BELLSOUTH TELECOMMUNICATIONS

TR 73501

LightGate® Service Interface and Performance Specifications

Technical Reference

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Issue 5

NOTICE

This Technical Reference describes LightGate® Service DS1, DS3, STS−1 and Synchronous Optical Network (SONET) Optical Carrier level (OC−N) interfaces. It describes signals as they appear at the Network Interface (NI), between BellSouth Telecommunications, Inc. (BST) and Customer Installations or Carriers for LightGate Service.

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LIGHTGATE® SERVICE INTERFACE AND PERFORMANCE SPECIFICATIONS

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LIGHTGATE® SERVICE INTERFACE AND PERFORMANCE SPECIFICATIONS

1. General

The requirements in this document were developed to establish a practical interface. Compliance with these specifications 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, BellSouth Telecommunications, Inc. (BST) and equipment suppliers. BST encourages customer participation to ensure an orderly, functional and mutually trouble−free interface at all locations.

1.1 Scope

This Technical Reference (TR) describes physical, protocol and performance requirements at the Network Interface (NI) necessary for compatible operation between BST and the Customer Installation (CI) or Carrier for LightGate® Service. This TR describes the LightGate Service DS1, DS3, STS−1 and optical interfaces offered by BST.

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 Telcodia, formerly Bellcore. 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:

- STS−1 Local Channel
- STS−1 Interoffice Channel
- OC−12 /OC−48 Interoffice Channel
- OC−12 Channel Interface
- Revised NC and NCI codes
- OC−192 Local Channel
- OC−192 Interoffice Channel
- OC−48 Channel System
- OC−48 Channel Interface

- OC−48 Optical Serving Wire Center Termination (OSWCT)
- OC−48 Optical Customer Termination (OCUT)
- OC−12 Channel System

2. Service Description

LightGate Service (a.k.a BellSouth SPA Point to Point Network) is a high capacity digital transport service consisting of DS1, DS3, STS−1, OC−3, OC−12, OC−48 and OC−192 channels. LightGate Service asynchronous local channels are provided in four system sizes: LightGate 1, LightGate 2, LightGate 3 and LightGate 4 Service systems. LightGate Service synchronous local channels are available in five system sizes: LightGate STS−1, LightGate OC−3, LightGate OC−12, LightGate OC−48 and LightGate OC−192 Service systems. Asynchronous systems are capable of transporting DS1 and DS3 channels. Synchronous systems are capable of transporting all channels. The capacity of LightGate local channel systems is depicted in Table 2−1.

Table 2−1. LightGate Local Channel System Capacity Limits

LightGate System	DS1	DS3	STS−1	OC−3	OC−12	OC−48
LightGate 1	28	1				
LightGate 2	84	3				
LightGate 3	336	12				
LightGate 4	672	24				
LightGate STS−1	28		1			
LightGate OC−3	84	3	3	1		
LightGate OC−12	336	12	12	4	1	
LightGate OC−48	1344	48	48	16	4	1
LightGate OC−192	5376	192	192	64	16	4

Interoffice channels are provided in six system sizes: an asynchronous LightGate 1, a synchronous LightGate STS−1, LightGate OC−3, LightGate OC−12, LightGate OC−48 and LightGate OC−192 system interoffice channel.

LightGate Service channels may be connected in tandem to provide end−to−end connections between remote customer premises (CPs), or they may be combined with other transport or switching offerings of BST to provide private line, private network or public network solutions to telecommunications needs.

Synchronous LightGate Service can provide an optical interface termination at either the serving wire center or customer's location. An optical serving wire center termination will support optical interconnection with other services. The OC−3, OC−12 and OC−48 optical channel interfaces and available optical customer termination allows the customer the option of establishing an optical interface at their location.

Channel interface availability varies with system size and transport architecture (asynchronous versus synchronous). Customers who provided their own optical termination equipment associated with LightGate systems with optical termination at customer's premises are required to utilize compatible channel interface combinations to function with BST provided Central Office channel interfaces.

2.1 Service Architecture

LightGate Service will generally be provided over fiber optic facilities as determined by BST. However, alternative high capacity technology may be used as appropriate. It is offered both for wire center access and for interoffice transport. LightGate Services may be used in link configurations for premises–to–premises applications or for hubbing applications.

Automatic protection switching capability is a standard service feature that automatically switches customer service to protection facilities upon primary facility failure. The level of protection varies for LightGate Service asynchronous and synchronous channels and systems. For asynchronous channels, automatic protection switching capability is a standard service feature that automatically switches customer service to protection facilities upon primary facility failure. Card protection (1 + n) is provided for DS1, DS3 and STS–1 channel interfaces as a standard feature. Synchronous Customer and Central Office Channel Interfaces provide either 2 or 4 fiber interfaces. Synchronous Optical Customer Termination (OCUT) allows the customer the option of providing the equipment at their premises. In selected link configurations for premises–to–premises applications or hubbing applications OCUT 2 and 4 fiber interfaces may be available. The Synchronous Optical Serving Wire Center Termination (OSWCT) interface provides a 4 fiber interface. In addition, two levels of reliability are offered as options of basic LightGate Service. These service levels provide guaranteed Separate Alternate Facilities Transport (SAFT Level I & II) for improved protection of local channel systems extended from the first outside plant service access point outside the BST serving wire center to the last outside plant service access point prior to entering a customer's premises.

2.2 Limitations

All LightGate Service local channel systems will be provided to a single location on a customer's premises. A local channel system may not be split between premises or terminated in multiple locations within a premises.

2.3 Floor Space and Entrance Facilities

Where BST provides termination equipment on a customer's premises, 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 LightGate Service.

3. DS1 Interface

This section defines the DS1 Network Interface (NI) requirements. It denotes existing documentation which details electrical and signal specifications and provides BST variations and clarifications. The physical layer of the DS1 NI is delineated in the following specifications.

ANSI T1.403	*Network and Customer Installation – DS1 Electrical Interface*
GR–342–CORE	*High–Capacity Digital Special Access Service Transmission Parameter Limits and Interface Combinations*

ANSI T1.403 applies to End–User interfaces and GR–342–CORE applies to Carrier interfaces.

A sketch of the DS1 NI is shown in Figure 1. The signal delivered to the NI by BST is identified as the BST signal, and the signal delivered to the NI by the customer is identified as the CI signal.

3.1 Framing Format

The DS1 signal must be framed, and it is strongly recommended that all DS1s utilize the Extended Superframe Format (ESF) described in ANSI T1.403.

3.2 Clear Channel Capability

BST uses the Bipolar with Eight Zero Substitution (B8ZS) method to provide a Clear Channel Capability (CCC). This supports transport of a framed DS1 signal with unconstrained payload bits. BST does not support the Zero–Byte Time Slot Interchange (ZBTSI) method of providing CCC.

