) service orders. Exhibit 2 provides NC and NCI codes for SMARTRing Service activations at Central Office and Customer Node locations.

9.4 SONET Optical Interfaces

For ordering purposes the NCI code for SMARTRing SONET optical interfaces should be specified as **02SOF.B or 04SOF.B**. The codes represent two fiber (02SOF.B) or four fiber (04SOF.B) SONET optical interface with LR1−SLM lasers. The optical interface will be jointly engineered by BST and the customer selecting the most appropriate transmitter and receiver for the specific application.

10. SONET Operations and Maintenance

The SONET interface may terminate in the network at three hierarchical layers: the Section, Line, and Path. The SONET path termination may include STS−Path, VT Path, or DSn Path. Maintenance capabilities associated with the Section, Line, and Path layers include Performance Monitoring (PM), alarm surveillance, and facility testing. Such maintenance capabilities are performed by Section, Line, and Path termination equipment contained within SONET network elements and are made possible by maintenance tools built into the Section, Line, and Path Overhead fields of the SONET framing structure.

The SONET overhead bytes required to perform such operations and maintenance functions for SONET are identified in GR−253−CORE and ANSI T1.105 and have previously been defined as active across the interface.

10.1 Fault and Alarm Management

Alarm surveillance deals with the detection and reporting of certain failure conditions in the network. SONET CI equipment is required to detect certain failure conditions relevant to the layer of functionality they provide. Detection of a failure in the network is often communicated throughout relevant portions of the network via maintenance signals built into the SONET frame structure. STS Path level maintenance signals include STS Path Alarm Indication Signal (AIS) and STS Path Remote Defect Indication (RDI). RDI is a performance indicator that is initiated immediately upon detection of a defect.

10.2 Failure States

The failure states, Loss of Signal (LOS), Loss of Frame (LOF), and Loss of Pointer (LOP) are defined in GR−253−CORE. SONET equipment shall detect failure states relevant to the layer of SONET overhead functionality it provides.

10.2.1 Equipment Failures

SONET CI equipment failures should be detected and reported according to the equipment failure conditions specified in GR−253−CORE.

10.2.2 Maintenance Signals

Failure states that persist for a defined period of time lead to indications that are reported to SONET equipment using the following maintenance signals.

10.2.2.1 Alarm Indication Signal (AIS)

SONET provided equipment provides different AISs for various layers of functionality including DS0, DS1, DS3, Path, and Line AISs. The Line AIS, STS Path AIS, and/or VT Path AIS generation and detection shall meet the AIS criteria stated in GR−253−CORE.

In many applications, SONET will be a transport medium for lower speed digital signals such as DS1 and DS3. Because of this, SONET CPE that has these DSn digital interfaces may need to detect and generate DSn AISs associated with these interfaces. On detection of a failure (Line AIS, STS Path AIS, and/or VT Path AIS) STS PTE (or VT PTE) shall generate downstream DSn AIS depending on the composition of the STS SPE (or VT SPE) or the functionality of the STS or VT PTE. SONET STS PTE, or VT PTE shall detect DSn AIS at all DSn interfaces at which DSn path is terminated. GR−253−CORE and TR−TSY−000191 specify requirements for DS1 and DS3 AIS.

10.2.2.2 Line Remote Defect Indication

Line Remote Defect Indication (RDI), formerly Line Far End Receive Failure, alerts the upstream equipment that a failure has been detected. SONET terminals shall generate, detect, deactivate (remove) STS Line RDI according to GR−253−CORE.

10.2.2.3 DSn Remote Failure Indication

Certain SONET payload mappings may require CPE with digital signal interfaces to detect and generate DSn Remote Failure Indication (RFI) signals, formerly Yellow. DSn RFI shall be detected or generated for DSn paths that are terminated according to GR−253−CORE.

10.2.2.4 STS−Path Remote Defect Indication

STS−Path RDI, formerly Far End Receive Failure, alerts the upstream equipment that a failure state has been detected. It is an objective for SONET to meet the STS−Path RDI as described in GR−253−CORE.

10.3 Performance Monitoring

BST will support performance monitoring (PM) in accordance with the strategies and set of layered PM parameters contained in the GR−253−CORE. Except as specifically noted, the layered PM requirements in GR−253−CORE apply to BST SONET interfaces.

SONET STS−Path terminated equipment shall provide Section, Line, and Path performance monitoring on incoming OC−N facilities and be capable of reporting threshold crossings according to the generic requirements in GR−253−CORE.

SONET equipment, if terminating the VT−Path level, shall also provide VT−Path performance monitoring according to GR−253−CORE.

SONET CI equipment interfacing with DS1, or DS3 signal shall detect Loss of Signal (LOS) on those signals according to the requirements in TR−TSY−000191, *Alarm Indication Signals Requirements and Objectives*.

