



Expanded Interconnection Service
DS1 and DS3 Level
Network Interface Specification

NOTICE

This Technical Reference describes the DS3 and DS1 metallic interfaces, referred to as the Network Interface (NI), between BellSouth Telecommunications (BST) and Collocators (COLs) for Expanded Interconnection Service (EIS). It establishes electrical, physical and protocol requirements at the NI necessary for compatible operation between BST and the COL. Interfaces such as Carrier-to-End User and Carrier-to-Carrier are not covered in this document.

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EXPANDED INTERCONNECTION SERVICE DS1 AND DS3 LEVEL NETWORK INTERFACE SPECIFICATION

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EXPANDED INTERCONNECTION SERVICE DS1 AND DS3 LEVEL NETWORK INTERFACE SPECIFICATION

1. SCOPE

This Technical Reference (TR) describes the DS3 and DS1 metallic interfaces, referred to as the Network Interface (NI), between BellSouth Telecommunications (BST) and Collocators (COLs) for Expanded Interconnection Service (EIS). It establishes electrical, physical and protocol requirements at the NI necessary for compatible operation between BST and the COL. Interfaces such as Carrier-to-End User and Carrier-to-Carrier are not covered in this document.

EIS provides for central office interconnections from a Collocator Point of Termination (COL-POT) to BST interstate special access services. Physical collocation will be provided subject to the availability of space and facilities in each central office site as designated in the National Exchange Carriers Association (NECA) Tariff, F.C.C. No. 4.

The tariff regulations contained in BST Tariff F.C.C. No. 1 will apply to each installation. It should be noted that the tariff includes specific information regarding: conditions of occupancy, service application, space preparation, interconnection space, insurance, installation and maintenance, security, rules of conduct, liability and damages, confidential information, title, assignment and force majeure.

Signals that appear as a result of the environment (e.g., induced voltages and currents, lightning hits, etc.) are not covered in this document.

1.1 PURPOSE

The EIS physical collocation NI 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 COL, BST and equipment suppliers.

1.2 USE OF THIS DOCUMENT

This document describes the EIS to be offered by BST. An overview of EIS is provided in Section 2. Technical details of the DS1 and DS3 interfaces are covered in Section 3 and Section 4, respectively. Supported Network Channel Interface (NCI) codes are identified in Section 5. Maintenance responsibilities are outlined in Section 6. A Glossary which defines terms and acronyms is included in Section 7. A list of references is provided in Section 8.

2. SERVICE DESCRIPTION

2.1 GENERAL

An Expanded Interconnection Service (EIS) Collocator (COL) provides fiber optic cable to a Bell-South Telecommunications (BST) central office manhole (entry point) and extends the fiber into the COL's designated interconnection space. Microwave facilities, in lieu of fiber facilities, may be used for interconnection where they may reasonably be provided. Upon receipt of a request for microwave interconnection, BST will negotiate the arrangements and file the appropriate rates and regulations for the service.

EIS provides for central office interconnection of COL–provided transmission equipment with BST interstate special access services. BST will designate a meet–point location within the central office where BST DS1/DS3 services will be terminated at the Network Interface (NI) for interconnection to the COL's transmission equipment.

EIS is provided pursuant to the regulations, rates, and charges contained in BST Tariff F.C.C. No. 1. BST is solely responsible for determining whether physical interconnection is feasible in its central office sites. EIS will be provided subject to the availability of space and facilities in each central office. BST's central office site designations are located in the National Exchange Carriers Association (NECA) Tariff F.C.C No. 4.

In states where the public utilities commission has issued orders in favor of virtual collocation for intrastate or allowed BST to choose the form of interconnection for intrastate, physical interconnection via EIS may not be offered.

Where EIS is offered, if BST determines there is insufficient space within a central office to accommodate physical interconnection via an EIS arrangement, BST will provide virtual interconnection arrangements in accordance with prescribed FCC requirements.

2.2 INTERCONNECTION FLOOR SPACE

Interconnection floor space is an enclosed room designated by BST within a BST central office to be used for the sole purpose of installing, maintaining, and operating equipment to interconnect a COL's fiber facilities to BST provided services and facilities. It will be referred to herein as interconnection space.

2.2.1 USE OF FLOOR SPACE

Floor space provided by BST will be the location where a COL may install and maintain the following central office transmission equipment.

- Optical Line Terminating Equipment
- DS3 to DS1 Multiplexing Equipment
- DS3/1 Digital Cross–Connect Systems

2.2.2 MULTIPLE MODULES

In the event the COL occupies more than one 100 square foot module of interconnection space within the same central office, the COL will be allowed to interconnect the transmission equipment contained within each of its modules. In these instances, the COL will be responsible for supplying and installing the cabling between the modules using BST designated supporting structures and BST approved technicians.

2.2.3 HEAT, AIR CONDITIONING AND POWER

In addition to floor space, BST will provide heat, air conditioning, –48 volt DC power with battery back–up, central office ground, 110/208 volt AC power, as well as other environmental support to the COLs equipment in the same manner that it provides these items to its own equipment and facilities within the central office. The DC power will be provided as two separate feeds of 40 amp fuse capacity each.

2.3 DS1 INTERCONNECTION

EIS may interconnect at the DS1 level with the following BST interstate special access services:

- DS1 Local Channel or Interoffice Channel
- DS1 Basic Channelization System
- FlexServ® Port in a Digital Cross–connect System
- DS1 Central Office Channel Interface associated with LightGate® or SMARTRingsSM

Shared use and shared network arrangements are not permissible in conjunction with EIS.

Further channelization is available in conjunction with EIS to provide for network access to voice grade or digital data access service. Above the Physical layer (the first layer of the Open Systems Interconnection (OSI) model), the channelization technical specifications can be found in BellSouth Technical Reference 73525, MegaLinkSM and MegaLink Channel ServiceSM Exchange Network Interface Specification.

2.4 DS3 INTERCONNECTION

EIS may interconnect at the DS3 level with the following BST interstate special access services:

- LightGate® Local Channel or Interoffice Channel DS3 Central Office Channel Interface
- SMARTRingsSM Central Office Node DS3 Channel Interface
- 28 DS1 Channelization System

Shared use and shared network arrangements are not permissible in conjunction with EIS.

2.5 LIMITATIONS

The following summarizes some of the limitations contained in BST Tariff F.C.C No. 1 which are directly relevant to this Technical Reference.

- COL will not be permitted to interconnect facilities with another COL's facilities within the same central office.
- EIS arrangements will be DS1 or DS3 electrical interconnections only.
- Switched Access Service as set forth in Section 6 of tariff FCC Number 1 may not be placed onto any DS1 or DS3 transport service that is connected to an EIS arrangement. Shared Use Provisions as outline in Section 7.4.8 of tariff FCC Number 1 are not applicable for services provided under EIS arrangements.
- Shared Network Arrangements as set forth in Section 7.2.9 E(3) of tariff FCC Number 1 do not apply to EIS arrangement elements.

3. DS1 – NETWORK INTERFACE

3.1 GENERAL

DS1 Expanded Interconnect Service (EIS) provides for the transmission of nominal 1.544 Mbit/s isochronous serial data between a Collocator Point of Termination (COL–POT) and BellSouth Telecommunications (BST) interstate special access services. A channelized DS1 may be used for bulk access to selected other network services as permitted by the tariff. Sufficient detail on channelized multiplexing is included to accommodate these applications.

These specifications describe the electrical, physical and protocol requirements necessary for interconnection of BST and COL–POT signals at the Network Interface (NI). A Sketch of the NI is shown in Figure 1. The signal delivered to the NI by BST is identified as the BST signal, and the signal delivered by the Collocator is identified as the COL signal.

At the NI, some of the electrical requirements for the BST signal differ from corresponding requirements for the COL signal. Pulse characteristics are specified at the BST DSX–1 cross–connect, not the NI. This is consistent with the manner in which BST specifies requirements for interconnection with its own terminal equipment and facilities.

3.2 ELECTRICAL SPECIFICATIONS

The following specifications describe common characteristics for all signals at the NI, except where noted. Differences between BST and COL signals are separately identified.

3.2.1 TRANSMISSION RATE

The transmission rate of the DS1 signal shall be in the range of 1.544 Mbit/s \pm 50 bits/s¹.

3.2.2 LINE CODE & PULSE DENSITY

The line code shall be Bipolar Return to Zero (BPRZ), which is also known as Alternate Mark Inversion (AMI), except where intentional bipolar violations are introduced by Bipolar with 8 Zero Substitution (B8ZS).

All terminals that generate a DS1 bipolar signal shall meet the following pulse density constraints:

- (1) No more than 15 consecutive zeros, and
- (2) At least N “ones” in each and every time window of 8 (N+1) digit time slots (where N can equal 1 through 23).

Test patterns such as the DS1 quasi–random signal source, as shown in Table 1, may be transmitted without meeting these pulse density requirements.

BST uses B8ZS to provided a Clear Channel Capability (CCC), a DS1 signal with proper framing in which the 192 information bits can represent any combination of zeros and ones. B8ZS is a code where eight consecutive “zeros” are replaced with the sequence 000+–0–+ if the preceding pulse was +, and with the sequence 000–+0+– if the preceding pulse was – (+ represents a positive pulse, – represents a negative pulse and 0 represents no pulse).

3.2.3 TEST LOAD

A termination of 100 Ω \pm 5% resistive shall be used at the interface as a test load to evaluate the pulse shape and other electrical parameters.

1. Older equipment may have rate variations up to \pm 200 bits/s.

3.2.4 STANDARD DS1 PULSE CHARACTERISTICS

Pulse shape, power levels and pulse imbalance requirements are defined in terms of a standard DS1 pulse and shall be met at the BST DSX-1 cross-connect.

3.2.4.1 PULSE SHAPE

A normalized and isolated pulse, either positive or inverted, shall fit the template shown in Figure 2. The pulse amplitude shall be between 2.4 and 3.6 volts measured at the center of the pulse, and may be scaled by a constant factor.

3.2.4.2 POWER LEVELS

For an all-ones transmitted pattern, the power in a 2- to 3-kHz band centered at 772 kHz shall be in the range of 12.0 to 19.0 dBm, and the power in a 2- to 3-kHz band centered at 1.544 kHz shall be at least 25 dB less.

3.2.4.3 PULSE IMBALANCE

In any window of 17 consecutive bits, the maximum variation in pulse amplitudes shall be less than 200 mv, and the maximum variation in pulse widths (half amplitude) shall be less than 20 nanoseconds.

3.2.5 SIGNAL FROM BST AT NETWORK INTERFACE

The BST signal requirement shall be met at the BST DSX-1 cross-connect. The NI serves only as a means of physical interconnection.

3.2.5.1 BST PULSE CHARACTERISTICS

At the BST DSX-1 cross-connect an isolated pulse, either positive or inverted, shall have a peak-to-base amplitude of between 2.4 and 3.6 volts and fit the template shown in Figure 2. If the distance between the BST DSX-1 cross-connect and NI is greater than 625 feet, an intermediate signal regenerator will be provided by BST.

3.2.5.2 BST SIGNAL ATTENUATION

At the NI the pulse characteristics shall be those of a standard pulse attenuated through 0 – 625 feet of ABAM cable or equivalent with characteristics as specified in Section 3.3.1.

The variable length of cable makes it impractical to define a pulse template for the BST signal at the NI. However, the DSX-1 pulse template may be used with the appropriate mathematical procedures to construct representative hypothetical signals for design purposes based on approximate electrical characteristics of the referenced ABAM cable.

3.2.6 SIGNAL FROM COLLOCATOR AT NETWORK INTERFACE

The COL signal requirement shall be met at the BST DSX-1 cross-connect. The COL signal will terminate on the BST DSX-1 cross-connect in the same manner that BST terminates signals from its own Terminal Equipment (TE) and facilities. The NI serves only as a means of physical interconnection. Network considerations and the potential for interference and crosstalk require that pulse characteristics be precisely controlled at a DSX-1 cross-connect as defined in ANSI T1.102-1987. At the BST DSX-1 cross-connect an isolated pulse, either positive or inverted, shall have a peak-to-base amplitude of between 2.4 and 3.6 volts and fit the template shown in Figure 2.

3.2.6.1 COL PULSE CHARACTERISTICS

It is an industry standard that the output of extended cross-connect package (EXCP) Terminal Equipment (TE) be capable of delivering a standard DSX-1 cross-connect level pulse after transmission through 655 feet of ABAM or equivalent cable. A nominal 6 volt peak-to-base output pulse allows this increased office cabling. When the distance from the TE output to the DSX-1 cross-connect point is less than approximately 85 feet, 6 dB of flat loss may be applied to meet the nominal 3 volt DSX-1 cross-connect requirement. When the cabling distance between the TE and DSX-1 cross-connect is between 85 and 655 feet, pre-emphasis (provided in steps base on the actual distance) must be provided to assure that the DSX-1 cross-connect pulse characteristics are met. Pre-emphasis is used to control pulse characteristics at a remote point by counteracting the attenuation and phase distortion effects (which are a function of frequency, cable length, cable attenuation and non-linear insertion phase of the cable) of specific amounts of cabling. The intent is to produce an approximate square wave at the DSX-1 cross-connect which fits the standard pulse template.

Typical DS1 Pre-Emphasis Settings

Distance BST DSX-1 to COL-TE (feet)	Approximate Loss of Pre-Emphasis Network at 772 KHz (dB)
0 – 220	6
220 – 440	5
440 – 655	4

An allocation of 30 feet has been made for cabling between the COL's TE and NI. When the distance from the NI to the BST DSX-1 cross-connect is less than 55 feet, the COL TE can utilize a nominal 3 volt source. If the distance from the NI to the BST DSX-1 cross-connect is between 55 and 625 feet, the COL's TE should use a nominal 6 volt source and must provide pre-emphasis.