3.3 Maintenance Signals

Maintenance signals are transmitted in–band and in the data link of the ESF format. ANSI T1.403 and BST TR 73525, provide additional information regarding specific maintenance, alarm and loopback signals.

3.4 DS1 End–User Interface

DS1 End–User (EU) interface requirements are defined in ANSI T1.403. At an EU customer NI, some of the electrical requirements for the BST signal differ from corresponding requirements for the CI signal.

3.4.1 BST Signal at Network Interface

The signal requirements will be met at the signal regenerator output nearest the NI. An isolated pulse will have a peak–to–base amplitude of between 2.25 and 3.6 volts. At the NI, the pulse characteristics will be those of this BST standard pulse transmitted through a cable pair with a loss in the range of 0 to 16.5 dB at 772 kHz between 100 ohm terminations as shown in Figure 1.

3.4.2 Customer Signal at Network Interface

The signal requirements will be met at the output of the customer Network Channel Terminating Equipment (NCTE) when its Line Buildout (LBO) is set to 0 dB. An isolated pulse shall have a peak−to−base amplitude of between 2.4 and 3.6 volts. At the NI, the pulse characteristics shall be those of a standard pulse transmitted through a cable pair with a loss in the range of 0 to 5.5 dB at 772 kHz between 100 ohm terminations as shown in Figure 1. When additional customer attenuation is required, it may be inserted by selecting the appropriate LBO setting in the NCTE (0, 7.5, 15 dB). For LightGate Service the NCTE LBO should be set to 0 dB, unless the customer is advised otherwise by BST. It is the customer's responsibility to properly option the NCTE to provide the required LBO setting. Failure to provide the specified LBO will jeopardize performance of the customer's service and has the potential to adversely impact the performance of other BST provided services.

3.4.3 Mechanical Interface

One balanced twisted pair shall be used for each direction of transmission. Interconnection at the DS1 End−User NI is through one of four Universal Service Order Code (USOC) connectors, RJ48C, RJ48X, RJ48M, RJ48H, as shown in ANSI T1.403 and Part 68 of the FCC Rules and Regulations as revised by Public Notice Numbers 4609 (September 21, 1988) and 4572 (October 3, 1988). The RJ48C or RJ48X jack is used for single DS1 line installations, and the RJ48M (8 DS1s) or RJ48H (12 DS1s) may be used for multiple circuit installations.

Alternatively, an appropriate DS1 rate digital cross connect panel may function as the interconnection arrangement at the NI.

3.4.4 Customer Responsibility

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

3.5 Carrier Interface

DS1 Carrier interface requirements are contained in Telcordia GR−342−CORE. BST and Carrier signals at the NI shall be those of a standard DSX−1 cross−connect pulse.

3.5.1 Mechanical Interface

One balanced twisted pair shall be used for each direction of transmission. Interconnection at the DS1 Carrier NI is through an appropriate DS1 rate digital cross−connect panel. Alternatively, suitable mechanical connecting arrangements may be the RJ48C, RJ48X, RJ48M or RJ48H connectors.

4. DS3 Interface

This section defines the DS3 Network Interface (NI) requirements. It denotes existing documentation which details electrical and signal specifications and provides BST variations and clarifications. At the NI the electrical requirements for the BST and customer signal are the same. The physical layer of the DS3 NI is delineated in the following specifications.

ANSI T1.404	*Network−to−Customer Installation − DS3 Metallic Interface Specification*
GR−342−CORE	*High−Capacity Digital Special Access Service Transmission Parameter Limits and Interface Combinations*

ANSI T1.404 applies to End−User Interfaces and GR−342−CORE applies to Carrier interfaces.

A sketch of the DS3 NI is shown in Figure 2. The signal delivered to the NI by BST is identified as the BST signal, and the signal delivered to the NI by the customer is identified as the CI signal.

4.1 Framing Format

The DS3 signal must be framed utilizing the framing structure defined in ANSI T1.107, *Digital Hierarchy Formats Specifications*. The asynchronous M13 multiplex format (combination of M12 and M23 formats) is specified for terminal equipment that multiplexes 28 DS1s into a DS3. Transport of DS3 C−Bit Parity structured applications support unchannelized applications with a payload of 44.210 Mbit/s or a modified M23 multiplex application with 28 DS1 channels as defined in ANSI T1.107.

4.2 Mechanical Interface

One coaxial cable is provided for each direction of transmission. The reference cable is 75 ohm coaxial cable with tinned copper meeting the requirements specified in ANSI T1.102, *Digital Hierarchy − Electrical Interfaces*. Interconnection at the DS3 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 a TNC connector. Currently, the preferred method of interconnection is via two BNC connectors.

4.3 Customer Responsibility

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

4.4 Maintenance Considerations

Customer Premises Equipment (CPE) shall provide the capability of generating and interpreting standard DS3 signals, alarm/defect indication signals and P−bit performance monitoring as defined in ANSI T1.404.

5. 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. LightGate SONET interfaces are highlighted and specific information is provided concerning the optical system reference diagram, optical parameter definitions, joint engineering and the system budget.

5.1 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[1]. 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 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 PMD, 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) 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.

For BST applications the Transport and Path Overhead bytes listed in Table 5−1 are the ones that are active or potentially active across the interface.

[1] 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.

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

[3] Except the Physical layer regenerator.

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

5.2 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 Criteria Physical Layer*, and ANSI T1.105, *Digital Hierarchy − Optical Interface Rates and Formats Specifications (SONET)*. The STS−1 frame structure 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).

Table 5−1. SONET Overhead Bytes Potentially 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 concatention & 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 (bits 5 − 8)	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)
	STS−1 REI−L (M0)	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 (formrerly FEBE)
	STS−N REI−L (M1)	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)

5.3 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 5−2. The Data Communications Channel (DCC) will not be active across the interface at this time.

Table 5−2. 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.

Some of the Transport Overhead bytes specified in GR−253−CORE and ANSI T1.105 are not required to be active across the interface, and content is undefined where they are not. Therefore, receiving equipment must be capable of ignoring their content. Any future utilization of those Transport Overhead bytes is expected to be consistent with SONET Industry Standards.

5.3.1 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.

5.3.2 Automatic Protection Switching

LightGate OC−N Customer and Central Office Channel Interfaces with a 4 fiber OC−N Channel Interface will have unidirectional 1+1 non−revertive APS provided across the interface. OC−N Channel Interface requirements are contained in Section 7.