11. Acronyms

ADM	Add Drop Multiplexer
AIS	Alarm Indication Signal
ANSI	American National Standards Institute
APS	Automatic Protection Switching
ATM	Asynchronous Transfer Mode
B3ZS	Bipolar with Three−Zero Substitution
BIP	Bit Interleaved Parity
CI	Customer Installation
CXR	Carrier
DCC	Data Communications Channel
DCS	Digital Cross−Connect System
D_{SRmax}	Maximum Dispersion Between Points S & R
DQDB	Distributed Queue Dual Bus
DSO	Digital Signal Level 0
DS1	Digital Signal Level 1
DS3	Digital Signal Level 3
DSX−1	Cross Connect for DS1 Signals
DSX−3	Cross Connect for DS3 Signals
EU	End User
FDDI	Fiber Distributed Data Interface
FEBE	Far End Block Error
FERF	Far End Receive Failure
IEC	Interexchange Carrier
ILEC	Independent Local Exchange Carrier
IR	Intermediate Reach (Optical Standard)
ITU/TSS	International Telecommunication Union/Telecommunication Standardization Sector

LEC	Local Exchange Carrier
LED	Light Emitting Diode
LTE	Line Terminating Equipment
MLM	Multi−Longitudinal Mode
NE	Network Element
OC−1	Optical Carrier level 1
OC−3	Optical Carrier level 3
OC−12	Optical Carrier level 12
OC−24	Optical Carrier level 12
OC−48	Optical Carrier level 48
OC−192	Optical Carrier level 192
OC−N	Optical Carrier level−N
ORL_{min}	Minimum System Optical Return Loss
OSI	Open Systems Interconnection
PMD	Physical Medium Dependent
P_O	Optical Path Power Penalty Between Points S and R
POH	Path Overhead
PPM	Parts per Million
P_{Rmax}, P_{Rmin}	Maximum and Minimum Receiver Power at Point R for $1x10^{-10}$ BER
PRS	Primary Reference Source
PTE	Path Terminating Equipment
P_{Tmax}, P_{Tmin}	Maximum and Minimum Coupled Transmitter Power at Point S
RDI	Remote Defect indicator
r_{emin}	Minimum Value of the Extinction Ratio
RFI	Remote Failure Indication (Formerly Yellow)
SDH	Synchronous Digital Hierarchy
SLM	Single Longitudinal Mode

SOH	Section Overhead
SONET	Synchronous Optical Network
SPE	Synchronous Payload Envelope
SR	Short Reach (Optical Standard)
SSR_{min}	Minimum Acceptable Side−Mode Suppression Ratio (SSR)
STE	Section Terminating Equipment
STM	Synchronous Transfer Mode
STS−1	Synchronous Transport Signal level 1
STS−3	Synchronous Transport Signal level 3
STS−12	Synchronous Transport Signal level 12
STS−3c	Concatenated Synchronous Transport Signal level 3
STS−12c	Concatenated Synchronous Transport Signal level 12
STS−N	Synchronous Transport Signal level N
STS−Nc	Concatenated Synchronous Transport Signal level N
STSX−1	Cross Connect for Synchronous Transport Signal level 1
TR	Technical Requirement
TA	Technical Advisory
VT1.5	Virtual Tributary at 1.5 Mb/s
$\lambda_{Tmin}, \lambda_{Tmax}$	Minimum and Maximum Central Operating Wavelengths
$\Delta\lambda_{rms}$	Root−Mean−Square (RMS) Spectral Width
$\Delta\lambda_{20}$	Full Spectral Width Measured 20 dB Down

12. References

BST TR 73501   LightGate® Service Interface and Performance
Specifications, Issue E, 2000

BellSouth documents may be ordered by contacting:

> BellSouth Documentation
> NW 5th Floor
> 3535 Colonnade Pkwy
> Birmingham, AL 35243
> 205−977−7135

BellSouth Technical References are also available at:
> http://www.interconnection.bellsouth.com/products/tech_ref.html

ANSI T1.101−1999	Synchronization Interface Standards for Digital Networks.
ANSI T1.102−1993	Digital Hierarchy − Electrical Interfaces.
ANSI T1.105−1995	Synchronous Optical Network (SONET) − Basic Description including Multiplex Structure, Rates and Formats
ANSI T1.105.01−1998	Synchronous Optical Network (SONET) − Automatic Protection Switching
ANSI T1.105.02−1995	Synchronous Optical Network (SONET) − Payload Mappings
ANSI T1.105.03−1994	Synchronous Optical Network (SONET) − Jitter at Network Interfaces
ANSI T1.105.03a−1995	Synchronous Optical Network (SONET) − Jitter at Network Interfaces − DS1 Supplement
ANSI T1.105.03b−1997	Synchronous Optical Network (SONET) − Jitter at Network Interfaces − DS3 Wander Supplement
ANSI T1.107−1995,	Digital Hierarchy Formats Specifications
ANSI T1.403−1999	Network and Customer Installation − DS1 Electrical Interface
ANSI T1.404−1994	Network−to−Customer Installation − DS3 Metallic Interface Specification
ANSI T1.404a−1996	Network−to−Customer Installation − DS3 Metallic Interface Specification − Supplement
ANSI T1.510 −1999	Network Performance Parameters for Dedicated Digital Services for Rates Up to and Including DS3 − Specifications
ANSI T1.514 −1995	Network Performance Parameters and Objectives for Dedicated Digital Services − SONET Bit Rates

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ANSI, IEC & CCITT documents can be ordered from:

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> 15 Inverness Way East
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NC/NCI/Decoder   *PC based application with a 1−year subscription for the NC/NCI code set*, Issue 3Q, September 1998

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This exhibit provides information regarding the use of Network Channel (NC) and Network Channel Interface (NCI) codes to support the mechanized access service order process for SMARTRing Service. Table E1−1 provides NC and NCI code combinations for OC−1, OC−3, OC−3+, OC−12, OC−48, OC−48+ and OC−192+ SMARTRing Service orders at the OC−N Ring Level. Service orders at the Ring Level provide NC and NCI codes for each link, channel connection, between adjacent SMARTRing nodes.