If the distance from the NI to the BST DSX-1 cross-connect is greater than 625 feet, an intermediate signal regenerator shall be provided between the NI and DSX-1 by BST. The output of the regenerator shall be compatible with standard DS1 pulse requirements and capable of delivering a pulse which meets signal requirements at the BST DSX-1 cross-connect.

3.2.6.2 COL SIGNAL ATTENUATION

At the NI the pulse characteristics shall be those of the COL's TE output pulse, nominal 3 volt or 6 volt pre-emphasized, attenuated through 0 – 30 feet of ABAM cable or equivalent with characteristics as specified in Section 3.3.1.

BST will advise the Collocator of the cable length between the BST DSX-1 and the NI. It is the Collocator's responsibility to properly option the TE to provide proper pulse pre-emphasis so that a pulse between 2.4 and 3.6 volts which fits the template shown in Figure 2 is delivered to the BST DSX-1 cross-connect. Failure to provide the proper equalization will jeopardize the performance of the Collocator's EIS service and has the potential to adversely impact the performance of other network provided services.

3.2.6.3 OTHER SIGNALS

The COL shall not apply voltages to the DS1 NI other than those described in this document. Signals at the NI that occur as a result of the environment are not covered, e.g., induced voltages, currents and lightning hits. See Bellcore TR-EOP-000001 and TR-TSY-000499 for these subjects. Direct current signals shall not be applied to the NI.

3.2.7 DS1 JITTER

DS1 timing jitter, i.e., the random phase modulation of the digital signal, can be produced in digital equipment. Jitter may introduce a number of impairments such as errors, slips, crosstalk and distortion to the original signal. Regenerator jitter is introduced by imperfections in the timing recovery process. Multiplexer jitter is introduced in the pulse stuffing mechanism that is used to synchronize the low speed incoming pulse stream. Jitter accumulation through the network is a complex process; for example, the stuffing and destuffing processes interact with input jitter in a non-linear way. This interaction alters the frequency of the input jitter as well as its amplitude.

Jitter is short-term variations of the significant instants of a digital signal from their ideal positions in time; wander is long-term variations of the same instants. The term jitter generally applies to variation above a frequency of 10 Hz. Wander is a long-term phenomenon with time constants of hours/minutes. The magnitudes of jitter and wander are specified in terms of Unit Intervals (UIs). One DS1 UI is equal to 648 nanoseconds.

The following is a provisional specification on DS1 jitter and wander, which is currently under study. DS1 jitter is specified in two frequency bands, band 1 and band 2, whose characteristic weighting functions are provided in Figure 3. Wander is classified as long-term (24 hours) and short-term (15 minutes), and the following specifications apply when measured against Primary Reference Source (PRS) as defined in ANSI T1.107-1988, Synchronization Interface Standards for Digital Networks.

3.2.7.1 BST SIGNAL JITTER

At the NI, the jitter of the BST-to-COL signal shall not exceed the following limits in both bands **simultaneously**:

- Band 1: 5.0 Unit Intervals peak-to-peak, and
- Band 2: 0.1 Unit Intervals peak-to-peak.

3.2.7.2 BST SIGNAL WANDER

At the NI, the wander of the BST signal shall not exceed 28 UIs, peak-to-peak, over any 24 hour period; nor shall it exceed 5 UIs, peak-to-peak, in any 15 minute interval.

3.2.7.3 COLLOCATOR SIGNAL JITTER

At the NI, the jitter of the COL-to-BST signal would be classified as Type II:

- Type I. Where the equipment on the COL side of the interface is the DS1 source, i.e., terminal equipment.
- Type II. Where the COL source is part of a **user** network and is transported over a **user's** facility to the NI.

At the NI, the jitter of the COL-to-BST signal shall not exceed the following Type II limits in both bands simultaneously:

Type 1

Band 1: 0.5 unit intervals peak-to-peak, and
Band 2: 0.05 unit Intervals peak-to-peak.

Type II

Band 1: 5.0 unit intervals peak-to-peak, and
Band 2: 0.1 unit Intervals peak-to-peak.

3.2.7.4 COLLOCATOR SIGNAL WANDER

At the NI, the wander of the COL signal shall not exceed 28 UIs, peak-to-peak, over any 24 hour period: nor shall it exceed 5 UIs, peak-to-peak, in any 15 minute period.

3.3 DS1 CONNECTING ARRANGEMENTS

One balanced twisted pair shall be used for each direction of transmission. Interconnection at the NI will be via the BST provided terminal panel.

3.3.1 CABLE CHARACTERISTICS

Reference cable for DS1 interconnections is multi-pair 22 AWG PIC construction with overall outer shield, meeting the characteristics of Figure 4. A separate 100 Ω twisted pair, 22 AWG ABAM or equivalent, that meets the phase and attenuation requirements shall be provided for each direction of transmission.

3.3.2 GROUNDING

The ABAM or equivalent cable sheath will be grounded at the NI. The cable should not be grounded at the BST DSX-1 or COL TE.

3.3.3 PHYSICAL INTERFACE

A DS1 interface panel will be provided as the NI. It will provide for the interconnection of individual pairs. Terminal pins that extend through the panel shall be used for wire-wrap interconnection of cable pairs. BST and COL pairs shall terminate on opposite sides of the interface panel. The BST and COL side will be clearly stenciled.

BST encourages customer participation to ensure an orderly, functional and mutually trouble-free interface at these and all locations.

3.4 DS1 FRAME FORMAT

This document specifies basic DS1 framing formats that are common to DS1 transmission facilities and compatible with those defined in ANSI T1.107-1988. In addition, the multiplex channel bank format is specified in order to assure proper operation with BST provided channelized multiplexing.

The BST and COL signal at the NI shall be framed in either the Superframe (SF) or Extended Superframe (ESF) format. Use of ANSI T1.403-1989 ESF is highly recommended to support improved testing and in-service performance monitoring. The same framing format shall be used in both directions of transmission. SF is the present predominant format, however telecommunications is moving toward the ESF format. BST will work with customers to resolve issues in this area.

3.4.1 FRAME

The DS1 frame consists of 193 bit time slots. The first time slot is the Framing bit (Ft) and the other 192 time slots are available for payload. The 192 information bits may be partitioned into 24 8-bit time slots as shown in Figure 5.

3.4.2 SUPERFRAME FORMAT

A Superframe (SF) consists of 12 consecutive DS1 frames (193 bits each) and contains 2316 bits. The SF format is a structure in which the F-bits are used for framing only. In the SF format, the F-bits are divided into two groups as shown in Table 2.

- (1) Terminal Framing (Ft) bits, used to identify frame boundaries.
- (2) Signaling Framing (Fs) bits, used to identify superframe boundaries. (When the 192 information digit time slots are channelized, the Fs bits are used to identify the robbed-bit signaling frames and associated signaling channels A and B.)

3.4.3 EXTENDED SUPERFRAME FORMAT

An Extended Superframe (ESF) consists of 24 consecutive DS1 frames and contains 4632 bits as shown in Table 3. The F-bits of contiguous frames are used to form an 8 Kbit/s channel which provides the following 3 sub-channels.

- (1) A 2 Kbit/s Framing Pattern Sequence (FPS) used to identify the frame and the extended superframe boundaries.
- (2) A 2 Kbit/s Cyclic Redundancy Check (CRC) that carries the CRC-6 code.
- (3) A 4 Kbit/s Data Link (DL) used for transmittal of performance information and control signals.

The use of ANSI T1.403-1989 ESF supports improved testing and in-service performance monitoring capabilities. Each second terminals send scheduled performance report messages, structured as shown in Figure 6, out over the data link based on CRC calculations and comparisons at the terminal. This enables either end of the path to access end-to-end performance for both directions of transmission. Unscheduled messages can be used to send alarms, commands and responses.

Additional detailed information concerning the ESF format and ESF DL uses and messages for carrying performance information and control signals across the NI are contained in BellSouth TR 73525, Issue B.

3.4.4 CLEAR CHANNEL CAPABILITY

The Bipolar with Eight Zero Substitution (B8ZS) method is used to provide a Clear Channel Capability (CCC), framed DS1 signal with unconstrained payload information bits (payload may represent any combination of zeros and ones). BST does not support the Zero-Byte Time Slot Interchange (ZBTSI) method of providing CCC.

3.5 DS1 CHANNELIZED MULTIPLEXING

In order to assure proper operation with BST provided DS1 Basic Channelization Systems, the COL channelization equipment must adhere strictly to form and protocol standards. Separate standards exist for the multiplex channel bank, for voice frequency encoding, for various signaling schemes, and for subrate digital access.

3.5.1 DS1 APPLICATION: 24 VOICE GRADE CHANNELS WITH ROBBED BIT SIGNALING CHANNEL

This is the traditional D-type channel bank application which can be used to provide for network access to voice grade channels. Eight bits are available for payload in 5 out of 6 of the DS1 frames. In every sixth frame, the eighth bit position of each channel is used for a payload overhead channel that transports signaling information. Detailed information concerning formats, coding, prohibited code words and other characteristics are contained in BellSouth TR 73525, Issue B.

3.5.2 DS1 APPLICATION: 24 DIGITAL DATA CHANNELS AT 64 KBIT/S

D-type channel bank systems equipped with dataport channel units support an application which can be used to provide for network access to digital data channels. Synchronous digital data formats are specified in ANSI T1.107b-1991. Interface options and service objectives are specified in Bellcore TR-NWT-000341.

3.5.3 SYNCHRONIZATION

To insure proper operation when connected to the BST digital network, channelized DS1 circuits should comply with Bellcore TA-NPL-000436, Digital Synchronization Network Plan and ANSI T1.101-1987. All timing information is transmitted as part of the DS1 signal. A separate clock lead is not provided. For end-user customer applications BST recommends that the customer equipment be loop-timed (slaved) to the incoming bit stream from the network.

COL TE should be synchronized from a timing source traceable to a Primary Reference Source (PRS). Synchronization may be achieved by deriving timing from a BST channelized DS1, by deriving timing from a different DS1 traceable to a PRS and timing all other facilities from it, or by providing timing traceable to a COL provided PRS. Improper timing will result in transmission impairing slips which can cause loss of data information.

3.6 MAINTENANCE SIGNALS

Maintenance signals are transmitted in-band in the SF format and in the data link of the ESF format. ESF is not universally available and is not always provisioned with full features. The Marketing Representative has location specific details.

In the SF format, the following framed codes may be used within the Network to support out-of-service maintenance operations. These codes are used in repetitive pulse patterns of at least 5 seconds. Network equipment may block customer transmission of long sequences of these patterns:

11000 (2 in 5)
11100 (3 in 5)
10100

3.6.1 YELLOW ALARM

A yellow alarm signal shall be transmitted in the outgoing direction when a DS1 terminal determines that it has effectively lost the incoming signal. A yellow alarm signal shall be transmitted to the interface in the following forms:

- (a) Superframe Format: For the duration of the alarm condition, but for at least one second, bit 2 in every eight-bit time slot shall be a "zero."

NOTE: It is recognized that some existing un-channelized equipment does not transmit yellow alarm.

- (b) Extended Superframe Format: For the duration of the alarm condition, but for at least one second, a repeating 16 bit pattern consisting of eight “ones” followed by eight “zeros” shall be transmitted continuously on the ESF data link, but may be interrupted for a period not to exceed 100 milliseconds by one or more fault isolation messages. After an interruption, one of the following fault indicating conditions shall appear at the interface in the same direction of transmission as the original Yellow Alarm.

Yellow Alarm
AIS
Loss of Signal

- (c) For either framing format, the minimum time between the end of one transmission and the beginning of another transmission shall be one second. Certain services provided by the network may require longer time intervals than these minimum values, or may require unequal “on” and “off” intervals, or both.

3.6.2 ALARM INDICATION SIGNAL (AIS)

An AIS should be transmitted to the NI upon a loss of originating signal, or when any action is taken that would cause a signal disruption. The AIS shall be removed when the condition triggering the AIS is terminated. The AIS shall be an unframed, all–ones signal.

3.6.3 LOOPBACKS

Loopbacks are used by BST, Carriers and Users as a maintenance tool to aid in problem resolution. The codes and protocols described in this Section may be used by BST for section testing or by the COL for Customer Installation (CI) to CI testing.

3.6.3.1 SF FORMAT LINE LOOPBACKS

The protocol currently in use by the Carriers for network access to a DS1 CI line loopback feature is in–band signaling control. Only the CI may respond to the in–band control line loopback codes described here.

With in–band signaling control, the line loopback shall operate upon receipt of specific framed pulse patterns. The line loopback pulse codes and functions are:

- (1) Activate:

A framed DS1 signal consisting of repetitions of four “zeros” followed by one “one”, lasting for a least 5 seconds, with the framing bits overwriting the pattern.

- (2) Deactivate:

A framed DS1 signal consisting of repetitions of two “zeros” followed by one “one”, lasting for at least 5 seconds, with the framing bits overwriting the pattern.

NOTE: Embedded network equipment exists which may react to the line loopback deactivate code and block the code from reaching the CI, requiring manual intervention to deactivate the line loopback.

The line loopback shall also operate upon receipt of the patterns in (1) and (2) above without framing to accommodate embedded equipment which sends unframed (non–standard) control signals. With the CI line loopback feature activated, the customer’s signal is interrupted and the DS1 signal received from the network is transmitted back to the network. The looped signal shall be regenerated by the CI without change in framing format or removal of bipolar violations.

3.6.3.2 ESF FORMAT LINE LOOPBACKS

Access to the Line Loopback feature in the ESF format is by means of the ESF Data Link Messages, shown in Table 4.

NOTE: Embedded NCTE equipment exists in which line loopback Activate and Deactivate are accomplished by either framed or unframed in-band codes.