LightGate Optical Customer Termination (OCUT) interfaces will have unidirectional 1+1 non−revertive switching or be arranged as a two−ring node utilizing ring software as determined by BST based upon the specific application and channel interfaces. OCUT interface requirements are contained in Section 8.

LightGate Synchonous Optical Serving Wire Center Termination (OSWCT) interfaces provide a 4 fiber interface generally with unidirectional 1+1 non−revertive automatic protection switching. OSWCT interface requirements are contained in Section 9.

5.3.3 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.

5.4 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 and STS−48 SPE.

OC−3, OC−12 and OC−48 interfaces support transport of properly mapped STS−1, STS−3, STS3c (concatenated), 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.

5.4.1 Sub−STS−1 Level Multiplexing

DS1 payloads can be directly mapped into the VT1.5 SPE using the asynchronous mapping for a DS1 contained in ANSI T1.105.02. 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.

5.5 LightGate SONET Interfaces

LightGate synchronous systems will support the following SONET interfaces:

LightGate Service−Customer & Central Office Channel Interface

- OC−3, OC−12 or OC−48 Optical (2 or 4 Fiber)
- STS−1 Electrical

LighGate Service−Optical Customer Termination (OCUT)

- OC−3, OC−12 or OC−48 (2[5] or 4 fiber)

LightGate Service−Optical Serving Wire Center Termination (OSWCT)

- OC−3, OC−12 or OC−48 (4 fiber)

5.6 Optical System Reference Diagram & Parameter Definitions

For the purpose of optical parameter specifications, optical interfaces are referred to a optical system reference diagram as shown in Figure 3. 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 for the SONET interfaces are addressed in the following subsections based upon the values given in GR−253−CORE.

[5] In selected link configurations for premises−to−premises applications or hubbing applications 2 fiber interfaces may be available. BSt reserves the right to determine the equipment, software and protection arrangement it employes for service.

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

LED	Light Emitting Diode
MLM	Multi−Longitudinal Mode lasers
λ_{Tmin},λ_{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.
SSR_{min}	Minimum acceptable value of the Side−mode Suppression Ration (SSR) in the presence of the worst−case reflections.
$\Delta\lambda_{20}$	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 3, 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 3.
P_{Rmax},P_{Rmin}	The maximum and minimum receiver power at point R in Figure 3 for $1x10^{-10}$ 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 3. P_O accounts for the total degradation along the optical path (reflections, jitter, intersymbol interference, mode−partition noise, and laser chirp).

5.6.1 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 generally 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*.

5.6.2 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.

5.6.3 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.

5.7 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 Short Reach (SR), Intermediate Reach−1 (IR−1) or Long Reach−1 (LR−1) applications. Transmitter, optical path and receiver parameters are summarized in Table 5−3 OC−3 Optical Parameters, Table 5−4 OC−12 Optical Parameters and Table 5−5 OC−48 Optical Parameters. Appropriate attenuation may be necessary to achieve a satisfactory interface.

Table 5−3. 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}[1]	NA	NA	NA	dB
D_{SRmax}	18/25	96	185	ps/nm
Attenuation	0−7	0−12	10−28	dB
Max. Reflectance 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
Max. Receiver Reflectance	NA	NA	NA	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.

NA − Not Applicable

Table 5−4. 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)[1]	1300−1325 (1296−1330)[1]	1280−1335	nm
$\Delta\lambda_{rms}$	14.5/35	4.0 (2.5)[1]	2.0 (1.7)[1]	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}[2]	NA	NA	20	20	dB
D_{SRmax}	13/14	46 (74)[1]	92 (109)[1]	NA	ps/nm
Attenuation	0−7	0−12	10−24	10−24	dB
Max. Reflectance 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
Max. Receiver Reflectance	NA	NA	−14	−14	dB

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

[2] 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 5−5. OC−48 Optical Parameters

Parameter	SR	IR−1	LR−1	Units
Transmitter	MLM	SLM	SLM	
$\lambda_{Tmin} - \lambda_{Tmax}$	1266−1360	1260−1360	1280−1355	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
Max. Reflectance Between S and R	−27	−27	−27	−27
Receiver				
P_{Rmax}	−3	0	−9	dBm
P_{Rmin}	−18	−18	−27	dBm
P_O	1	1	1	dB
Max. 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

5.8 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 and 0−12 dB for intermediate Reach−1 (IR−1) and 10−24/28 dB for Long Reach−1 (LR−1) 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.

6. STS−1 Interface

This section defines the Synchronous Transport Signal level 1 (STS−1) Network Interface (NI) requirements. 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 5 comprise the complete set of interface characteristics.

6.1 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 described in GR−253−CORE and ANSI T1.105.

6.1.1 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 5−2, see Section 5.3. 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.

6.2 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

6.3 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.

6.4 Customer Responsibility

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

6.5 Maintenance Considerations

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.

7. OC−N Channel Interface

This section defines the Network Interface (NI) requirements for optical OC−N Customer and Central Office Channel Interfaces. It denotes existing documentation that details signal specifications and provides BST variations and clarifications. The specifications in this section, together with the SONET hierarchy specifications in Section 5 comprise the complete set of interface characteristics. The physical layer of the OC−N Customer Channel Interface NI is delineated in the following specifications.

GR−253−CORE	*Synchronous Optical Network (SONET) Transport Systems: Common Criteria Physical Layer*
GR−1365−CORE	*SONET Private Line Service Interface Generic Criteria for End Users*
ANSI T1.105	*Digital Hierarchy − Optical Interface Rates and Formats Specifications (SONET)*

At this time, optical interfaces should be jointly engineered by BST and the customer.

7.1 Signal Format

The optical signal shall utilize the frame structure in GR−253−CORE and ANSI T1.105. Section 5 of this Technical Reference contains additional details regarding the SONET signal format.

7.1.1 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, GR−1365−CORE and ANSI T1.105. Transport and Path Overhead bytes active across the interface are summarized in Table 5−1, see Section 5.3. 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.

7.1.2 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:

- 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

The OC−3 interface supports transport of properly mapped STS−1, STS−3, STS−3c (concatenated) signals. The OC−12 interface supports transport of properly mapped STS−1, STS−3, STS−3c, STS−12 or STS−12c signals. The OC−48 interface supports transport of properly mapped STS−1, STS−3, STS−3c, STS−12, STS−12c, STS−48 STS−48c signals. Payloads that 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 ATM, FDDI, and 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.

7.2 Fiber Transmission Media

LightGate service optical interfaces shall use single−mode fiber with a nominal zero dispersion wavelength at 1310 nanometers. The conventional dispersion−unshifted singel−mode fiber (also known as EIA/TIA Class IVa fiber) shall generally 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*.