In each case a second NCI code is required of 02SOF.BU for all Ring types except OC−48+ and OC−192+ which has second NCI code of 02SOF.BB to indicate that it is a Bi−directional Ring.

Table E1−1. SMARTRing (OC−1 to OC−192) Ring Level NC/NCI Code Matrix

Node Size	Central Office (CO) Link NC Code	Customer Node (CN) Link NC Code	Informational NCI Code (CO & CN)
OC−1	OAIC	OAKD	02SMF.A01
	OAIG (CNM)[1]	OAKH (CNM)[1]	02SM6.A1
OC−3	OBIC	OBKD	02SMF.+++
	OBIG (CNM)[1]	OBKH (CNM)[1]	02SMF.+++
OC−3+/OC−12	ODIC	ODKD	02SMF.+++
	ODIG (CNM)[1]	ODKH (CNM)[1]	02SMF.+++
OC−12	ODIC	ODKD	02SMF.+++
	ODIG (CNM)[1]	ODKH (CNM)[1]	02SMF.+++
OC−48+/OC−48	OFIC	OFKD	02SNF.+++
	OFIG (CNM)[1]	OFKH (CNM)[1]	02SNF.+++
OC−192+	OGIC	OGKD	02SQF.+++

[1] Contact a BST Account Team representative regarding availability.
[+] Consult Table E1−1A for code SM, Table E1−1B for code SN, Table E1−1C for code SQ

Exhibit 1−SMARTRing Ring Level NC/NCI Codes
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Table E1−1A. Protocol Code SM (OC−3s/DS3s/STS−1s/DS1s)

Protocol Code	+=Number of OC3s	+=Number of DS3s/STS−1s	+=Number of DS1s
SM	A=0	0=0	1=28
	B=1	1=1	2=56
	C=2	2=2	3=84
	D=3	3=3	4=112
	E=4	4=4	5=140
		5=5	6=168
		6=6	7=196
		7=7	8=224
		8=8	9=252
		9=9	
		A=10	
		B=11	
		C=12	

Exhibit 1−SMARTRing Ring Level NC/NCI Codes
Page 2 of 4

Table E1−1B. Protocol Code SN (OC−12s/OC−3s/DS3s/STS−1s)

Protocol	+=Number of OC12S	+=Number of OC3s	+=Number of DS3s/STS−1s
SN	A=0	0=0	1=3
(No OC−48	B=1	1=1	2=6
Drops)	C=2	2=2	3=9
	D=3	3=3	4=12
	E=4	4=4	5=15
	F=5	5=5	6=18
	G=6	6=6	7=21
	H=7	7=7	8=24
	I=8	8=8	9=27
	J=9	9=9	A=30
	K=10	A=10	B=33
	L=11	B=11	C=36
	M=12	C=12	D=39
	N=13	D=13	E=42
	O=14	E=14	F=45
	P=15	F=15	G=48
	Q=16	G=16	H=60
		H=20	I=72
		I=24	J=84
		J=28	K=96
		K=32	L=108
		L=36	M=120
		M=40	N=132
		N=44	O=144
		P=48	P=156
		Q=52	Q=168
		R=56	R=180
		S=60	S=192
		T=64	

Exhibit 1−SMARTRing Ring Level NC/NCI Codes
Page 3 of 4

Table E1−1C. Protocol Code SQ (OC−48s/OC−12s/OC−3s/DS3s/STS−1s)

Protocol Code	+=Number of OC48s/OC12s	+=Number of OC3s	+=Number of DS3s/STS−1s
SQ	A=1/0	0=0	1=3
	B=1/1	1=1	2=6
	C=1/2	2=2	3=9
	D=1/3	3=3	4=12
	E=1/4	4=4	5=15
	F=1/5	5=5	6=18
	G=1/6	6=6	7=21
	H=1/7	7=7	8=24
	I=1/8	8=8	9=27
	J=1/9	9=9	A=30
	K=1/10	A=10	B=33
	L=1/11	B=11	C=36
	M=1/12	C=12	D=39
	N=2/0	D=13	E=42
	P=2/1	E=14	F=45
	Q=2/2	F=15	G=48
	R=2/3	G=16	H=60
	S=2/4	H=20	I=72
	T=2/5	I=24	J=84
	U=2/6	J=28	K=96
	V=2/7	K=32	L=108
	W=2/8	L=36	M=120
	X=3/0	M=40	N=132
	Y=3/1	N=44	O=144
	Z=3/2	P=48	P=156
	1=3/3	Q=52	Q=168
	2=3/4	R=56	R=180
	3=4/0	S=60	S=192
		T=64	

Note: If number of OC−48 drops = 0, use the SN protocol option

Exhibit 1−SMARTRing Ring Level NC/NCI Codes
Page 4 of 4

This exhibit provides Network Channel (NC) and Network Channel Interface (NCI) codes for SMARTRing Service activations at Central Office and Customer Node locations.