3.6.3.3 PAYLOAD LOOPBACKS

Payload loopback is supported only by the ESF format. When a payload loopback is activated, the received information bits (192 information bits per frame) are transmitted in the outgoing direction. The framing bits (frame synchronization, CRC-6 and DL) are originated at the point of the payload loopback. The payload loopback shall maintain bit sequence integrity for the information bits, which requires that the timing of the transmitted payload loopback signal. The payload loopback need not maintain the integrity of eight-bit time slots, frames, or superframes. Payload loopback commands are shown in Table 4.

4. DS3 – NETWORK INTERFACE

4.1 GENERAL

DS3 Expanded Interconnect Service (EIS) provides for the transmission of nominal 44.736 Mbit/s isochronous serial data between a Collocator Point of Termination (COL-POT) and BellSouth Telecommunications (BST) interstate special access services. It may be used for bulk access to other network services at the DS1 or lower bit rates. Sufficient detail on DS3 formatting is provided to accommodate each of these applications.

These specifications describe the electrical, physical and protocol requirements necessary for interconnection of BST and COL-POT signals at the Network Interface (NI). A Sketch of the NI is shown in Figure 1. The signal delivered to the NI by BST is identified as the BST signal, and the signal delivered by the Collocator is identified as the COL signal.

At the NI, some of the electrical requirements for the BST signal differ from corresponding requirements for the COL signal. Pulse characteristics are specified at the BST DSX-3 cross-connect not the NI. This is consistent with the manner in which BST specifies requirements for interconnection with its own Terminal Equipment (TE) and facilities.

4.2 ELECTRICAL SPECIFICATIONS

The following specifications describe common characteristics for all signals at the NI, except where noted. Differences between BST and COL signals are separately identified.

4.2.1 TRANSMISSION RATE

The transmission rate of the DS3 signal shall be 44.736 Mbit/s \pm 895 bits/s.

4.2.2 LINE CODE

The line code shall be Bipolar with 3 Zero Substitution (B3ZS). In the B3ZS format, each block of three consecutive zeros is removed and replaced by B0V or 00V, where B represents a pulse conforming with the bipolar rule and V represents a pulse violating the bipolar rule. The choice of B0V or 00V is made so that the number of B pulses between consecutive V pulses is odd.

The following example of B3ZS coding assumes the polarity of the last pulse transmitted was negative (-). If the last pulse transmitted had been positive (+), then the resulting bipolar signals would be the inverse of the example shown here. Case 1 assumes that an odd number of pulses have been transmitted since the last bipolar violation.

TABLE 4–1. EXAMPLE OF B3ZS CODING

Binary Signal	101	000	11	000	000	001	000	1...
Case 1, Odd	B0B +0–	00V 00–	BB +–	B0V +0=	B0V –0–	00B 00+	00V 00+	B... –
Case 2, Even	B0B +0–	B0V +0+	BB –+	B0V +0+	B0V +0+	00B 00–	00V 00–	B... +

B represents a pulse conforming with the bipolar rule.

V represents a pulse violating the bipolar rule.

+ represents a positive pulse.

– represents a negative pulse.

4.2.3 TEST LOAD

A termination of $75 \Omega \pm 5\%$ resistive shall be used at the interface as a test load to evaluate the pulse shape and other electrical parameters.

4.2.4 STANDARD DS3 PULSE CHARACTERISTICS

Pulse shape, power levels and pulse imbalance requirements are defined in terms of a standard DS3 pulse and shall be met at the BST DSX–3 cross–connect.

4.2.4.1 PULSE SHAPE

A normalized and isolated pulse shall fit the template shown in Figure 7. The pulse amplitude shall be between 0.36 and 0.85 volts (peak), measured at the center of the pulse, and may be scaled by a constant factor.

4.2.4.2 POWER LEVEL

For an all–ones transmitted pattern,¹ the power in a band no wider than 3 kHz, centered at 22.368 MHz shall be –1.8 to +5.7 dBm. The power in a band no wider than 3 kHz, centered at 44.736 MHz, shall be at least 20 dB below the power level at 22.368 MHz.

4.2.4.3 PULSE IMBALANCE

The ratio of amplitudes of any positive and negative isolated pulses shall be between 0.9 and 1.1, and both pulses shall conform to the mask of Figure 7.

1. This must be a pure all–ones signal, without framing or other terminal control bits. It is recognized that such a signal may be difficult to provide at a DSX–3 cross–connect.

4.2.5 SIGNAL FROM BST AT NETWORK INTERFACE

The BST signal requirement shall be met at the BST DSX-3 cross-connect. The NI serves only as a means of physical interconnection.

4.2.5.1 BST PULSE AMPLITUDE

At the BST DSX-3 cross-connect a normalized isolated pulse shall have a amplitude of between 0.36 and 0.85 volts (peak) and fit the template shown in Figure 7. If the distance between the BST DSX-3 cross-connect and NI is greater than 420 feet, an intermediate signal regenerator will be provided by BST. The output of the regenerator shall be compatible with standard DS3 pulse requirements and capable of satisfactory operation with the COL TE.

4.2.5.2 BST SIGNAL ATTENUATION

At the NI the pulse characteristics shall be those of a standard pulse attenuated through 0 to 420 feet of 728A coaxial cable or equivalent with characteristics as shown in Section 4.3.1.

The variable length of cable makes it impractical to define a pulse template for the BST signal at the NI.

4.2.6 SIGNAL FROM COLLOCATOR AT NETWORK INTERFACE

The COL signal requirement shall be met at the BST DSX-3 cross-connect. The COL signal will termination on the BST DSX-3 cross-connect in the same manner that BST terminates signals from its own Terminal Equipment (TE) and facilities. The NI serves only as a means of physical interconnection. Network considerations and the potential for interference and crosstalk require that pulse characteristics be precisely controlled at a DSX-3 cross-connect as defined in ANSI T1.102-1987. At the BST DSX-3 cross-connect a normalized isolated pulse shall have an amplitude between 0.36 and 0.85 volts (peak), measured at the center of the pulse, and fit the template shown in Figure 7.

4.2.6.1 COL PULSE CHARACTERISTICS

It is an industry standard that the output of DS3 TE be capable of delivering a standard DSX-3 cross-connect level pulse after transmission through 450 feet of 728A or equivalent cable. DS3 Line Build-out (LBO) is used to control pulse characteristics by providing pulse shaping and loss equivalent to specific amounts of cable. Typical DS3 TE provides an on-board LBO equivalent to 225 feet of 728A cable that can be inserted into the signal path transmitted toward a DSX-3 cross-connect. When the cabling distance between the TE and DSX-3 cross-connect is between 0 and 225 feet, LBO must be provided to assure that the DSX-3 cross-connect pulse characteristics are met.

Typical DS3 Line Build-Out

Distance BST DSX-3 to COL-TE (feet)	Line Build-Out (Setting)
0 - 225	LBO
225 - 450	No LBO

An allocation of 30 feet has been made for cabling between the COLs TE and NI. When the distance from the NI to the BST DSX-3 cross-connect is between 0 and 195 feet, the COLs TE must provide LBO. If the distance from the NI to the BST DSX-3 cross-connect is between 195 and 420 feet, no LBO is required.

If the distance between the BST DSX-3 cross-connect and NI is greater than 420 feet, an intermediate signal regenerator shall be provided between the NI and DSX-3 by BST. The output of the regenerator shall be compatible with standard DS3 pulse requirements and capable of delivering a pulse which meets signal requirements at the BST DSX-3 cross-connect.

4.2.6.2 COL SIGNAL ATTENUATION

At the NI the pulse characteristics shall be those of the COLs TE output pulse (with LBO as required) attenuated through 0 – 30 feet of 728A cable or equivalent with characteristics as specified in Section 4.3.1.

BST will advise the Collocator of the cable length between the BST DSX-3 and the NI. It is the Collocator's responsibility to properly option the TE to provide proper pulse LBO pre-emphasis so that a pulse between 0.36 and 0.85 volts which fits the template shown in Figure 7 is delivered to the BST DSX-3 cross-connect. Failure to provide the proper equalization will jeopardize the performance of the collocator's EIS service and has the potential to adversely impact the performance of other network provided services.

4.2.6.3 OTHER SIGNALS

The COL shall not apply voltages to the DS3 NI other than those described in this document. Signals at the NI that occur as a result of the environment are not covered, e.g., induced voltages, currents and lighting hits. See Bellcore TR-EOP-000001 and TR-TSY-000499 for these subjects. Direct current signals shall not be applied to the NI.

4.2.7 DS3 JITTER

Timing jitter is defined as the short term variations of the significant instants of a digital signal from their ideal positions in time, where the phase oscillations are of a frequency greater than or equal to 10 Hz. Jitter can be produced by terminals, multiplexers and repeaters. It is commonly introduced by equipment which maintains timing via bit stuffing mechanisms. Accumulated jitter may be observed at the DS3 rate as a component of the DS3 signal itself or of any or all of the embedded DS1 signals.

The magnitude of jitter is specified in terms of Unit Intervals (UIs). A UI is equal to the nominal difference in time between consecutive significant instants of an isochronous signal, for DS3 signals one UI equals 22.35 nanoseconds. Jitter is specified in two frequency bands (band 1 and band 2) whose characteristics weighing functions are provided in Figure 8.

4.2.7.1 BST SIGNAL JITTER

At the NI, the jitter of the BST-to-COL signal shall not exceed the following limits in both bands simultaneously:

- Band 1: 5.0 Unit Intervals peak-to-peak, and
- Band 2: 0.1 Unit Intervals peak-to-peak.

4.2.7.2 COLLOCATOR SIGNAL JITTER

At the NI, the jitter of COL-to-BST signal shall fall into one of two categories:

- Type I. Where the equipment on the COL side of the interface is the DS3 source, i.e., a DS3/1 digital cross-connect system.
- Type II. Where the COL source is part of a **user** network and is transported over a **user's** facility to the NI.

At the NI, the jitter of the COL-to-BST signal shall not exceed the following limits in both bands simultaneously:

- Type 1
 - Band 1: 0.5 unit intervals peak-to-peak, and
 - Band 2: 0.05 unit Intervals peak-to-peak.
- Type II
 - Band 1: 5.0 unit intervals peak-to-peak, and
 - Band 2: 0.1 unit Intervals peak-to-peak.

4.2.8 WANDER

Wander is similar to jitter, but for frequencies below 10 Hz. Requirements for signal wander are the subject of further study.

4.2.9 TIMING SYNCHRONIZATION

DS3 signals intended for demultiplexing by BST must adopt the asynchronous multiplex format. The required line rate tolerance shall be maintained by bit stuffing according to the M13 multiplex specification. No separate leads for timing or control purposes will be provided. DS1 Synchronization issues are addressed in Section 3.5.3.

4.3 DS3 CONNECTING ARRANGEMENTS

One coaxial pair shall be used for each direction of transmission. Interconnection at the NI will be via the BST provided terminal panel.

4.3.1 CABLE CHARACTERISTICS

The reference cable for DS3 interconnections at the NI is 75 Ω coaxial cable with tinned copper shield meeting the characteristics of of Figure 9. A separate cable shall be provided for each direction of transmission of the full duplex circuit.

4.3.2 GROUNDING

The shields of the connecting coaxial cables that meet at the NI may interconnect the BST and COL TE equipment grounds through the BNC connector. This may not be a suitable as the common ground reference and it may be necessary that the BST and COL TE be interconnected by other methods to form the common ground reference. General grounding requirements for transport equipment are contained in TR-EOP-000063 and the National Electric Code, ANSI/NFPA 70. High frequency pulse isolation transformers may be required at the NI to prevent excessive ground currents in the shields of the connecting cables.

4.3.3 PHYSICAL INTERFACE

A DS3 interface panel will be provided as the NI. It shall be used for the interconnection of individual coaxial cables. A BNC connector will be mounted within the panel and BST and COL cables shall terminate on opposite sides of the interface panel. The BST and COL sides will be clearly stenciled.

BST encourages customer participation to ensure an orderly, functional and mutually trouble-free interface at these and all locations.

4.4 DS3 FRAME FORMAT

This document specifies a basic DS3 framing format that is common to DS3 transmission facilities. In addition, the asynchronous M13 multiplex format (a combination of M12 and M23 formats) is specified for terminal equipment that multiplexes 28 DS1s into a DS3.

Uninterrupted customer premises-to-customer premises communications at the DS3 rate may utilize formats other than M13 compatible. Where other formats are used, “stuff indicator bits” are not constrained and may be used for application purposes. Framing overhead is still required, however, and timing must be maintained within the rate and tolerance specification.

The basic DS3 framing format shall be as specified in ANSI T1.107a and as show in Figures 10. This framing format is required of all terminal equipment to allow the signal to successfully transit BST facilities or terminate in BST’s network.

The DS3 signal is portioned into M-frames of 4760 time slots, as shown in Figure 11, and each M-frame is divided into 7 subframes of 680 time slots. Every subframe is further divided into 8 blocks of 85 time slots, with 84 of the 85 slots available for payload and one used for control. The first time slot of each block carries 1 overhead bit for a total of 56 overhead bits in each M-frame. The remaining time slots are reserved for the payload. Overhead bits are generated by the terminal equipment.

4.4.1 FRAME OVERHEAD

The 56 overhead bits in an M-frame are assigned various functions as listed in the M-frame overhead bit sequence table contained in Figure 10. The three M-bits (M1, M2 and M3) form the M-frame alignment channel, the 28 F-bits (F1, F2, F3, and F4 in each of the 7 sub-frames) are used to align the information bits in the sub-frames, the two P-bits (P1 and P2) are designated for a parity channel and the two X-bits (X1 and X2) are designated for an alarm channel. The remaining 21 C-bits (C1, C2 and C3 in each sub-frame) are control bits that are reserved for application specific uses in the terminal equipment. The M23 Multiplex application uses the C-bits to indicate the presence or absence of stuffing bits. The C-bits are not deliberately altered in BST’s transmission facilities.