7.3 Mechanical Interface

At the fiber customer channel 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. If the customer's fibers must be spliced at the NI box (housing), fusion splicing techniques must be used. 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 jack will be 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) as shown in Figure 4 must be provided at the NI. For 4 fiber interfaces, two fiber pairs (4 individual fibers − 2 working and 2 protection) must be provided at the NI as shown in Figure 5. Each connector plug will contain 2 fibers, one for each direction of transmission.

7.4 Automatic Protection Switching

For LightGate Service with a 4 fiber channel interface, unidirectional 1+1 non−revertive Automatic Protection Switching (APS) will be provided across the NI. Switching is controlled by the K1 and K2 bytes. Use of the K1 and K2 bytes is specified in GR−253−CORE and ANSI T1.105.01.

7.5 Physical Media Characteristics

The interface shall meet the physical media characteristics defined in GR−253−CORE for either the Short Reach (SR), Intermediate Reach−1 (IR−1) or Long Reach−1 (LR−1) applications. Transmitter, optical path and receiver parameters are summarized in Tables 5−3 to 5−5, see Section 5.7. Appropriate padding may be necessary to achieve a satisfactory interface.

7.5.1 Optical Power Limitations

Customer provided lasers shall not exceed +17.0 dBm in output power at 1550 nm (Class IIIb laser). In addition, the customer shall tell BST which class of laser that they will be utilizing on their equipment.

7.6 Maintenance Considerations

Customer Premises Equipment (CPE) shall provide the capability of generating and interpreting standard 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.

8. Optical Customer Termination

LightGate Optical Customer Termination (OCUT) allows the customer the option of providing the SONET equipment at their premises. Customer provided equipment must be compatible with BST approved equipment used in the Serving Wire Center. BST reserves the right to determine the equipment, software and protection arrangement it employs for service. In selected link configurations for premises−to−premises applications or hubbing applications 2 and 4 fiber interfaces may be available.

This section defines the Network Interface (NI) requirements for OC−3, OC−12 and OC−48 OCUT interfaces. It denotes existing documentation which details signal specifications and provides BST variations and clarifications. The specifications in this section, together with the SONET hierarchy specifications in Section 5 comprise the complete set of interface characteristics.

The physical layer of the NI is delineated in the following specifications.

GR−253−CORE	*Synchronous Optical Network (SONET) Transport Systems: Common Criteria Physical Layer*
GR−1365−CORE	*SONET Private Line Service Interface Generic Criteria for End Users*
ANSI T1.105	*Digital Hierarchy – Optical Interface Rates and Formats Specifications (SONET)*

At this time, optical interfaces should be jointly engineered by BST and the customer.

8.1 Signal Format

The optical signal shall utilize the frame structure specified in GR−253−CORE and ANSI T1.105.

8.1.1 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, GR−1365−CORE and ANSI T1.105. Transport and Path Overhead bytes active across the interface are summarized in Table 5−1, see Section 5.3. 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 those overhead bytes is expected to be consistent with SONET Industry Standards.

8.1.2 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:

- 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

The OC−3, OC−12 and OC−48 OCUT interfaces support transport of properly mapped STS−1, STS−3, STS−12, STS−3c, STS−12, STS−12c, STS−48 and STS−48c 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 ATM, FDDI, and 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.

8.2 Fiber Transmission Media

LightGate OCUT interfaces 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 generally 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*.

8.3 Mechanical Interface

At the 2 or 4 fiber NI optical customer termination, either duplexable SC type (EIA/TIA SCFOC/2.5) plug and jack type connectors or a BST provided splice will be used to support transmission over single−mode fiber with a nominal zero dispersion wavelength at 1310 nanometers. For a 4 fiber interface BST will install the two connector jacks at the NI, as shown in Figure 5. If the customer’s fibers must be spliced at the NI box (housing), fusion splicing techniques must be used. BST and the customer must each provide two connector plugs to terminate the 2 fiber pairs (4 individual fibers − 2 working and 2 protection) 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.

At mid−span meet locations BST will establish the method of interconnection. It will be either a SC connector jack (at most above ground installations) or a splice (at most below ground installations). At above ground installations, BST will provide, install and splice the SC connector jack/NI box. At below ground installations, BST will provide, install and splice the closure that will contain the NI splice. The splice will be the demarcation point between BST and the CI. If customer cable must be placed in BST structures, BST will install it.

8.4 Automatic Protection Switching

For 4 fiber LightGate Optical Customer Termination (OCUT) interfaces the line side of the SONET system will have unidirectional 1+1 non−revertive switching or be arranged as a two−ring node utilizing ring software as determined by BST based upon the specific application and channel interfaces.

8.5 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−1 (LR−1) applications. Transmitter, optical path and receiver parameters are summarized in Tables 5−3 to 5−5, see Section 5.7. Appropriate padding may be necessary to achieve a satisfactory interface.

8.5.1 Optical Power Limitations

Customer provided lasers shall not exceed +17.0 dBm in output power at 1550 nm (Class IIIb laser). In addition, the customer shall tell BST which class of laser that they will be utilizing on their equipment.

8.6 Maintenance Considerations

Customer Premises Equipment (CPE) shall provide the capability of generating and interpreting standard 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.

9. Optical Serving Wire Center Termination

LightGate Optical Serving Wire Center Termination (OSWCT) allows for the optical transport of LightGate Service through the Serving Wire Center. This supports OC−3, OC−12 or OC−48 interconnection with other services, such as SMARTRing®, via a 4 fiber interface in the Serving Wire Center with unidirectional 1+1 non−revertive automatic protection switching. BST reserves the right to determine the equipment, software and protection arrangement it employs for service.

The specifications in this section, together with the SONET hierarchy specifications in Section 5 compromise the complete set of interface characteristics. The physical layer of the NI is delineated in the following specifications.

GR−253−CORE	*Synchronous Optical Network/(SONET) Transport Systems: Common Criteria Physical Layer*
ANSI T1. 105	*Digital Hierarchy − Optical Interface Rates and Formats Specifications (SONET)*

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.

The customer must cooperatively disable (turn−off) optical transmission equipment (customer channel interfaces or optical terminations) whenever BST must perform maintenance on those facilities.

10.1 Fault and Alarm Management

Alarm surveillance deals with the detection and reporting of certain failure conditions in the network. SONET Customer Installation (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 CI 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.

<u>Alarm Indication Signal (AIS)</u>

SONET provided equipment provides different AISs for various layers of functionality including DS1, DS3, Path, and Line AISs. The Line AIS, STS Path AIS, and/or VT Path AIS generation and detection shall meet the 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 PTE) 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.

Line Remote Defect Indication

Line Remote Defect Indication (RDI), formerly line Far End Receive Failure (FERF), 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.