Table E2−1 provides NC codes for SMARTRing Service activations.

Table E2−1. SMARTRing Service Activation NC Codes

NC Code	NC Code Description
HF− −	DS3 Non−Channelized
HF−6	DS3 Non−Channelized ATM UNI
HF−D	DS3 Non−Channelized Frame Relay UNI
HF−E	DS3 Non−Channelized Frame Relay NNI
HF−J	DS3 Non−Channelized Frame Relay NNI Via ATM
HF−M	DS3 Channelized Central Office Mux
HF−P	DS3 Channelized Mux at Both Ends, Customer Premises
HF−Q	DS3 Channelized Customer Premises
HF−R	DS3 Channelized Customer Premises & Central Office Mux
HF−T	DS3 Channelized TRANSMUX Central Office
HF−T	DS3 Channelized TRANSMUX Customer Premises
HF−Y	DS3 Channelized Mux at Both Ends, Central Office
HFC−	DS3 Non−Channelized C−BIT Parity
HFC6	DS3 Non−Channelized C−BIT Parity ATM UNI
HFCD	DS3 Non−Channelized C−BIT Parity Frame Relay UNI
HFCE	DS3 Non−Channelized C−BIT Parity Frame Relay NNI
HFCJ	DS3 Non−Channelized C−BIT Parity Frame Relay NNI Via ATM
HFZM	DS3 Channelized Central Office Mux, B8ZS Capable
HFZP	DS3 Channelized Mux at Both Ends, Customer Premises, B8ZS Capable
HFZQ	DS3 Channelized Customer Premises Mux, B8ZS Capable
HFZR	DS3 Channelized Central Office and Customer Premises Mux, B8ZS Capable
HFZT	DS3 Channelized TRANSMUX Central Office, B8ZS Capable
HFZT	DS3 Channelized TRANSMUX Customer Premises, B8ZS Capable
HFZY	DS3 Channelized Mux at Both Ends Central Office, B8ZS Capable

Exhibit 2 −SMARTRing Service Activation NC/NCI Codes
Page 1 of 5

Table E2−1 (Continued). SMARTRing Service Activation NC Codes

NC Code	NC Code Description
JI−−	STS−1 Non−Channelized
JIAA	STS−1 Channelized Mux at Central Office
JIAB	STS−1 Channelized Mux at Customer Premises
JIAC	STS−1 Channelized Mux at Both Ends, Central Office
JIAG	STS−1 Channelized Mux at Both Ends, Customer Premises
OB−−	OC−3 Non−Channelized Non−Concatenated
OB−C	OC−3 Mux at Central Office
OB−D	OC−3 Mux at Customer Premises
OB−E	OC−3 Mux at Both Ends
OB−R	OC−3 Non−Channelized Concatenated
OBA6	OC−3 Non−Channelized ATM UNI
OBIC	OC−3 SMARTRing Central Office
OBIG	OC−3 CNM SMARTRing Central Office
OBKD	OC−3 SMARTRing Customer Premises
OBKH	OC−3 CNM SMARTRing Customer Premises
OD−−	OC−12 Non Channelized Non−Concatenated
OD−C	OC−12 Mux at Central Office
OD−D	OC−12 Mux at Customer Premises
OD−E	OC−12 Mux at Both Ends
OD−R	OC−12 Non Channelized Concatenated
ODA6	OC−12 Non Channelized ATM UNI
ODIC	OC−12 SMARTRing Central Office
ODIG	OC−12 CNM SMARTRing Central Office
ODKD	OC−12 SMARTRing Customer Premises
ODKH	OC−12 CNM SMARTRing Customer Premises

Exhibit 2 − SMARTRing Service Activation NC/NCI Codes
Page 2 of 5

Table E2−1 (Continued). SMARTRing Service Activation NC Codes

NC Code	NC Code Description
OF−−	OC−48 Non−Channelized Non−Concatenated
OF−C	OC−48 Mux at Central Office
OF−D	OC−48 Mux at Customer Premises
OF−E	OC−48 Mux Both Ends
OF−R	OC−48 Non−Channelized Concatenated
OFIC	OC−48 SMARTRing Central Office
OFIG	OC48 CNM SMARTRing Central Office
OFKD	OC−48 SMARTRing Customer Premises
OFKH	OC−48 CNM SMARTRing Customer Premises
OG−E	OC−192 Mux at Both Ends
OGIC	OC−192 SMARTRing Central Office
OGKD	OC−192 SMARTRing Premises

Exhibit 2 −SMARTRing Service Activation NC/NCI Codes
Page 3 of 5

Table E2−2 provides the NCI codes for SMARTRing Service activations.