Additional information concerning the M, F, X, P and C overhead bits is contained in BellSouth TR 73501 and ANSI T1.107a. It should be noted that the two X-bits must be equal, i.e., 11 or 00, in order to avoid false framing. If a DS3 source uses the X bits for asynchronous low speed signalling, it shall not change the state of the X-bits more than once ever second. In addition, the C-bits are reserved for application specific uses determined by the signal source. However, for multiplexing within the network, the specific application of the C-bits is for stuffing indicators. BellSouth TR 73501 provides additional detail concerning this application.

4.4.2 M13, M12 AND M23 MULTIPLEX APPLICATION

When signals are intended to remain intact at the DS3 rate from one location to another, no multiplexing is needed. The M13, M12 and M23 format specifications apply when signals that originate at the DS3 rate are disassembled and directed to different points within the network.

The M23 multiplex application combines 7 DS2 bit-streams (each of which must comply with the M12 multiplex format specification) plus frame overhead into a DS3 bit-stream. The 7 DS2 bit-streams are individually bit-stuffed at a rate sufficient to synchronize them with the DS3 signal rate. The bit-stuffed DS2 bit-streams are then bit-interleaved to form the asynchronous DS3 signal. The C-bits are used as stuff indicators.

The M23 application is typically used in combination with the M12 multiplex format application. The M12 multiplex format produces a DS2 signal by bit-by-bit interleaving 4 DS1 bit-streams with 24 frame overhead bits. Thus the resulting M13 DS3 signal contains 28 DS1 bit-streams. Both the M23 and M12 application are specified in ANSI T1.107a and BellSouth TR 73501.

4.5 MAINTENANCE SIGNALS

4.5.1 IDLE SIGNAL

The idle signal is a signal with a valid M-frame Alignment Channel ($M1=0$, $M2=1$ and $M3=0$), M-subframe Alignment Channel ($F1=1$, $F2=0$, $F3=0$ and $F4=1$) and P-bit Channel ($P1=1$ and $P2=1$ or $P1=0$ and $P2=0$). The information bits shall be set to a 1100.... sequence, starting with a one-one (11) after each M-frame alignment, M-subframe alignment, X-bit, P-bit, and C-bit channel. The C-bits shall be set to zero (0) in M-subframe 3. The remaining C-bits (the 3 C-bits in M-subframes 1,2,4,5,6 and 7) may individually be a one (1) or zero (0) and may vary with time. The X-bits shall be set to one ($X1=1$ and $X2=1$).

4.5.2 ALARM INDICATION SIGNAL (AIS)

The AIS is a signal transmitted in place of the normal signal to maintain transmission continuity and indicate to the receiving terminal that there is a transmission fault that is located either at or upstream from the transmitting terminal. The AIS is a signal with valid M-frame Alignment Channel, M-subframe Alignment Channel and P-bit Channel. The information bits are set in a sequence of 101010....(LtR), starting with a one (1) after each F, M, P, X and C bit. The C-bits are set to zero (0) and the X-bits are set to one (1).

4.5.3 YELLOW ALARM/SEVERELY ERRORED FRAME (SEF) AND AIS DEFECT INDICATOR

Yellow alarms or Severely Errored Frame (SEF) defect and AIS defect indicators are used in the network to report upstream that a failure has been detected inbound from the upstream span. When a DS3 sink detects SEF defect (DS3 sink fails to frame on a received signal) or AIS, the associated DS3 source should be capable of controlling the setting of the X-bits. The X-bits should be set to zero ($X1=0$ and $X2=0$) in the returning DS3 signal. The X-bits should be set to one ($X1=1$ and $X2=1$) otherwise. The DS3 source shall not change the state of the X-bits more than one every second.

4.6 PERFORMANCE MONITORING CHANNEL

The P-bit channel provides parity information for the preceding M-frame. In any one M-frame, the two P-bits shall be identical ($P1=P2=0$ or $P1=P2=1$). The DS3 source shall count parity over the 4,704 information bits following the first X bit in an M-frame and insert the resulting parity information in the P bit positions of the following frame. If the modulo 2 sum of all the information bits is one (1), then $P1=P2=1$. If the modulo 2 sum of all the information bits is zero (0), then $P1=P2=0$. The frame overhead bits, (M, F, X and C) are not included in the parity calculation. The P-bits are not suitable for end-to-end performance monitoring because in-stream systems may change the bits if a parity error is detected.

5. INTERFACE DESCRIPTIONS

5.1 GENERAL

This section provides information on Network Channel Interface (NCI) codes including interface descriptions. The NCI code describes the number of conductors, protocol, impedance, protocol options and transmission level point(s) reflecting characteristics at the Point of Termination (POT)/Network Interface (NI). Existing Network Channel (NC) codes will be used for interconnecting EIS services. The appropriate interface ordering procedures, which use these NCI and NC codes, are covered in other publications such as Bellcore SR-ST5-000307.

5.2 NETWORK CHANNEL INTERFACE (NCI) CODE COMPONENTS

The electrical characteristics of the interface with the Collocator (COL) are identified by an NCI code. Compatible NCI codes for the service desired must be specified by the COL when ordering EIS and other network special access services. Definitions of specific NCI codes that apply to EIS services are covered in this section. Descriptions of the component parts of the NCI code are provided to aid the customer in understanding the relationship of these codes to the electrical characteristics of the interface.

The components of an NCI code furnish the information concerning the electrical characteristics for the interface at the Point of Termination (POT). Positions 1 and 2 of the NCI code are numeric characters indicating the total number of conductors at the interface. Positions 3 and 4 are two alphabetic characters indicating the protocol code. Position 5 indicates the reference impedance. Position 6, if used, is a delimiter and indicates the start of the protocol option code. Positions 7, 8, and 9, if used, indicate options available for the protocol code in use. The component parts of the NCI codes and their definitions are listed in the tables in this Section. Additional information about Network Channel Interface Codes may be found in Bellcore SR-ST5-000307.

5.2.1 NUMBER OF CONDUCTORS

This component describes the number of conductors required to provide the service. Table 5-1 lists allowable entries for this component.

TABLE 5-1. NUMBER OF CONDUCTORS¹

Number of Conductors	Code
2	02
4	04
6	06
8	08

5.2.2 **PROTOCOL CODE**

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 COL-POT and CXR-POT or EU-POT.

The protocol code combinations specified for the CXR-POT and the COL-POT may be the same or different. However, only certain combinations are technically possible. Table 5-2 lists the protocol codes that apply to EIS Special Access Service.

1. Wire Code is in Character Positions 1 & 2

TABLE 5–2. SELECTED PROTOCOL CODES AND OPTIONS²

Code	Option	Definition
Manual Cross–Connect Termination DSX Bay with no subrate capabilities at COL–POT		
QB	1 1	DS1 to DS1 Cross–Connects
	3 3	DS3 to DS3 Cross–Connects
DS1 Digital Hierarchy Interface at the CXR–POT		
DS	1 K	1.544 Mbit/s (DS1) “ANSI” T1.403 Extended Superframe (ESF) format per TR–NPL–000342
	1 S	1.544 Mbit/s (DS1) “ANSI” T1.403 Extended Superframe (ESF) format and B8ZS Clear Channel Capability per TR–NPL–000342
	1 5	1.544 Mbit/s (DS1) Superframe (SF) format per TR–NPL–000342
	1 5 B	1.544 Mbit/s (DS1) Superframe (SF) format and B8ZS Clear Channel Capability (CCC) per TR–NPL–000342
DS3 Digital Hierarchy Interface at the CXR–POT or EU–POT		
DS	4 4 A	44.736 Mbit/s (1–DS3)
	4 4 C	44.736 Mbit/s (3–DS3)
	4 4 G	44.736 Mbit/s (12–DS3)
	4 4 N	44.736 Mbit/s (24–DS3)
DS1 Digital Hierarchy Interface at EU–POT		
DU	1 K N	1.544 Mbit/s (DS1) “ANSI” T1.403 Extended Superframe (ESF) format per TR–NPL–000054 without line power
	1 S N	1.544 Mbit/s (DS1) “ANSI” T1.403 Extended Superframe (ESF) format and B8ZS Clear Channel Capability per TR–NPL–000054 without line power
	B N	1.544 Mbit/s (DS1) Superframe (SF) format per TR–NPL–000054 without line power
	D N	1.544 Mbit/s (DS1) Superframe (SF) format and B8ZS Clear Channel Capability (CCC) per TR–NPL–000054 without line power

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

5.2.3 NOMINAL REFERENCE IMPEDANCE

The nominal reference impedance is the third component of the NCI code. This is the impedance at which the customer will terminate the service for the purpose of evaluating transmission performance. Table 5–3 list allowable values related to EIS service.

Table 5–3. REFERENCE IMPEDANCE CODE³

Impedance Value⁴	Code
110	0
135	5
75	6
100	9

5.3 COMPATIBLE NCI CODE COMBINATIONS

NCI code selection for EIS Special Access Service should be coordinated between the Collocator and BST during the initial service order discussion. Table 5–4 lists compatible EIS NCI interface combinations. DS1 interfaces can only be interconnected with DS3 interfaces or vice versa, if the customer purchases DS3/DS1 multiplexing. For codes associated with interconnecting High Capacity Digital Access services, consult existing technical publications or a Marketing Representative.

TABLE 5.4. COMPATIBLE EIS NCI INTERFACE COMBINATIONS

COLLOCATOR	EU–POT	COLLOCATOR	CXR–POT
04QB9.11	04DU9.1KN 04DU9.1SN 04DU9.BN 04DU9.DN	04QB9.11	04DS9.1K 04DS9.1S 04DS9.15 04DS9.15B
04QB6.33	04DS6.44A 04DS6.44C 04DS6.44G 04DS6.44N	04QB6.33	04DS6.44A 04DS6.44C 04DS6.44G 04DS6.44N

³ Reference Impedance Code is in Character Position 5.

⁴ The reference impedance is the impedance the customer is expected to use to terminate the channel for the purpose of evaluating transmission performance.

6. MAINTENANCE OF SERVICE

The following outlines BST and COL maintenance of service responsibilities.

6.1 RESPONSIBILITIES OF BST

BST will be responsible for all installation, maintenance, and related activities associated with equipment up to and including the NI. BST will maintain assignment control up to the NI.

6.2 RESPONSIBILITIES OF COL

The COL will be responsible for providing, installing, maintaining, and repairing the following:

- Fiber optic cable(s) from entry point to COL interconnection space.
- COL transmission equipment provided in interconnection space.
- Cable from COL's transmission equipment to BST designated meet–point at the NI.

The COL will be responsible for notifying BST of significant outages which could impact or degrade BST switches and services, and will provide COL's estimated time for restoration.

The COL is responsible for providing a contact number for maintenance support that is readily accessible 24 hours per day, 7 days per week.

The COL is responsible for providing trouble report status when requested.

Troubles reported to or observed by the COL should be tested and isolated by the COL prior to reporting the trouble to BST.

7. GLOSSARY

7.1 DEFINITIONS

Alarm Indication Signal (AIS)

A signal transmitted in lieu of the normal signal to maintain transmission continuity, and indicate to the receiving terminal that there is a transmission fault which is located either at the transmitting terminal or upstream of the transmitting terminal.

American National Standards Institute (ANSI)

An organization that has accredited projects undertaken by the telecommunications independent standards committee T1.

Bipolar (Alternate Mark Inversion) Signal

A pseudo-ternary signal, conveying binary digits, in which successive “ones” (marks, pulses) are of alternating, positive (+) and negative (–) polarity, equal in amplitude, and in which a “zero” (space, no pulse) is of zero amplitude.

B8ZS (Bipolar with 8–Zero Substitution)

A code in which eight consecutive “zeros” are replaced with the sequence 000VB0VB, where V is a binary one in which the polarity is in violation of the bipolar rule and B is a binary one in which the polarity is in conformance with the bipolar rule.

Bipolar Violation

In a bipolar signal, a one (mark, pulse) which has the same polarity as its predecessor.

Bit

An abbreviation of binary digit. One of the members of a set of two in the binary number system. Either digit 0 or 1. Also, a unit of information; one bit of information is sufficient to specify one of two equally likely possibilities.

B3ZS (Bipolar with 3–Zero Substitution)

A code where three consecutive “zeros” are replaced with the sequence B0V or 00V, where B represents a pulse conforming with the bipolar rule and V represents a pulse violating the bipolar rule. The choice of B0V or 00V is made so that the number of B pulses between consecutive V pulses is odd.

Cable Space

Denotes any passage or opening in, on, under/over or through the central office cable support structure (e.g., cable risers, cable racks, cable vault or alternate splicing chamber, etc.) required to bring fire retardant fiber optic riser cable from the interconnection space to the location where the riser cable and the feeder cable meet and are spliced and the spaces between the interconnection space and the BST Point of Termination and any other space required to bring other fire retardant communications cable from one interconnection space module to another interconnection space module of the same Collocator.

Carrier

An organization that provides telecommunications service to the public.

Central Office (CO)

A local switching system and its associated equipment located at a wire center.

Channel

An electrical or optical communication path between two or more locations.

Channelize

The process of multiplexing and demultiplexing channels using analog or digital techniques.

Clear Channel Capability

A characteristic of a DS1 transmission path in which the 192 “information” bits in a frame can represent any combination of zeros and ones.

Collocator

Any person, corporation, or other legal entity to whom the telephone company has extended or hereafter shall extend an authorization to occupy its central office or conduit system(s), in accordance with the EIS tariff provisions.

Collocator’s Facilities

Denotes the transmission cables and equipment owned/leased and installed by the Collocator for the sole use of the Collocator within its interconnection space, in accordance with the EIS tariff provisions.

Customer Installation (CI)

Equipment and wiring at the customer’s location on the customer side of the NI.

Customer Premises (CP)

The premises of the end user of the telecommunications service.

Cyclic Redundancy Check (CRC)

A method of checking the integrity of received data, where the check uses a polynomial algorithm based on the content of the data.