DSN Remote Failure Indication

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

STS−Path Remote Defect Indication

STS−Path RDI, formerly Far End Receive Failure (FERF), 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

In order to support effective maintenance and maintain high service levels, it is desirable that BST and CI SONET equipment provide the same performance monitoring capabilities.

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

11. Performance

The performance objectives for LightGate Service are stated in terms of Error Free Seconds (EFS), Severely Errored Seconds (SES), and Service Availability.

11.1 Error Free Seconds

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. EFS objectives are long term, i.e. 30 days or more.

11.2 Severely Errored Seconds

A SES is defined as any second in which the Bit Error Ratio (BER) is $1x10^{-3}$ or worse. SES objectives are long term.

11.3 Annual Service Availability

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.

11.4 Quality Objectives

Performance quality objectives on the network side of the NI are stated in terms of: Error Free Seconds (EFS), Severely Errored Seconds (SES) and Service Availability. STS−1/DS3 and DS1 performance objectives are summarized in Table 11−1.

Table 11−1. LightGate Service Quality Performance Objectives

Performance Parameter	STS−1/DS3 Objectives (Long Term)	DS1 Objectives (Long Term)
%Error Free Seconds (%EFS)	EFS > 99.5%	EFS > 99.95%
%Severely Errored Seconds (%SES)	SES < 0.009%	SES < 0.009%
%Annual Service Availability	Availability > 99.99%	Availability > 99.99%

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

12. 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 LightGate 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.

13. Channel Codes

The Network Channel Interface (NC) code identifies the service and provides an encoded representation of the LightGate Service Channel. The electrical characteristics of the interface at the Network Interface (NI)/Point of Termination (POI) are identified by the Network Channel Interface (NCI) Code. Existing Network Channel (NC) codes will be used for LightGate Service.

When ordering service, the customer must specify compatible codes. An overview and definitions of specific codes that apply to LightGate 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.

13.1 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.

The following Table depicts selected NC codes for LightGate transport service. Codes for link connectable services such as: Asynchronous Transfer Mode, Frame Relay, Video etc. can be obtained from the BST Account Team.

Table 13−1. Selected Network Channel Codes

Network Channel (Service)	Optional Feature Code Character 3		Optional Feature Code Character 4	
HC−− (HC1)	SF & AMI	−	None	−
HC−D (HC1)	SF & AMI	−	Direct Digital Connection on a Switch	D
HC−M (HC1)	SF & AMI	−	Central Office Multiplex DS1/DSO	M
HCD− (HC1)	ANSI T1.403 ESF & AMI	D	None	−
HCDD (HC1)	ANSI T1.403 ESF & AMI	D	Direct Digital Connection on a Switch	D
HCDM (HC1)	ANSI T1.403 ESF & AMI	D	Central Office Multiplex DS1/DSO Channelization	M
HCE− (HC1)	ANSI T1.403 ESF & B8ZS	E	None	−
HCED (HC1)	ANSI T1.403 ESF & B8ZS	E	Direct Digital Connection on a Switch	D
HCEM (HC1)	ANSI T1.403 ESF & B8ZS	E	Central Office Multiplex DS1/DSO Channelization	M
HCZ_ (HC1)	B8ZS & SF	Z	None	−
HCZD (HC1)	B8ZS & SF	Z	Direct Digital Connection on a Switch	D
HCZM (HC1)	B8ZS & SF	Z	Central Office Multiplex DS1/DSO Channelization	M
HF−− (HC3)	None	−	None	−
HF−M (HC3)	None	−	Central Office DS3/DS1 Channelization	M
HFC− (HC3)	C−Bit Parity	C	None	−
HFZM (HC3)	B8ZS Compatible	Z	Central Office Multiplexing	M
JI−− (STS1)	None	−	None	−
JIAA (STS1)	VT1 Structured	A	Central Office Multiplexing	A
JIAB (STS1)	VT1 Structured	A	Field End Multiplexing	B
JIAC (STS1)	VT1 Structured	A	Multiplexed Both Ends, in CO(s)	C

Table 13−1. Selected Network Channel Codes−Continued

Network Channel (Service)	Optional Feature Code	Character 3	Optional Feature Code	Character 4
JIAG (STS1)	VT1 Structured	A	Field End Multiplexing, Both Ends	G
OB−− (OC−3)	None Point to Point	−	Non−Channelized	−
OB−R (OC−3)	None Point to Point	−	STS3C Payload	R
OD−− (OC−12)	None Point to Point	−	Non−Channelized	−
OD−R (OC−12)	None Point to Point	−	STS12C Payload	R
OF−− (OC−48)	None Point to Point	−	Non−Channelized	−
OF−R (OC−48)	None Point to Point	−	STS48C Payload	R
OG−E (OC−192)	None Point to Point	−	Terminal ADM Both Ends	E

13.2 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 Interface (POI). NCI code selection for LightGate 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 impendance that will terminate the channel for the purpose of evaluating the transmission performance at the POI; i.e. **F** represents 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 LightGate.

Selected codes applicable to LightGate Service are depicted in Table 13−2. Additional information about Network Channel Interface Codes may be found in Telcordia SR−STS−000307, *Industry Support Interface (ISI): NC/NCI Dictionary*.

Table 13−2. Selected Protocol Codes and Options[6]

Protocol Code	Option Code	Definition
DS1 Digital Hierarchy Interface at the CXR−POT		
DS	1 K	1.544 Mbit/s (DS1) "ANSI" T1.403 Extended Superframe (ESF) format per GR−342−CORE
	1S	1.544 Mbit/s (DS1) "ANSI" T1.403 Extended Superframe (ESF) format and B8ZS Clear Channel Capability per GR−342−CORE
	15	1.544 Mbit/s (DS1) Superframe (SF) format per GR−342−CORE
	15 B	1.544 Mbit/s (DS1) Superframe (SF) format and B8ZS Clear Channel Capability per GR−342−CORE
DS1 Digital Hierarchy Interface at EU−POT		
DU	1 K N	1.544 Mbit/s (DS1) "ANSI" T1.403 Extended Superframe (ESF) format per GR−54−CORE without line power
	1 S N	1.544 Mbit/s (DS1) "ANSI" T1.403 Extended Superframe (ESF) format and B8ZS Clear Channel Capability per GR−54−CORE without line power
	BN	1.544 Mbit/s (DS1) Superframe (SF) format per GR−54−CORE without line power
	DN	1.544 Mbit/s (DS1) Superframe (SF) format and B8ZS Clear Channel Capability per GR−54−CORE without line power
DS3 Digital Hierarchy Interface at CXR−POT		
DS	44	44.736 Mbit/s (DS3)
	44A	44.736 Mbit/s (DS3) Unchannelized and C−Bit Parity
DS3 Digital Hierarchy Interface at EU−POT		
DS	44	44.736 Mbit/s (DS3)
	44A	44.736 Mbit/s (DS3) Unchannelized and C−Bit Parity
SONET Electrical		
ST	A	SONET STS−1 Electrical
SONET Optical		
SO	B	LR1−SLM

[6] Protocol Code is in Character Positions 3 & 4. Option Code is in Character Positions 7, 8 & 9.