Table E2−2. (Continued). SMARTRing Service Activation NCI Codes

NC Code	NC Code Description
02SOF.B	SONET OC−N Optical (2 Fiber − Unprotected)
04SOF.B	SONET OC−N Optical (4 Fiber − 1+1 Protected)
02QBF.LL	SONET OC−N Optical Collocation (2 Fiber)
04QBF.LL	SONET OC−N Optical Collocation (4 Fiber − 1+1 Protected)
04ST6.A	SONET STS−1 Electrical
04QB6.S1	SONET STS−1 Electrical Collocation
04DS6.44	44.736 Mbps (DS3) M23 Format
04DS6.44A	44.736 Mbps (DS3) C−Bit Parity
04QB6.33	44.736 Mbps (DS3) Collocation
04DS6.44C	3 DS3s
04DS6.44G	12 DS3s
04DS6.44N	24 DS3s
04DS9.15	1.544 Mbps (DS1) SF & AMI − DSX−1 Level Interface
04DS9.1K	1.544 Mbps (DS1) ANSI ESF & AMI − DSX−1 Level Interface
04DS9.1S	1.544 Mbps (DS1) (ANSI ESF & B8ZS) − DSX−1 Level Interface
04DS9.15B	1.544 Mbps (DS1) SF & B8ZS − DSX−1 Level Interface
04QB9.11	1.544 Mbps (DS1) Collocation
04DU9.BN	1.544 Mbps (DS1) SF & AMI − Smart Jack Interface
04DU9.1KN	1.544 Mbps (DS1) ANSI ESF & AMI − Smart Jack Interface
04DU9.1SN	1.544 Mbps (DS1) ANSI ESF & B8ZS − Smart Jack Interface
04DU9.DN	1.544 Mbps (DS1) SF & B8ZS − Smart Jack Interface
04CS9.10R	DS1/DS0 Customer Reconfigurable − FlexServ Termination in Central Office
04CS9.11R	DS1/DS1 Customer Reconfigurable − FlexServ Termination in Central Office
04CS6.31R	DS3/DS1 Customer Reconfigurable − FlexServ Termination in Central Office
04CS6.33R	DS3/DS3 Customer Reconfigurable − FlexServ Termination in Central Office

Exhibit 2 − SMARTRing Service Activation NC/NCI Codes
Page 4 of 5

Table E2−2 (Continued). SMARTRing Service Activation NCI Codes

NC Code	NC Code Description
04CM9.1	SONET ADM DS1 Port Termination for Customer Reconfiguration
04CM6.3	SONET ADM DS3 Port Termination for Customer Reconfiguration
04CM6.S	SONET ADM STS−1 Port Termination for Customer Reconfiguration
02CMF.C3	SONET ADM OC−3 Port Termination for Customer Reconfiguration (2 Fiber)
04CMF.C3	SONET ADM OC−3 Port Termination for Customer Reconfiguration (4 Fiber)
02CMF.C12	SONET ADM OC−12 Port Termination for Customer Reconfiguration (2 Fiber)
04CMF.C12	SONET ADM OC−12 Port Termination for Customer Reconfiguration (4 Fiber)
02SMF.+++	SMARTRing Node − OC−3/OC−12 (2 Fiber)
04SMF.+++	1+1 Card Protection Point to Point − OC−3/OC−12 (4 Fiber)
02SNF.+++	SMARTRing Node − OC−48/OC−192 (2 Fiber)
04SNF.+++	1+1 Card Protection Point to Point − OC−48/OC−192 (4 Fiber)
02SQF.+++	SMARTRing − OC−192 (2 Fiber)
04SQF.+++	1+1 Card Protection Point−to−Point − OC−192 (4 Fiber)

+ Consult Table E1−1A for code SM, Table E1−1B for code SN, Table E1−1C for code SQ

Exhibit 2 −SMARTRing Service Activation NC/NCI Codes
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90 Bytes