DS1 (Digital Signal Level 1)

A digital signal transmitted at the nominal rate of 1.544 Mbit/s.

DS3 (Digital Signal Level 3)

A digital signal transmitted at the nominal rate of 44.736 Mbit/s.

Duplex Channel

A channel capable of supporting simultaneous transmission in both directions.

Encode

To apply a set of unambiguous rules specifying the way in which data may be represented such that subsequent decoding is possible.

Entry Point

The physical entrance into the central office and/or central office vault.

Exchange

A unit established by the telephone company for the administration of communication services in a specified geographic area that usually embraces a city, town or village and its environs.

Frame

In digital communications, a group of bits that constitute the smallest independently definable entity in a continuous data stream.

Framing Bits

Non-information carrying bits used to make possible the separation of information in a serial bit stream.

In-Band

Using or involving the information digit time slots of a DS1 frame; i.e., bit assignments of a frame exclusive of the framing bit.

Interconnection Floor Space or Interconnection Space

An enclosed room designated by the telephone company within a central office to be used for the sole purpose of installing, maintaining, and operating equipment to interconnect a Collocator's fiber facilities to BST services and facilities.

Interexchange Carrier (IC) or Interexchange Common Carrier

Any individual, partnership, association, joint-stock company, trust, government entity or corporation engaged for hire in interstate or foreign communication by wire or radio, between two or more exchanges.

Isochronous Transmission

A transmission process in which there is always an integral number of unit intervals between any two significant instants. The transmission is characterized by a constant pulse rate, a constant time interval or multiples thereof between voltage or electromagnetic field intensity transitions and gating by a controlled clock.

Isolated Pulse

A pulse free from the effects of the other pulses in the same signal. (A suitable testing signal is a repetitive pattern of one "one" and seven "zeros.")

Jitter

Short-term variation of the significant instants of a digital signal from their ideal positions in time. Short-term implies that these variations are high frequency (greater than 10 Hz).

LAPD

Link Access Procedure for the D Channel.

Line Loopback

A loopback in which the signal transmitted beyond the loopback point (the forward signal), when the loopback is activated, is the same as the received signal at the loopback point.

Loopback

A state of a transmission facility in which the received signal is returned towards the sender.

Manhole

A sub-surface enclosure which personnel may enter and use for the purpose of installing, operating, maintaining and repairing communications facilities.

Mbit/s

Megabits per second.

MegaLink Channel Service (MCS)

The DS1 bit stream channelized to the DS0 level.

Multiplex

A technique to use a signal transmission channel to provide several transmission channels, such as by sharing the time of the channel (time-division multiplexing) or superimposing many frequencies at the same time (frequency-division multiplexing) in order that many signal sources and sinks may communicate during a given time period.

Network

A collection of transmission and switching facilities used to establish communications channels.

Network Interface (NI)

The point of demarcation between the Network and the CI.

Open Systems Interconnection (OSI)

A model used to describe layered network architecture. OSI has seven layers that define categories of modularized functions that are provided by hardware and software.

Payload

The 192 information bits of a DS1 frame.

Pulse Density

A measure of the number of “ones” (marks, pulses) in relation to the total number of digit time slots transmitted.

Quasi-Ransom Signal (QRS)

A signal consisting of a bit sequence which approximates a random signal.

Regenerator

Equipment that reconstructs and retransmits a received pulse train.

Serial

Pertaining to the sequential or consecutive occurrence of two or more related activities in a single device or channel. In the telecommunications network, binary digital data is transmitted serially.

Terminal Equipment (TE)

Equipment which originates or terminates signals at the specified rate.

T1 Line

A full duplex digital transmission facility that is composed of two twisted metallic pairs and regenerators that carry one DS1 signal.

Unit Interval

The nominal difference in time between consecutive significant instants of an isochronous signal.

Voice Grade Channel

A channel with frequency response characteristics such that it effectively transmits voice frequency signals. Such a channel will provide a passband of approximately 300 Hz to 3000 Hz.

Wander

Long-term variations of the significant instants of a digital signal from their ideal positions in time. Long-term implies that these variations are low frequency (less than 10 Hz).

ZBTSI (Zero-Byte Time Slot Interchange)

A technique used on a DS1 signal to ensure that pulse density requirements are met, where zero octets are replaced by an address chain which is decoded by the receiving terminal.

8. REFERENCES

ANSI T1.101–1987, Synchronization Interface Standards for Digital Networks.

ANSI T1.102–1987, Digital Hierarchy – Electrical Interfaces.

ANSI T1.107–1988, Digital Hierarchy – Formats Specifications.

ANSI T1.107a–1990, Digital Hierarchy – Supplement to Formats Specifications (DS3 Format Applications)

ANSI T1 107b–1991, Digital Hierarchy – Supplement to Formats Specifications (Synchronous Digital Data Format).

ANSI T1.403–1989, Carrier–to–Customer Installation – DS1 Metallic Interface

Code of Federal Regulations, Title 47, FCC Rules and Regulations, Part 68, Revised December, 1987.

Rules and Regulations, Part 68, Federal Communications Commission.

BellSouth TR 53545 SynchroNet Service Network Interface Specifications, Issue C, November, 1992.

Bellcore TR–EOP–000001 Lightning, Radio Frequency and 60 Hz Disturbances at the Bell Operating Company Interface, Issue 2, June, 1987.

Bellcore TR–NWT–000063 Network Equipment – Building System (NEBS) Generic Requirements, Issue 4, July, 1991.

ANSI/NFPA 70 National Electric Code.

Bellcore TR–TSY–000191 Alarm Indication Signals Requirements and Objectives, Issue 1, May, 1986.

Bellcore TR–NWT–000341 Digital Data Special Access Service Transmission Parameter Limits and Interface Combinations, Issue 2, February, 1993.

Bellcore TA–NPL–000436 Digital Synchronization Network Plan, Issue 1, November, 1986.

Bellcore SR–STS–000307 Industry Support Interface (ISI): NC/NCI Code Dictionary, Issue 3, January, 1992.

Bellcore PUB 43801 Digital Channel Bank Requirements and Objectives, November, 1982.

Bellcore TR–TSY–000499 Transport Systems Generic Requirements (TSGR), Common Requirements, Issue 4, November, 1991.

BellSouth TR 73525 MegaLink and MegaLink Channel Service Exchange Network Interface Specifications, Issue B, September, 1992.

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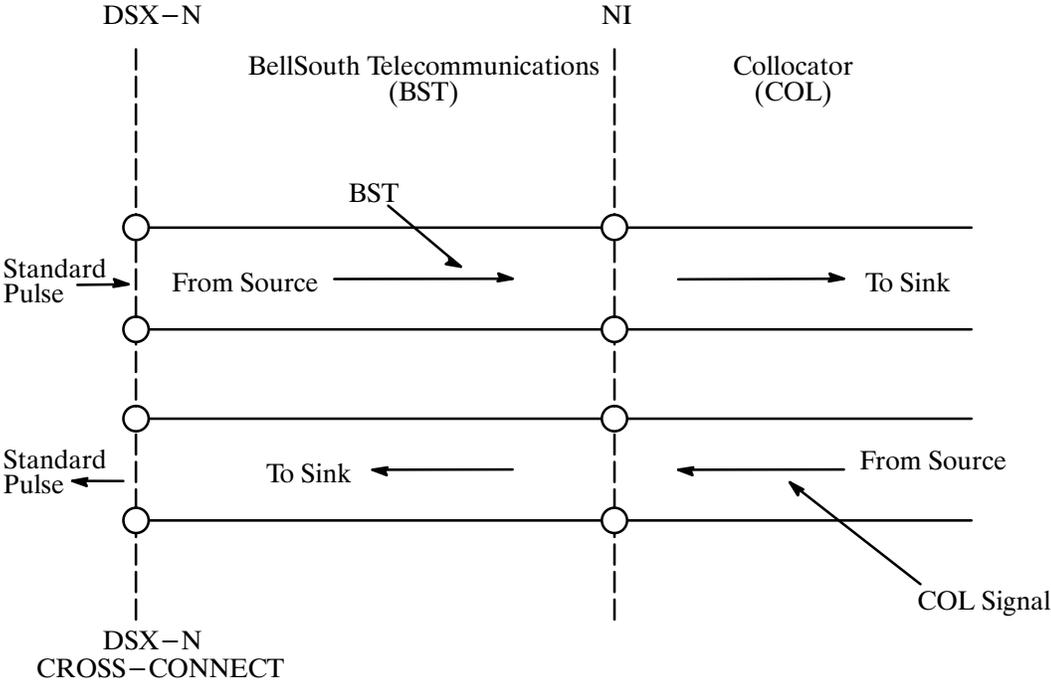
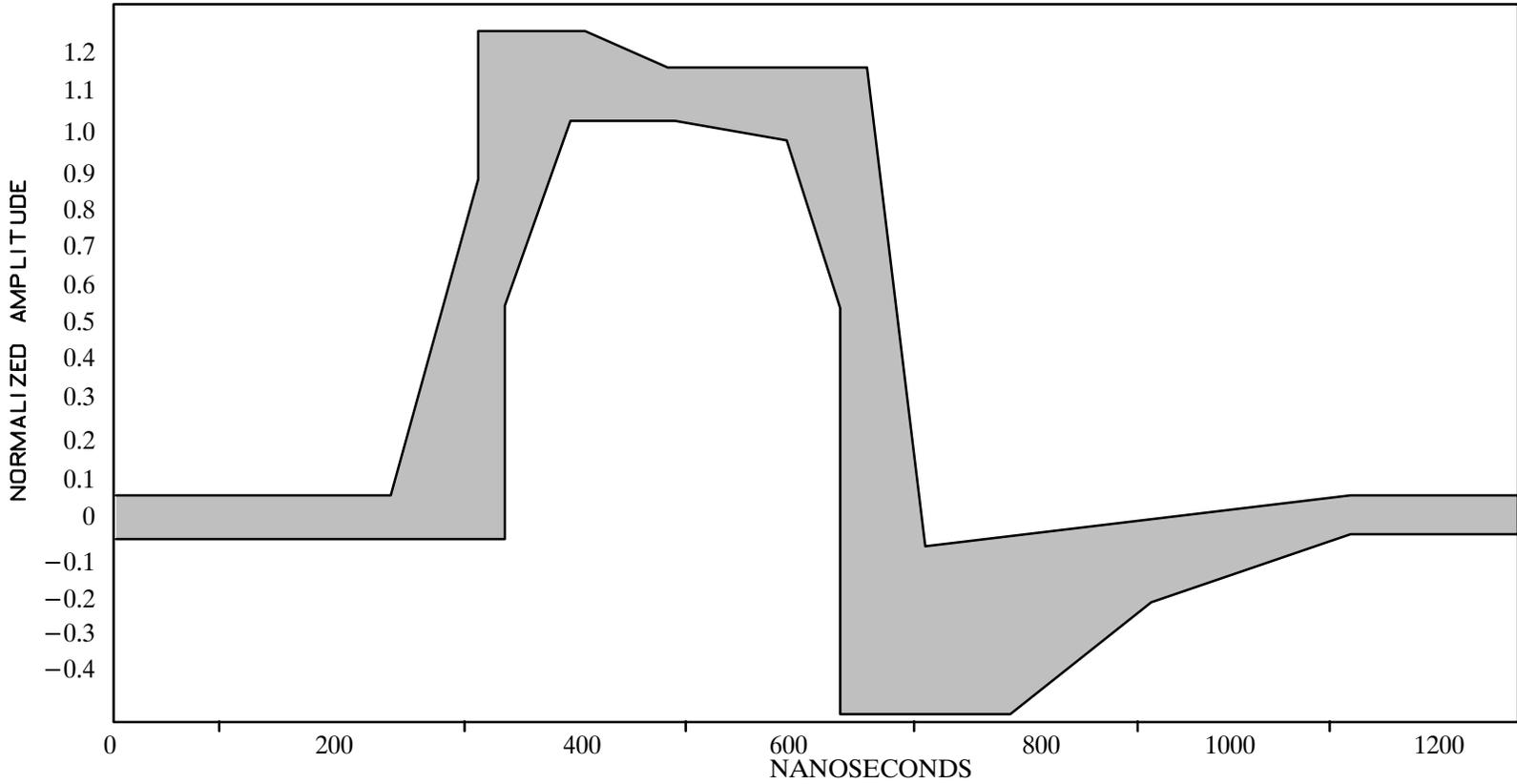