Table 13−2. Selected Protocol Codes and Options⁻ Continued

Protocol Code	Option Codes	Definition
FlexServ		
CS	10R	DS1/DS0 FlexServ Termination in Central Office
	11R	DS1/DS1 FlexServ Termination in Central Office
	31R	DS3/DS1 Flexserv Termination in Central Office
	33R	DS3/DS3 FlexServ Termination in Central Office
Customer Reconfigurable		
CM	1	SONET ADM DS1 Port Termination (for Customer Reconfiguration)
	3	SONET ADM DS3 Port Termination (for Customer Reconfiguration)
	S	SONET ADM STS−1 Port Termination (for Customer Reconfiguration)
	C3	SONET ADM OC−3 Port Termination (for Customer Reconfiguration)
	C12	SONET ADM OC−12 Port Termination (for Customer Reconfiguration)
SONET Multiplexers		
SM	+ + +	SONET Terminal Multiplexer for OC−3 to OC−192
SN	+ + +	SONET Terminal Multiplexer for OC−12 to OC−192
SQ	+ + +	SONET Terminal Multiplexer for OC−48 to OC−192

NOTE: + **Consult Table 13−3 for code SM, Table 13−4 for code SN, and Table 13−5 for code SQ**

Table 13−3. 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	

Table 13−4. Protocol Code SN (OC−12s/OC−3s/DS3s/STS−1)

Potocol	+=Number of OC12S	+=Number of OC3s	+=Number of DS3s/STS−1s
SN (No OC−48 Drops)	A=0	0=0	1=3
	B=1	1=1	2=6
	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	

Table 13−5. 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.

13.2.1 SONET Optical Interfaces

For ordering purposes the NCI code for LightGate 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 LR−1 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.

Table 13−2. Optical NCI Code

No. of Conductors	Protocols	Impedance	Protocol Options
02=2 fiber 04=4 fiber	SO=SONET	F=fiber	B=LR−1 SLM

[7] Protocol Code is in Character Positions 3 & 4. Option Code is in Character Positions 7, 8 & 9.

14. Acronyms

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
IR	Intermediate Reach (Optical Standard)
ITU/TSS	International Telecommunication Union/Telecommunication Standardization Sector
LED	Light Emitting Diode
LTE	Line Terminating Equipment
MLM	Multi−Longitudinal Mode
NE	Network Element
OC−N	Optical Carrier level−N
ORL_{min}	Minimum System Optical Return Loss
OSI	Open Systems Interconnection
PMD	Physical Media 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−N	Synchronous Transport Signal level N
STS−Nc	Concatenated Synchronous Transport Signal level N
TR	Technical Requirement
VT1.5	Virtual Tributary at 1.5 Mb/s
λ_{Tmin},λ_{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

15. References

BST TR 73575	*MegaLink® Service, MegaLink Channel Service, MegaLink Plus Service, and MegaLink Light Service Interface and Performance Specification,* Issue D, October 1999
BST TR 73582	SMARTRing® Service OC−N & STS−1 Interface & Performance Specifications, Issue C, October, 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 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*
ANIS 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*
IEC 825−1	*Safety of Laser Products, Part 1: Equipment classification, requirements and user's guide, First Edition, 1993−11*
IEC 825−2	*Safety of Laser Products, Part 2: Safety of optical fiber communication systems, First Edition, 1993−09*

IEC and ANSI documents can be ordered from:
Global Engineering Documents
15 Inverness Way East
Englewood, CO 80112−5704
(800) 854−7179

EIA/TIA−559	*Single−Mode Fiber Optic System Transmission Design*

EIA/TIA documents may be ordered by contacting:

Telecommunications Industry Association
Engineering Department
2001 Pennsylvania Avenue N.W.
Washington, D.C. 20006
(202) 457−4966

GR−20−CORE	*Generic Requirements for Optical Fiber and Optical Fiber Cables, Issue 1, December, 1994*
GR−253−CORE	*Synchronous Optical Network (SONET) Transport Systems: Common Criteria Physical Layer, Issue 1, December 1994*
GR–342–CORE	*High Capacity Digital Special Access Service Transmission Parameter Limits and Interface Combination,* Issue 1, December, 1995
GR–436–CORE	*Digital Network Synchronization Plan, Issue 1, June 1994*
GR–1365–CORE	SONET *Private Line Service Interface Generic Criteria for End Users, Issue 1, December 1994*
TR–TSY–000191	*Alarm Indication Signals Requirements and Objectives*, Issue 1, May 1986
SR–STS–000307	*NC/NCI Code Dictionary*, Issue 8, April, 1997
NC/NCI/Decoder	PC based application with a 1–year subscription for the NC/NCI code set, Issue 3Q, September 1998

Telcodia (formerly BellCore) documents may be ordered by contacting:

Telcordia Customer Relations
8 Corporate Place – Room 3A–184
Piscataway, NJ 08854–4156
1–800–521–2673