9 Bytes

Section Overhead

Line Overhead

A_1	A_2	C_1
B_1	E_1	F_1
D_1	D_2	D_3
H_1	H_2	H_3
B_2	K_1	K_2
D_4	D_5	D_6
D_7	D_8	D_9
D_{10}	D_{11}	D_{12}
Z_1	Z_2	E_2

Path Overhead

J_1
B_3
C_2
G_1
F_2
H_4
Z_3
Z_4
Z_5

Transport Overhead

Payload

Payload

125 μsec
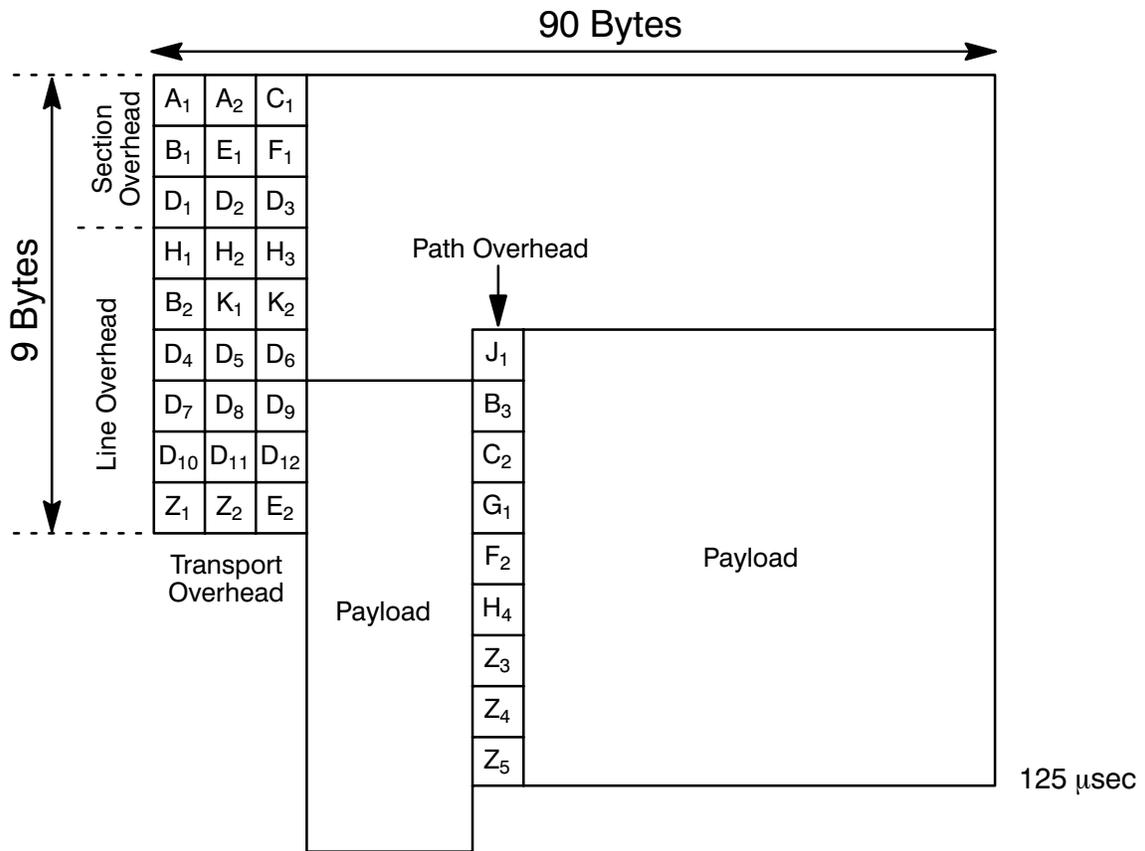
Figure 1 − SONET STS−1 Frame Structure

Connector
Plug

Point S

Point R

Connector
Plug

Transmitter
(Tx)

Plant Fiber

Receiver
(Rx)

Fiber
Pigtail

Transmitter
Connector
C_{Tx}

Receiver
Connector
C_{Rx}
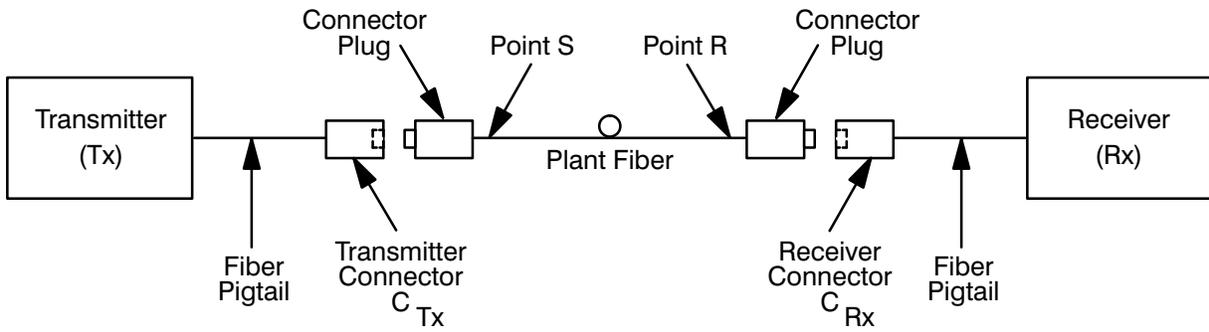
Fiber
Pigtail

Figure 2 − Optical System Interfaces (Points S and R)

NI

BellSouth Telecommunications
(BST)

Customer Installation
(CI)