FIGURE 1 – NETWORK INTERFACE

FIGURE 2 – DSX-1 PULSE TEMPLATE CORNER POINTS –
RECOMMENDED FOR NEW EQUIPMENT



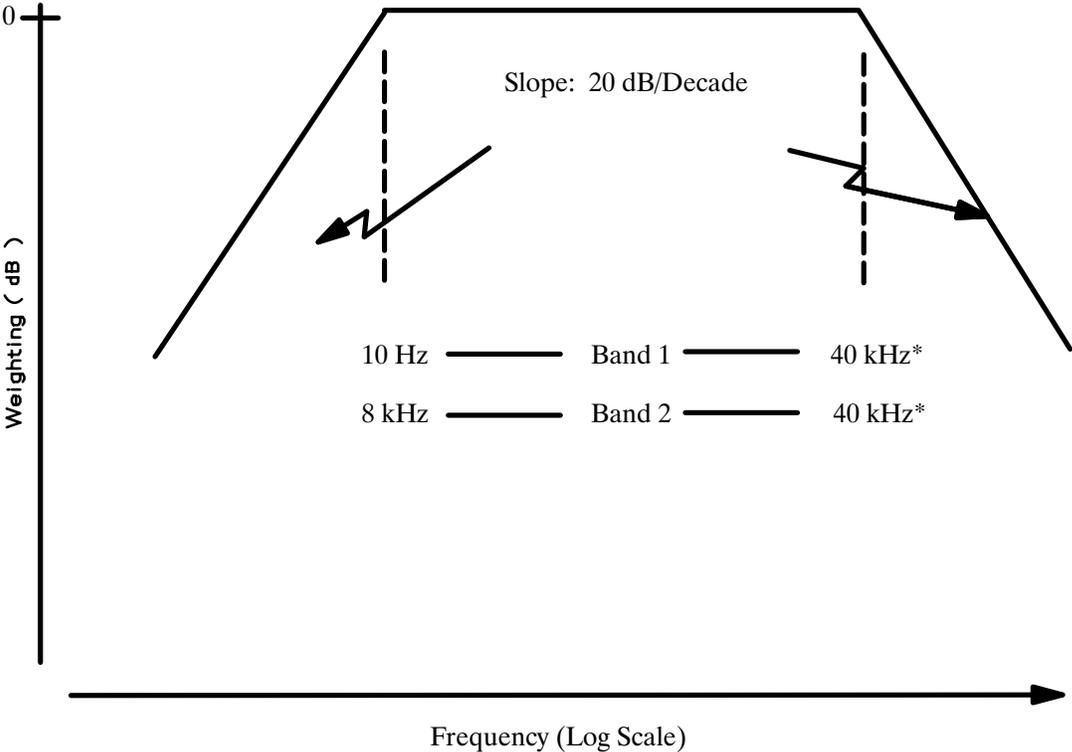
Minimum Curve

- (0, -0.05)
- (350, -0.05)
- (350, 0.5)
- (400, 0.95)
- (500, 0.95)
- (600, 0.9)
- (650, 0.5)
- (650, -0.45)
- (800, -0.45)
- (925, -0.2)
- (1100, -0.05)
- (1250, -0.05)

Minimum Curve

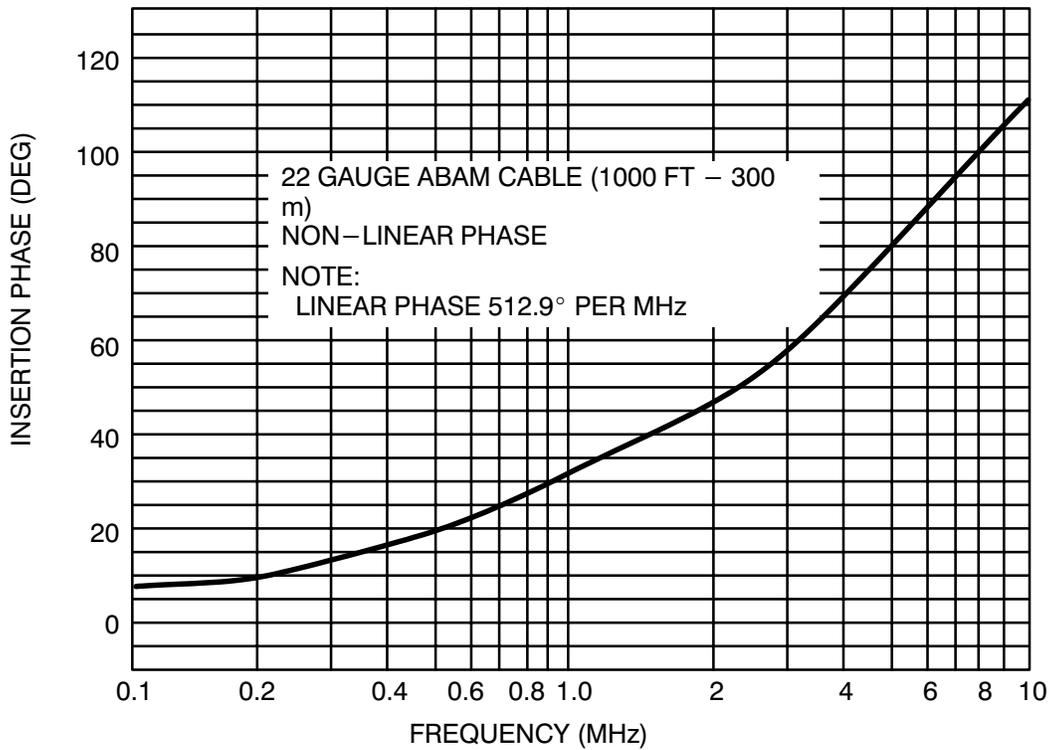
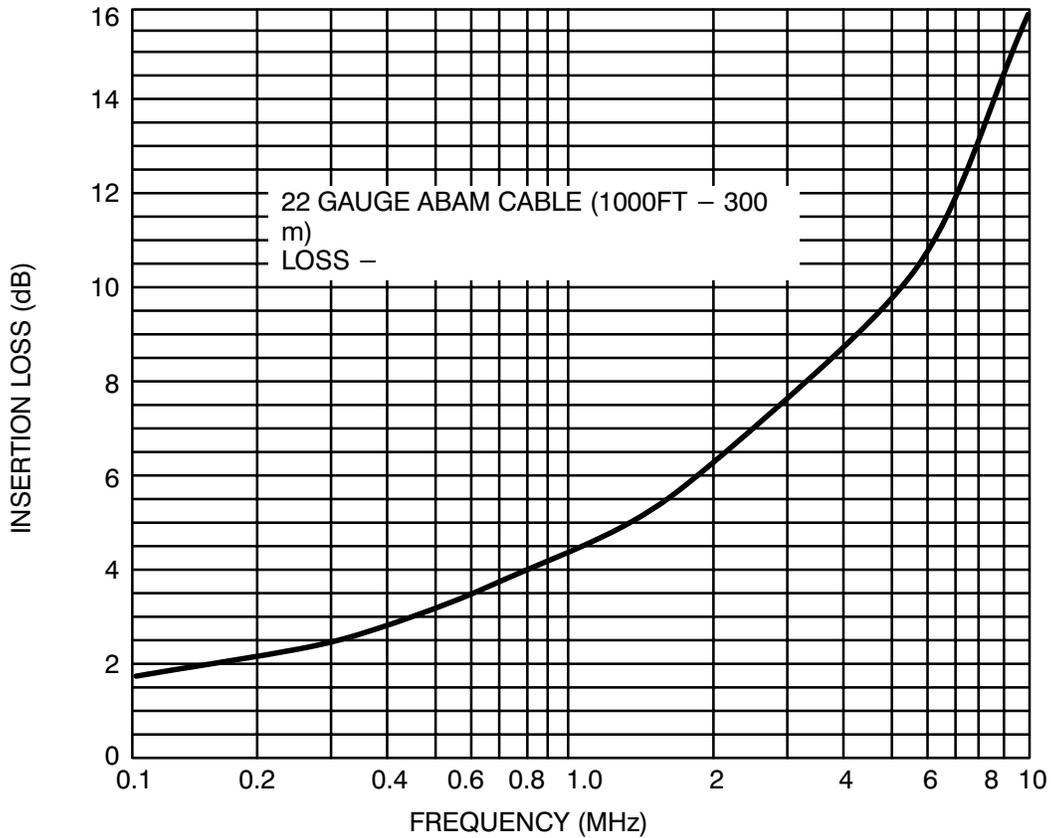
- (0, 0.05)
- (250, 0.05)
- (325, 0.8)
- (325, 1.15)
- (425, 1.15)
- (500, 1.05)
- (675, 1.05)
- (725, -0.07)
- (1100, 0.05)
- (1250, 0.05)

Successive corner points are joined by straight lines to form the template.



* 40 kHz represents the current upper limit for the bands 1&2 cutoff frequency based on current test equipment.

FIGURE 3 – FREQUENCY WEIGHTING FUNCTIONS FOR DS1 JITTER SPECIFICATIONS



NOTE: The charts show the insertion loss and phase of 1000 feet (300 meters) of 22 AWG PIC construction with overall outer shield (AKA 22 AWG ABAM, or equivalent). For DS1, reference length is 655 feet (200 meters); indicated loss in dB and phase should be decreased by 1/3.

FIGURE 4 – INSERTION LOSS AND PHASE OF REFERENCE CABLE FOR DS1

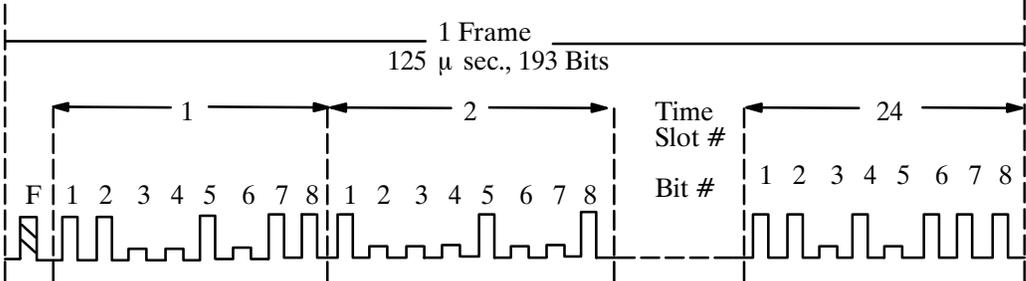
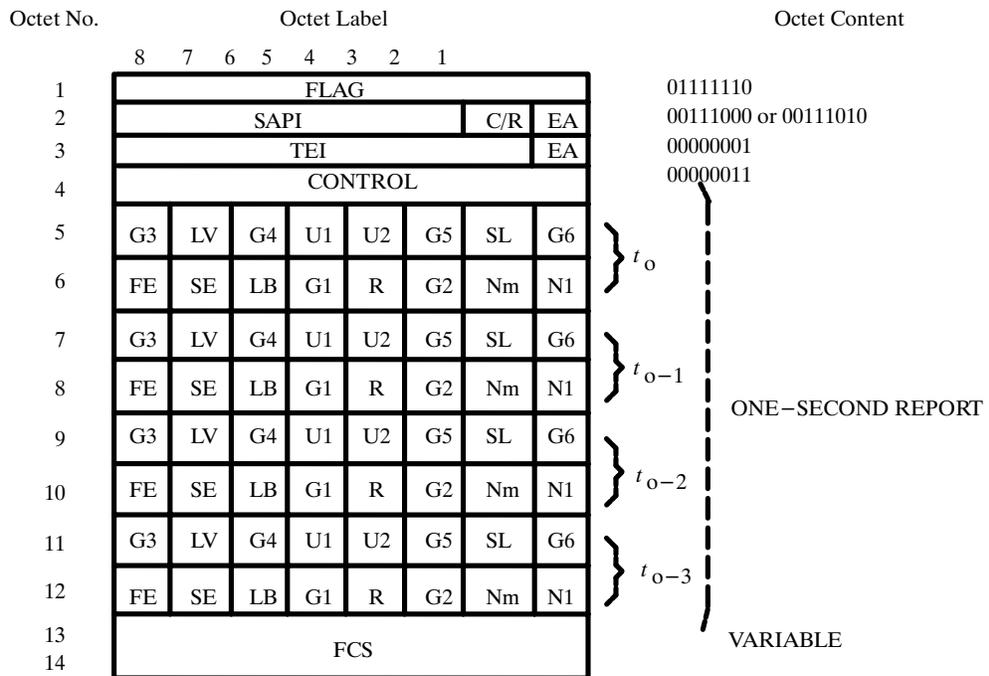


FIGURE 5 – CHANNELIZED DS1 FRAME BIT ASSIGNMENTS



ADDRESS

00111000
00111010
00000001

INTERPRETATION

SAPI=14, C/R=0 (CI) EA=0
SAPI=14, C/R=1 (Carrier) EA=0
TEI=0, EA=1

CONTROL

00000011

INTERPRETATION

Unacknowledged Information Transfer

ONE-SECOND REPORT

G1 = 1
G2 = 1
G3 = 1
G4 = 1
G5 = 1
G6 = 1

INTERPRETATION

CRC Error Event = 1
1 < CRC Error Event ≤ 5
5 < CRC Error Event ≤ 10
10 < CRC Error Event ≤ 100
100 < CRC Error Event ≤ 319
CRC Error Event ≥ 320

SE = 1

Severely-Errored Framing Event ≥ 1 (FE shall=0)

FE = 1

Frame Synchronization Bit Error Event ≥ 1 (SE shall=0)

LV = 1

Line Code Violation Event ≥ 1

SL = 1

Slip Event ≥ 1

LB = 1

Payload Loopback Activated

U1, U2 = 0

Under study for synchronization

R = 0

Reserved (Default value is 0)