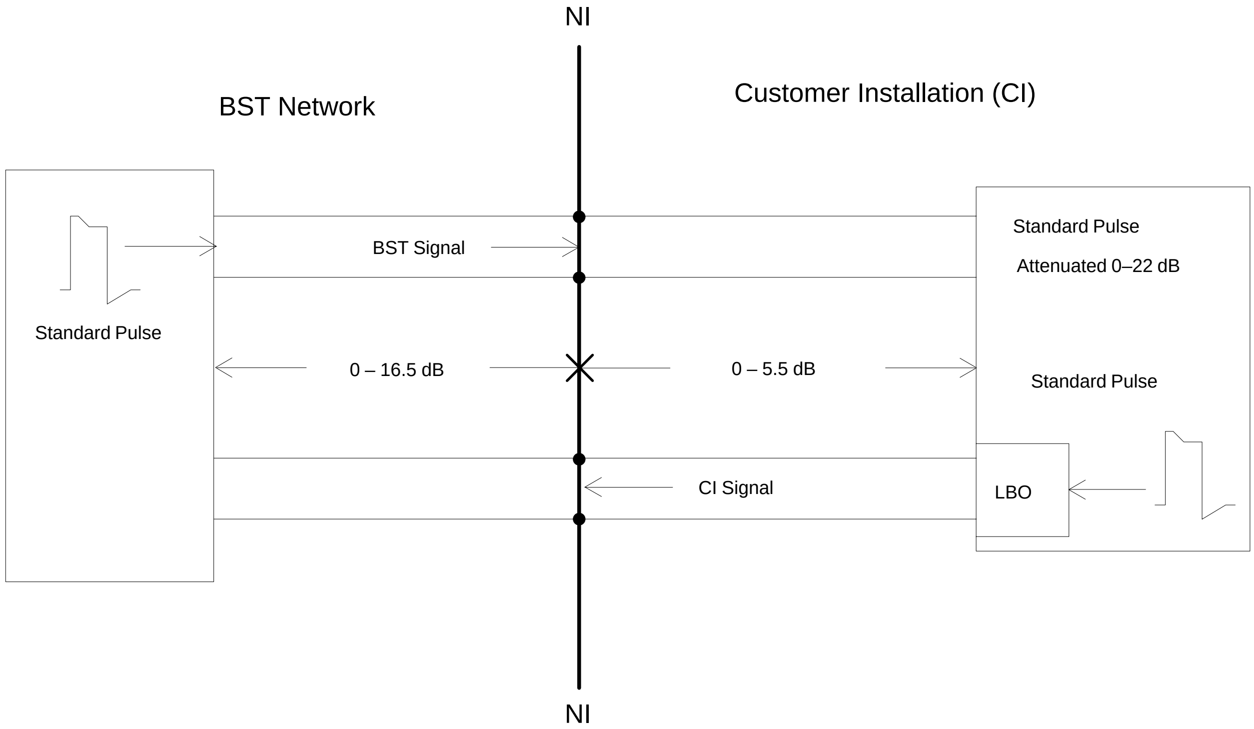
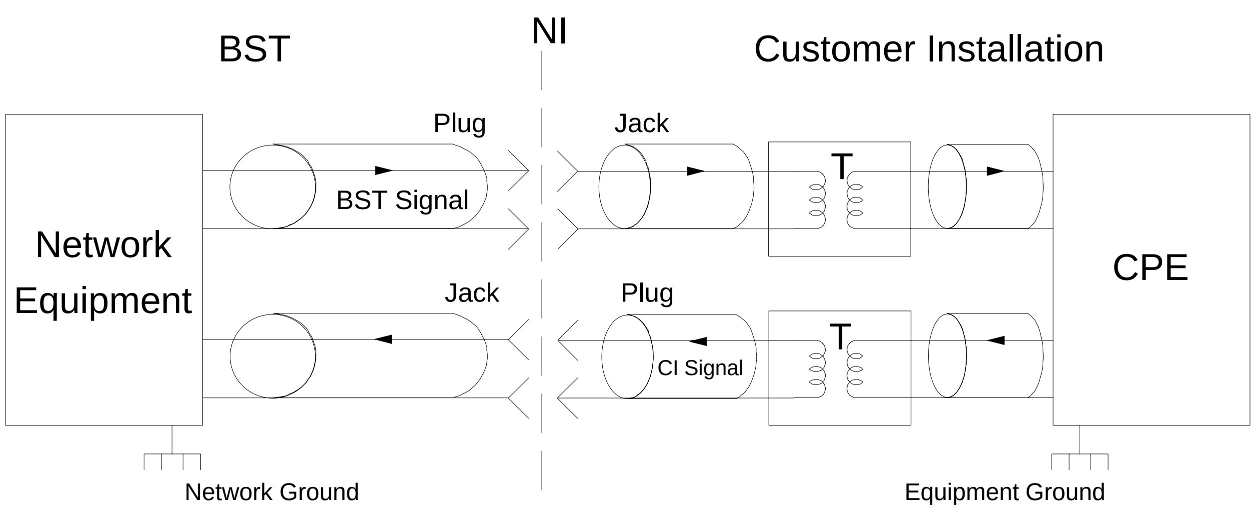


Figure 1 − DS1 Network Interface



1) This diagram indicates signal continuity arrangements.

2) Equipment grounding should follow appropriate installation practices consistent with existing safety standards.

3) T – optional wideband transformers to mitigate ground currents.