PLUG   B   B   A   A   PLUG

WORKING   WORKING

A   A   B   B

JACK

FROM BST

NETWORK

TO CI

PLUG   B   B   A   A   PLUG

PROTECTION   PROTECTION

A   A   B   B

JACK

NI
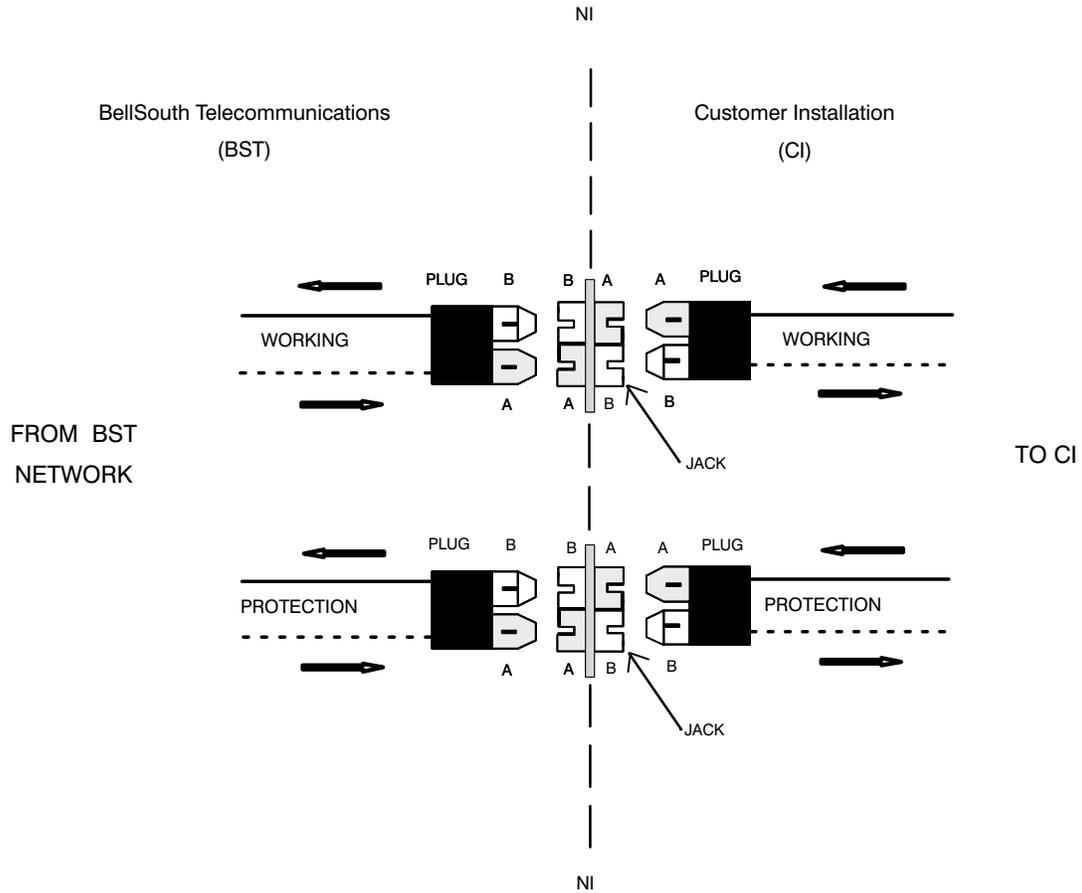
NOTES:

1 LIGHT LEAVES "A" PLUG AND ENTERS "A" JACK

2 LIGHT LEAVES "B" JACK AND ENTERS "B" PLUG

3 JACK AT NI PROVIDED BY BST (OPTIONALLY MAY BE PART OF OTHER NETWORK EQUIPMENT)

4 A SINGLE FIBER IS USED FOR EACH DIRECTION OF TRANSMISSION

5 FOR 2 FIBER INTERFACE ONLY WORKING PROVIDED

6 FOR 4 FIBER INTERFACE BOTH WORKING AND PROTECTION PROVIDED

DIRECTION OF LIGHT
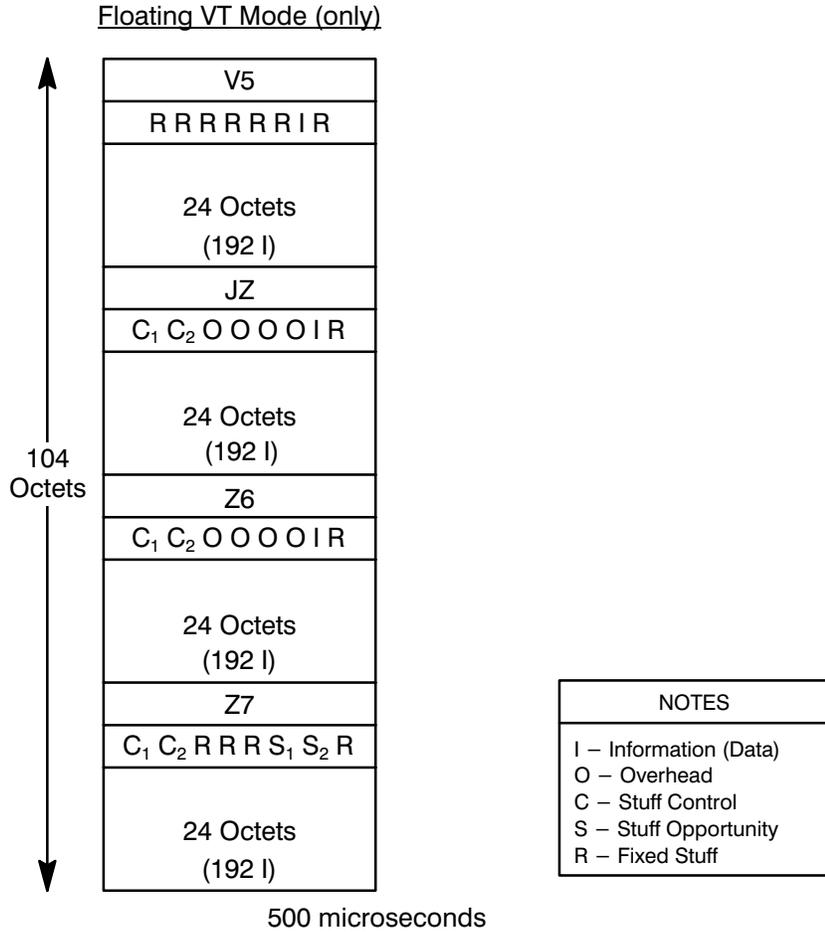
Figure 3 − Optical Mechanical Network Interface