NmNl = 00, 01, 10, 11

One-second report module 4 counter

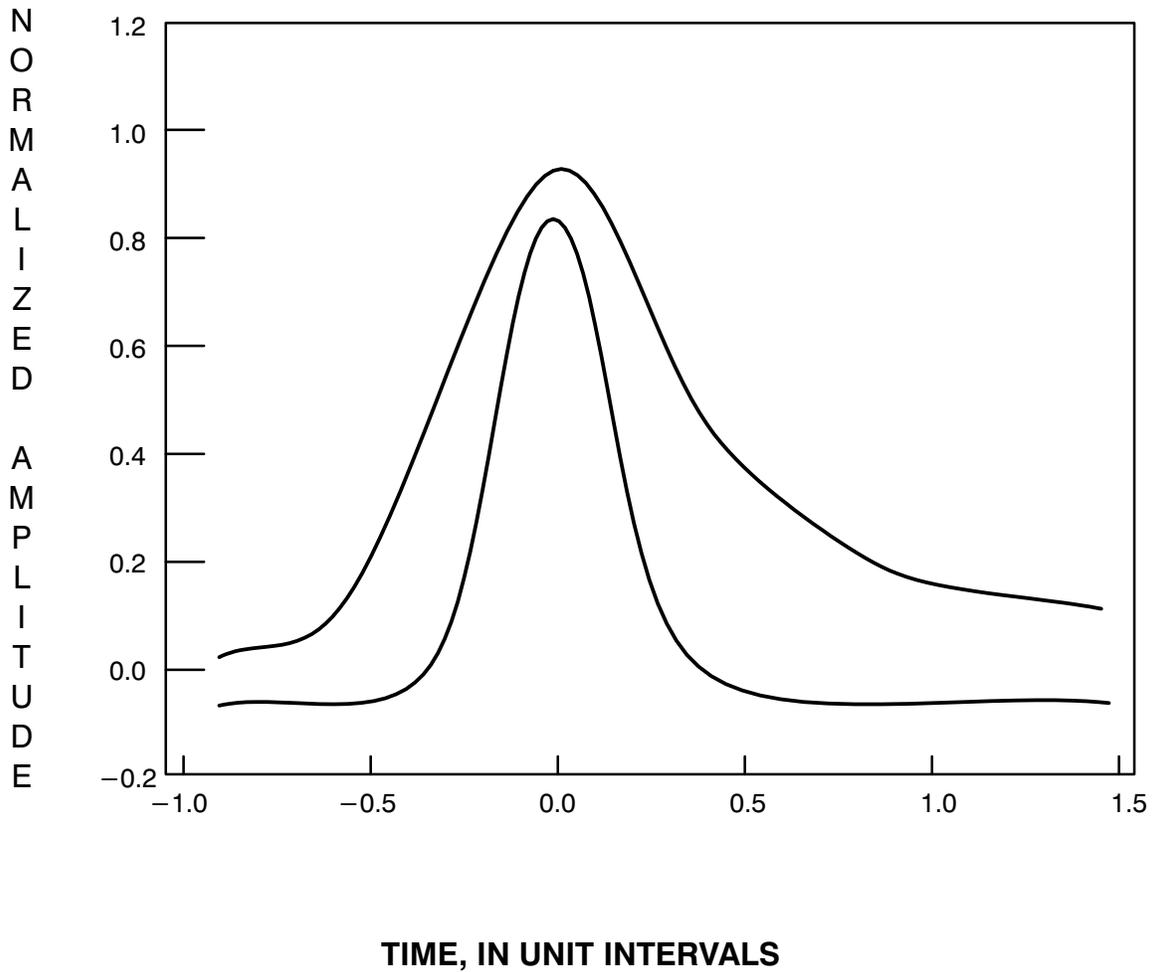
FCS

VARIABLE

INTERPRETATION

CRC16 Frame Check Sequence

FIGURE 6 – PERFORMANCE REPORT MESSAGE STRUCTURE



NI PULSE TEMPLATE BOUNDARIES		
CURVE	TIME UNIT INTERVALS	NORMALIZED AMPLITUDE
MAXIMUM CURVE	$T \leq -0.68$	0.03
	$-0.68 \leq T \leq 0.36$	$0.5 \{ 1 + \sin[(\pi/2) (1 + T/0.34)] \} + 0.03$
	$0.36 \leq T$	$0.05 + 0.407e^{-1.84(T-0.36)}$
MINIMUM CURVE	$T \leq -0.36$	-0.03
	$-0.36 \leq T \leq 0.36$	$0.5 \{ 1 + \sin[(\pi/2) (1 + T/0.18)] \} - 0.03$
	$0.36 \leq T$	-0.03

FIGURE 7 – TEMPLATE FOR ISOLATED DS3 STANDARD PULSE

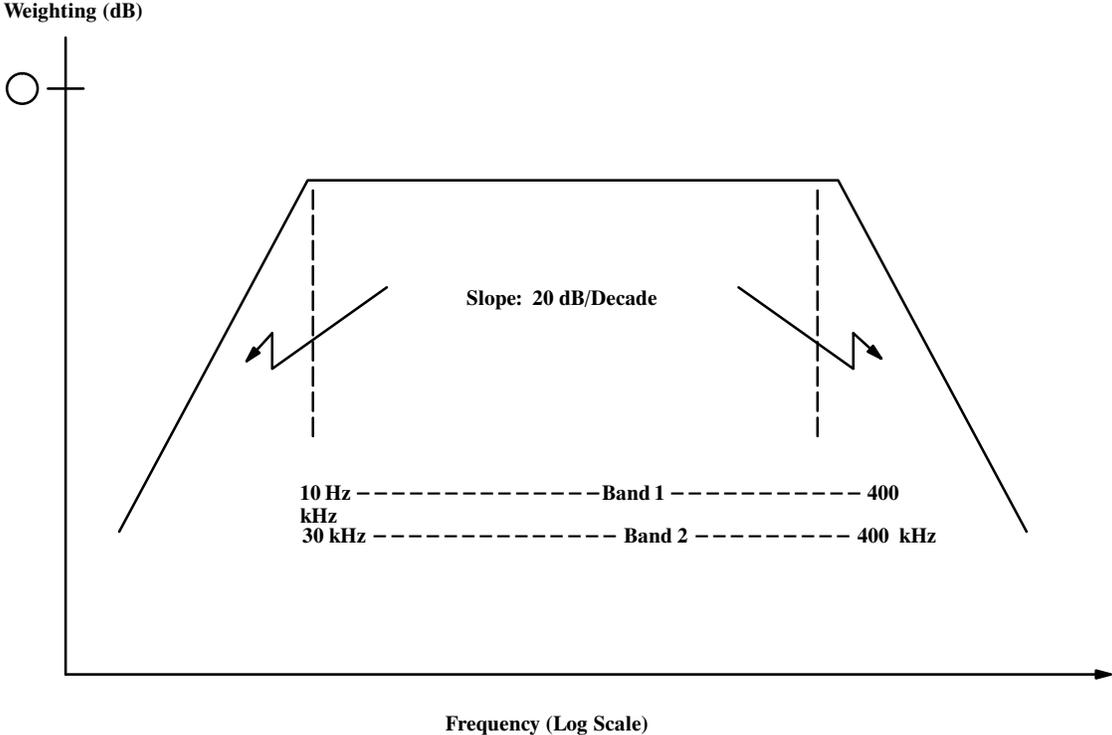


FIGURE 8 – FREQUENCY WEIGHTING FUNCTIONS FOR DS3 JITTER SPECIFICATIONS

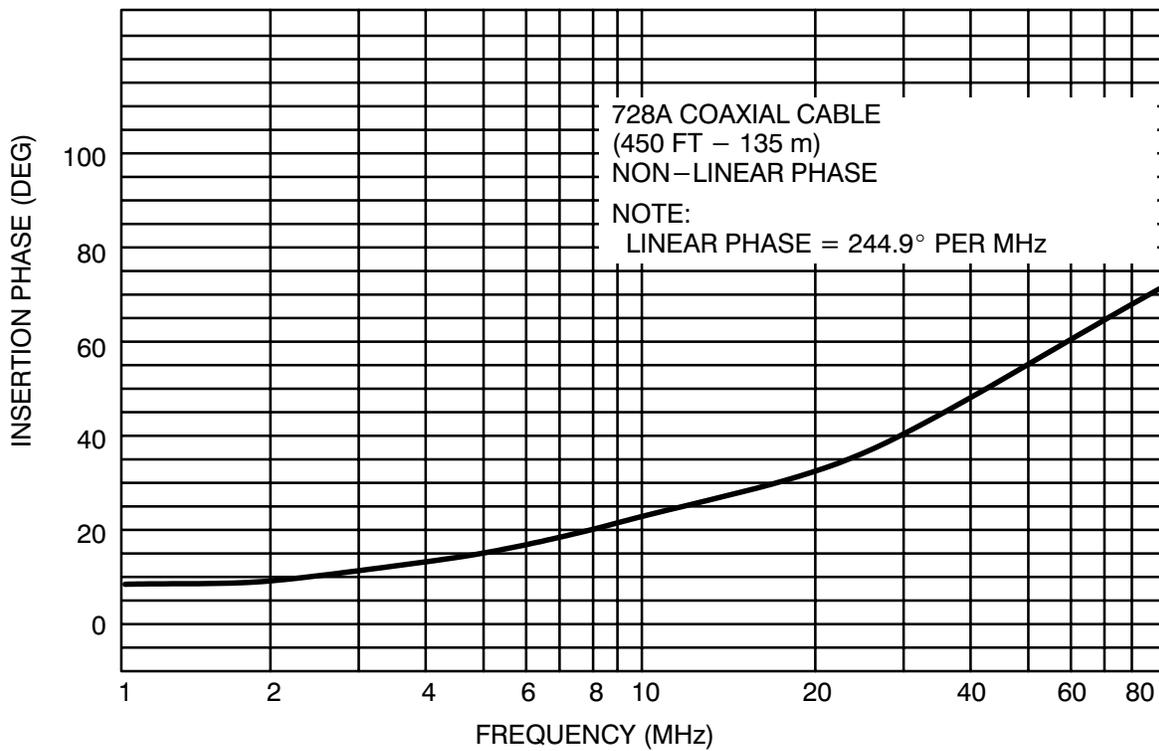
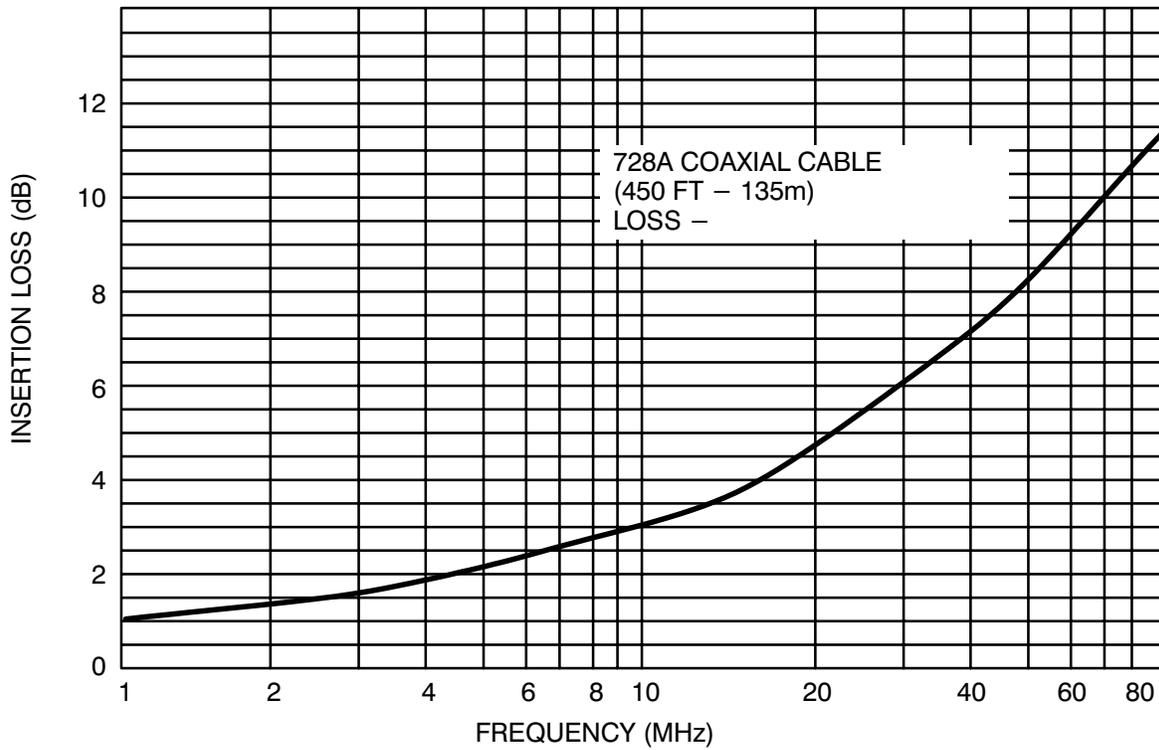
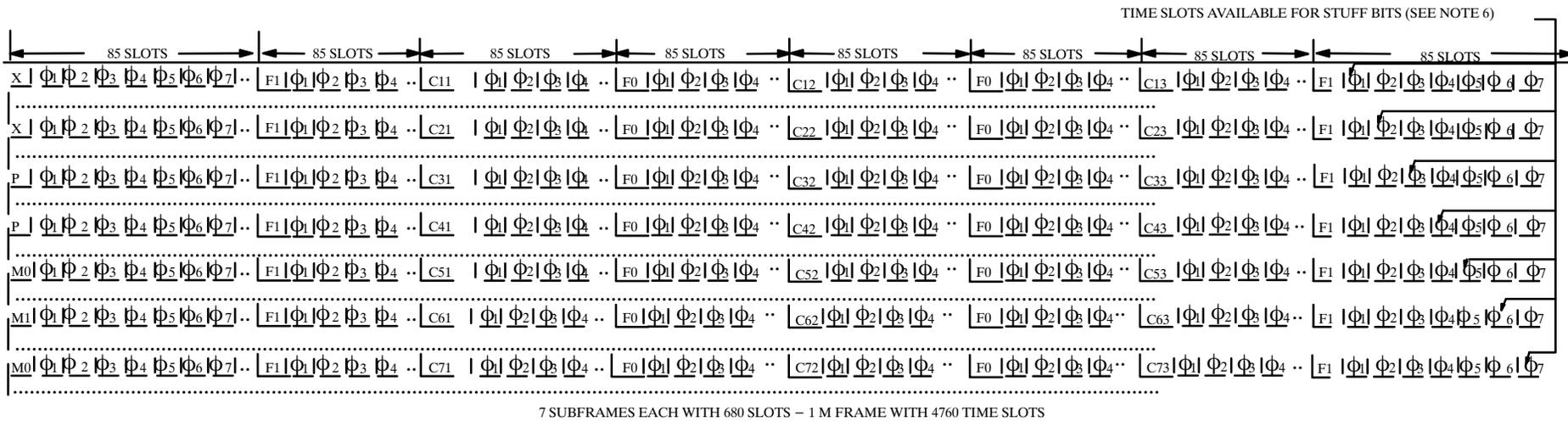