Figure 2 − DS3 Network Interface

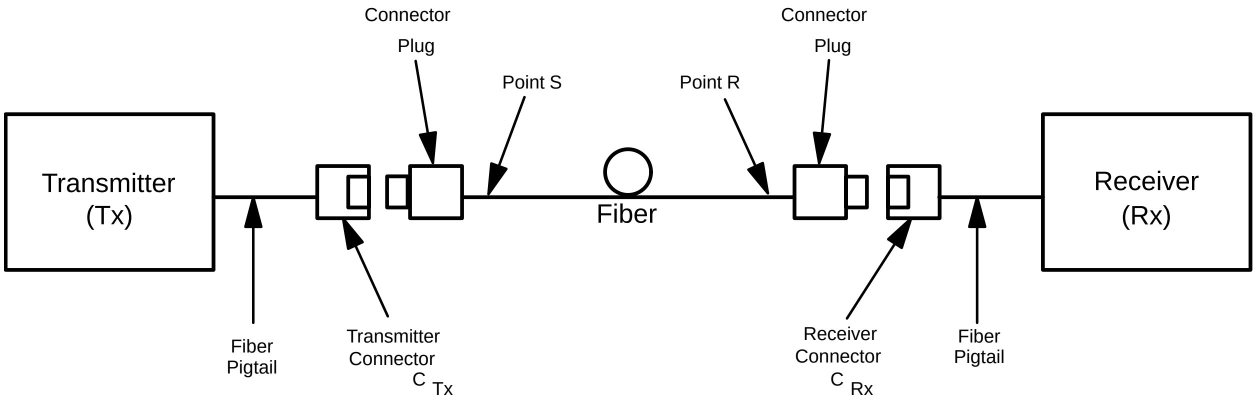
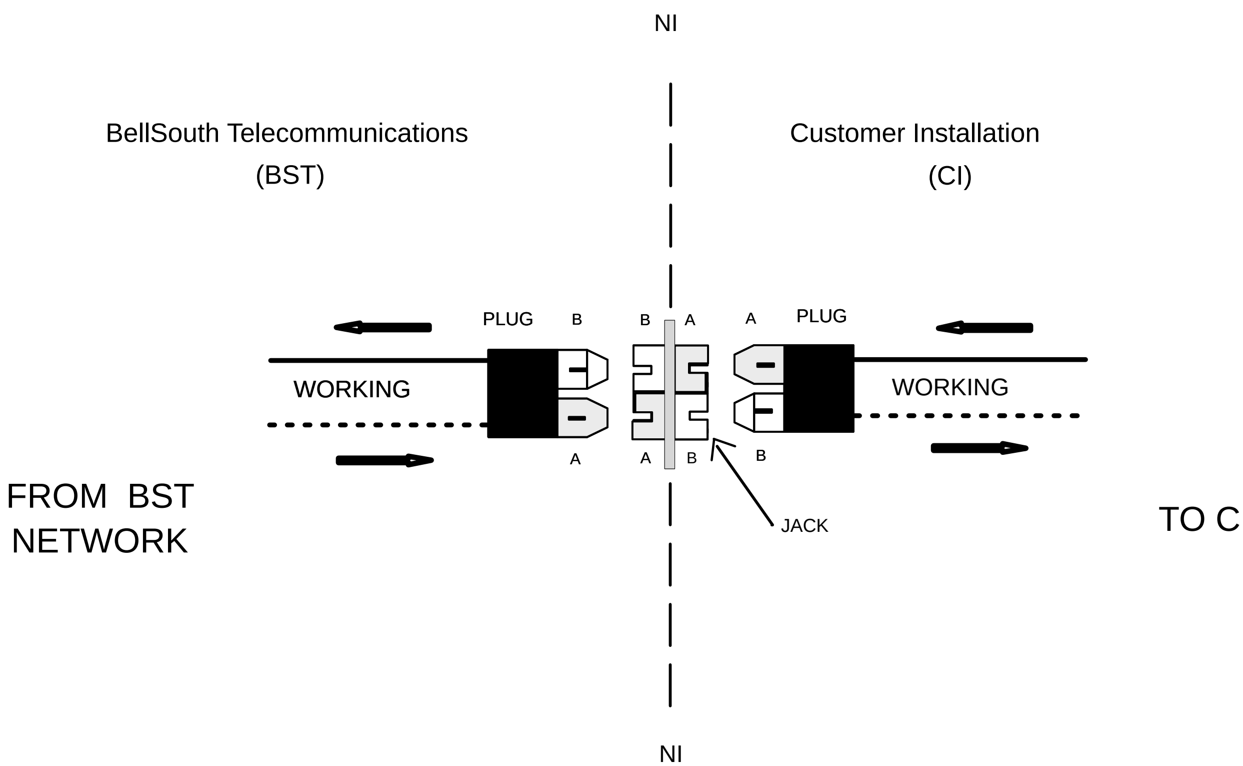


Figure 3 − Optical System Interfaces (Points S and R)



NOTES:

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

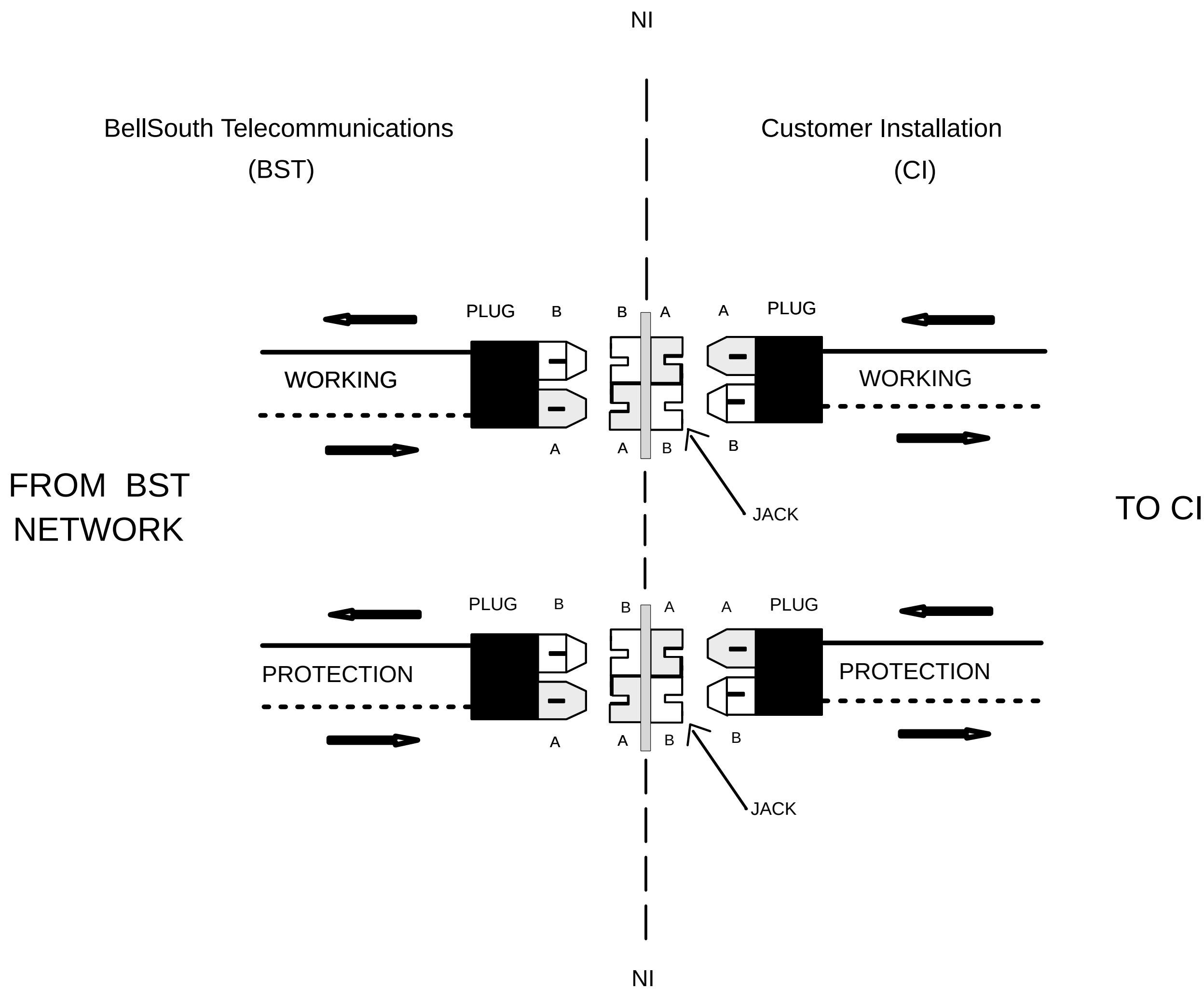
2 LIGHT LEAVES "B" JACK AND ENTERS "B" PLUG

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

→ DIRECTION OF LIGHT

Figure 4 − 2 Fiber Optical Mechnical Network Interface



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 5 − 4 Fiber Optical Mechnical Network Interface

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