Floating VT Mode (only)

V5
R R R R R R I R
24 Octets (192 I)
JZ
C_1 C_2 O O O O I R
24 Octets (192 I)
Z6
C_1 C_2 O O O O I R
24 Octets (192 I)
Z7
C_1 C_2 R R R S_1 S_2 R
24 Octets (192 I)

104 Octets

500 microseconds

NOTES
I − Information (Data) O − Overhead C − Stuff Control S − Stuff Opportunity R − Fixed Stuff

Figure 4 − Asynchronous Mapping for DS1 Payload

				28 Octets					28 Octets					28 Octets	
	r	r	c1	25 i		r	c2	i	25 i		r	c3	i	25 i
	r	r	c1	25 i		r	c2	i	25 i		r	c3	i	25 i
	r	r	c1	25 i		r	c2	i	25 i		r	c3	i	25 i
STS Path Overhead	r	r	c1	25 i	Fixed Stuff	r	c2	i	25 i	Fixed Stuff	r	c3	i	25 i
	r	r	c1	25 i		r	c2	i	25 i		r	c3	i	25 i
	r	r	c1	25 i		r	c2	i	25 i		r	c3	i	25 i
	r	r	c1	25 i		r	c2	i	25 i		r	c3	i	25 i
	r	r	c1	25 i		r	c2	i	25 i		r	c3	i	25 i
	r	r	c1	25 i		r	c2	i	25 i		r	c3	i	25 i

Octets:

← 8 bits →

i	–	I I I I I I I I

r	–	R R R R R R R R

c1	–	F F C I I I I I

c2	–	C C R R R R R R
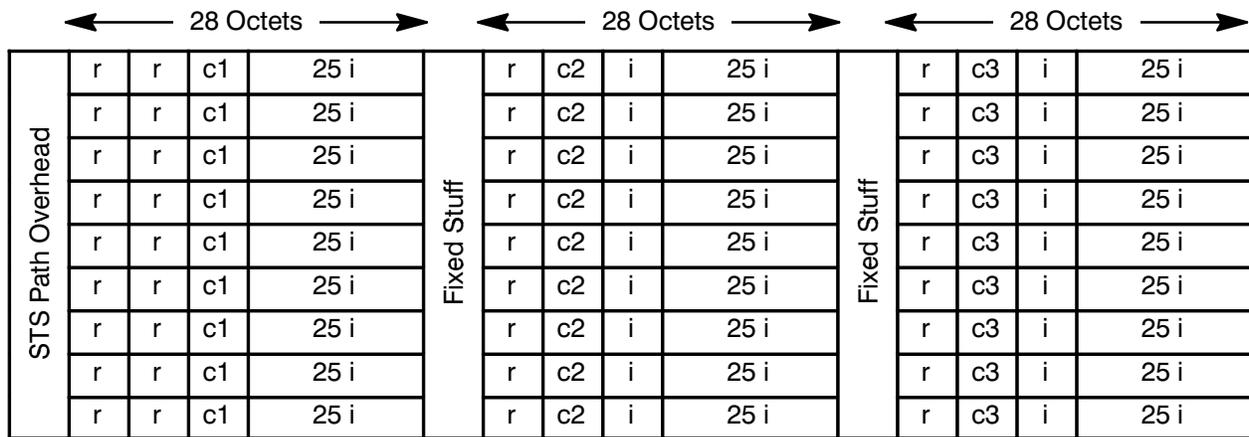
c3	–	C C R R O O R S
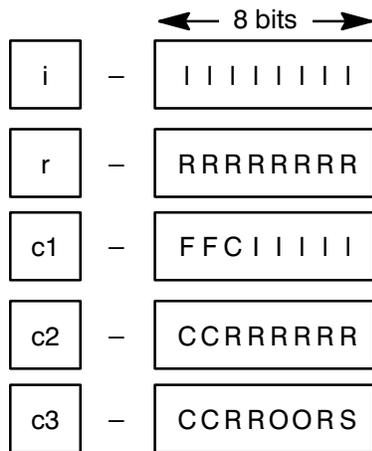
Bits:

I = information bit
R = fixed stuff bit
C = justification control bit
S = justification opportunity bit
O = overhead bit

Figure 5 − Asynchronous Mapping for DS3 Payload

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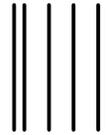Was the information presented logically and clearly? Yes _____ No _____

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