FIGURE 9 - INSERTION LOSS AND PHASE OF REFERENCE CABLE FOR DS3

FIGURE 11 – DS3 SIGNAL FORMAT



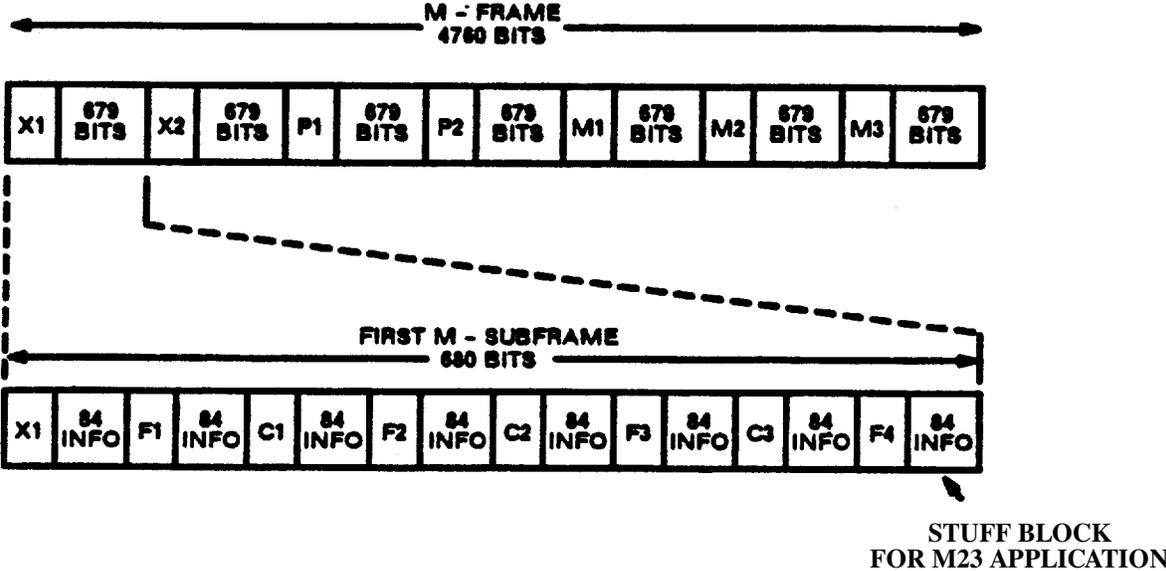
CONTROL BIT SEQUENCE – EACH CONTROL BIT OCCUPIES A CONTROL BIT TIME SLOT

F1 X F1 C11 F0 C12 F0 C13 F1 X F1 C21 F0 C22 F0 C23 F1 P F1 C31 F0 C32 F0 C33 F1 P F1 C41 F0 C42 F0 C43 F1 M0 F1 C51 F0 C52 F0 C53 F1 M1 F1 C61 F0 C62 F0 C63 F1 M0 F1 C71 F0 C72 F0 C73 F1

M FRAME

DS3 NOTES

1. THE INFORMATION BITS FROM INPUTS 1–7 AND THE STUFFED BITS USED TO SYNCHRONIZE EACH OF THE SEVEN INPUTS ARE TO BE ENTERED INTO SLOTS DESIGNATED $\Phi_1, \Phi_2, \Phi_3, \Phi_4, \Phi_5, \Phi_6$ AND Φ_7 .
2. THE M FRAME ALIGNMENT BITS ARE ENTERED INTO THE SLOTS DESIGNATED AS F0 AND F1. THE BITS IN THE F0 SLOTS ARE TO BE ZEROS, THE BITS IN THE F1 SLOTS ARE TO BE ONES.
3. THE MULTIFRAME ALIGNMENT BITS ARE TO BE ENTERED INTO THE SLOTS DESIGNATED AS M0, M1 AND M0, WHERE M0 INDICATES A 0 BIT AND M1 A 1 BIT, GIVING A SIGNAL OF 010.
4. THE TWO SLOTS DESIGNATED AS P ARE USED TO TRANSMIT PARITY INFORMATION. IF THE PARITY COUNT, TAKEN ON THE 4704 INFORMATION TIME SLOTS OF THE PRECEDING M FRAME, IS ODD, I.E. 1, THE TWO P BITS ARE TO BE ONES. IF THE PARITY COUNT IS EVEN, I.E. 0, THE TWO P BITS ARE TO BE ZEROS.
5. THE TWO SLOTS DESIGNATED AS X ARE USED AS CONDITION INDICATOR X BITS. THEY MUST ALWAYS BE IDENTICAL. I.E. 11 OR 00.
6. THE STUFF INDICATOR BITS ARE ENTERED INTO THE SLOTS DESIGNATED AS C11, C12, C13, ETC. THE BITS ENTERED INTO THESE THREE C SLOTS IN EACH SUBFRAME ARE USED TO INDICATE THE NATURE OF THE BIT PLACED IN THE TIME SLOT AVAILABLE FOR THE STUFF BIT IN THAT SUBFRAME. IF ALL THREE, OR TWO OUT OF THREE, C BITS ARE ONES, THEN THE BIT IN THE SLOT AVAILABLE FOR THE STUFF BIT IS A STUFF BIT. (THE INPUT STUFFED IS INDICATED BY THE Φ DESIGNATION. Φ_1 IS A SLOT FOR STUFFING INPUT ONE, ETC.). IF ALL THREE, OR TWO OUT OF THREE, C BITS ARE ZEROS, THEN THE BIT IN THE SLOT AVAILABLE FOR THE STUFF BIT IS AN INFORMATION BIT.



M – FRAME OVERHEAD BIT SEQUENCE
56 OVERHEAD BITS OCCUPIES SEQUENTIAL OVERHEAD BIT POSITIONS AS FOLLOWS

M-Subframe 1	X1,	F1,	C1,	F2,	C2,	C3,	F4,
M-Subframe 2	X2,	F1,	C1,	F2,	C2,	C3,	F4,
M-Subframe 3	P1,	F1,	C1,	F2,	C2,	C3,	F4,
M-Subframe 4	P2,	F1,	C1,	F2,	C2,	C3,	F4,
M-Subframe 5	M1,	F1,	C1,	F2,	C2,	C3,	F4,
M-Subframe 6	M2,	F1,	C1,	F2,	C2,	C3,	F4,
M-Subframe 7	M3,	F1,	C1,	F2,	C2,	C3,	F4,

NOTES:

- (1) See ANSI T1.107 for description of X1 and X2 bits.
- (2) See ANSI T1.107 for description of P1 and P2 bits.
- (3) The M-frame alignment signal is M1 = 0, M2 = 1, and M3 = 0.
- (4) The M-subframe alignment signal is F1 = 1, F2 = 0, F3 = 0, and F4 = 1.
- (5) C1, C2, and C3 bit positions are available for application specific use.

FIGURE 10 – DS3 FRAME STRUCTURE

THIS FIGURE IS LABELED TR73572F11 IN A SEPARATE DOCUMENT

FIGURE 11 – DS3 SIGNAL FORMAT

Table 1. Quasi–Random Signal

The quasi–random signal is a 1,048,575–bit sequence generated by a 20–stage shift register with feedback taken from the 17th and 20th stages. The output signal is taken from the 20th stage, and an output bit is forced to be “one” whenever the next 14 bits are all “zero.” The QRS is used for maintenance and other purposes.

The quasi–random sequence satisfies the following:

$$Q_{n+1}(k + 1) = Q_n(k), n = 1, 2, \dots, 19,$$

$$Q_1(k + 1) = Q_{17}(k) \oplus Q_{20}(k), \text{ and}$$

$$RD(k) = Q_{20}(k) + \overline{Q_6(k)} + \dots + \overline{Q_{19}(k)}$$

where

$Q_n(k)$ = Present state for nth stage

$Q_n(k + 1)$ = Next state for nth stage

$RD(k)$ = Present value of output

$+$ = a logic OR operation

\oplus = a logic EXCLUSIVE OR
(modulo– two– addition) operation

$\overline{\quad}$ = a logic NEGATION operation

CIs transmitting the QRS to the NI should transmit the QRS in the 1.536 Mb/s payload; the carrier may transmit the QRS either framed or unframed to the NI.

Table 2. Superframe Format

FRAME NO	F BITS			BIT USE IN EACH TIME SLOT		SIGNALING BIT USE OPTIONS	
	BIT NO	TERM FRAM F_t	SIG FRAM F_s	TRAFFIC	SIG	T	SIGNALING CHANNEL
1	0	1	–	1–8	–		
2	193	–	0	1–8	–		
3	386	0	–	1–8	–		
4	579	–	0	1–8	–		
5	772	1	–	1–8	–		
6	965	–	1	1–7	8	–	A
7	1158	0	–	1–8	–		
8	1351	–	1	1–8	–		
9	1544	1	–	1–8	–		
10	1737	–	1	1–8	–		
11	1930	0	–	1–8	–		
12	2123	–	0	1–7	8	–	B

Notes: **Frame 1 transmitted first.**
Frames 6 and 12 are denoted signaling frames.
Option T – Traffic (bit 8 not used for robbed bit signaling)

Table 3. Extended Superframe Format

FRAME NO	F BITS				BIT USE IN EACH TIME SLOT		SIGNALING BIT USE OPTIONS			
	BIT NO	FPS	DL	CRC	TRAFFIC	SIG	T	2	4	16
1	0	–	m	–	1–8	–				
2	193	–	–	C1	1–8	–				
3	386	–	m	–	1–8	–				
4	579	0	–	–	1–8	–				
5	772	–	m	–	1–8	–				
6	965	–	–	C2	1–7	8	–	A	A	A
7	1158	–	m	–	1–8	–				
8	1351	0	–	–	1–8	–				
9	1544	–	m	–	1–8	–				
10	1737	–	–	C3	1–8	–				
11	1930	–	m	–	1–8	–				
12	2123	1	–	–	1–7	8	–	A	B	B
13	2316	–	m	–	1–8	–				
14	2509	–	–	C4	1–8	–				
15	2702	–	m	–	1–8	–				
16	2895	0	–	–	1–8	–				
17	3088	–	m	–	1–8	–				
18	3281	–	–	C5	1–7	8	–	A	A	C
19	3474	–	m	–	1–8	–				
20	3667	1	–	–	1–8	–				
21	3860	–	m	–	1–8	–				
22	4053	–	–	C6	1–8	–				
23	4246	–	m	–	1–8	–				
24	4439	1	–	–	1–7	8	–	A	B	D

- Notes:**
- Frame 1 transmitted first.**
 - Frames 6, 12, 18 and 24 are denoted signaling frames.**
 - FPS – Framing Pattern Sequence (...001011...)**
 - DL – 4kb/s Data Link (Message Bits m)**
 - CRC – CRC–6 Cyclic Redundancy Check (Bits C1–C6)**
 - Option T – Traffic (Bit 8 not used for robbed–bit signaling)**
 - Option 2 – 2–State Signaling (Channel A)**
 - Option 4 – 4–State Signaling (Channels A and B)**
 - Option 16 – 16–State Signaling (Channels A, B, C, and D)**

Table 4. Assigned Bit–Oriented ESF Data Link Messages

Function	Codeword
Priority Messages	
Yellow Alarm (RAI)	0 000000 011111111
Loopback Retention	0 010101 011111111
Command and Response Messages	
Line Loopback (I_a) Activate	0 000111 011111111
Line Loopback (I_a) Deactivate	0 011100 011111111
Line Loopback (I_b) Activate	0 010000 011111111
Payload Loopback Activate	0 001010 011111111
Payload Loopback Deactivate	0 011001 011111111
Network Use (Loopback Activate)	0 001001 011111111
Universal Loopback (Deactivate)	0 010010 011111111
CI (Loopback Activate)	0 010111 011111111
Protection Switch Line 1	0 100001 011111111
Protection Switch Line 2	0 100010 011111111
Protection Switch Line 3	0 100011 011111111
Protection Switch Line 4	0 100100 011111111
Protection Switch Line 5	0 100101 011111111
Protection Switch Line 6	0 100110 011111111
Protection Switch Line 7	0 100111 011111111
Protection Switch Line 8	0 101000 011111111
Protection Switch Line 9	0 101001 011111111
Protection Switch Line 10	0 101010 011111111
Protection Switch Line 11	0 101011 011111111
Protection Switch Line 12	0 101100 011111111
Protection Switch Line 13	0 101101 011111111
Protection Switch Line 14	0 101110 011111111
Protection Switch Line 15	0 101111 011111111
Protection Switch Line 16	0 110000 011111111
Protection Switch Line 17	0 110001 011111111
Protection Switch Line 18	0 110010 011111111
Protection Switch Line 19	0 110011 011111111
Protection Switch Line 20	0 110100 011111111
Protection Switch Line 21	0 110101 011111111
Protection Switch Line 22	0 110110 011111111
Protection Switch Line 23	0 110111 011111111
Protection Switch Line 24	0 111000 011111111
Protection Switch Line 25	0 111001 011111111
Protection Switch Line 26	0 111010 011111111
Protection Switch Line 27	0 111011 011111111
Protection Switch Acknowledge	0 001100 011111111
Protection Switch Release	0 010011 011111111

Table 4. Assigned Bit–Oriented ESF Data Link Messages (Cont'd)

Synchronization	0 011000 011111111
Synchronization	0 000110 011111111
Synchronization	0 010001 011111111
Synchronization	0 010100 011111111

- Notes:**
- (1) **Right–most bit transmitted first.**
 - (2) **The “Protection Switch Line” codes of the form 01XXXXX0 11111111 use the five X–bits to indicate the number of the line, 1 through 27, to be switched to a protection line. Rightmost bit transmitted first.**
 - (3) **The “Line Loopback (I_a) Deactivate” and “Payload Loopback Deactivate” codewords are listed here to be consistent with ANSI T1.403. See ANSI T1.408 Section 8.3.4 for the discussion on the deactivation or line and payload loopbacks for primary rate access.**