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DRAFT AMERICAN NATIONAL STANDARD

TITLE: Network and Customer Installation Interfaces – DS1 Electrical Interface

SOURCE*: T1E1.2 Editor

PROJECT: T1C1-01, Standard for the DS1 Carrier-to-Customer Installation Interface

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ABSTRACT

This standard specifies a DS1-rate electrical interface at the network interface (NI) between the network and a customer installation (CI). It establishes requirements at the NI necessary for compatible operation between a network and the CI. This standard specifies a basic DS1 interface, and provides criteria that is common to a set of standards, the T1.403 series, which define specific DS1 applications. The documents which are included in the T1.403 series (at the time that this document is approved) are listed below:

T1.403.01-199x, "Network and Customer Installation Interfaces - Integrated Services Digital Network (ISDN) Primary Rate Layer 1 Electrical Interface Specification".

T1.403.02-199x, "Network-to-Customer Installation Interfaces - Robbed Bit Signaling State Definitions

This version is intended for use in the preparation of a default ballot, and includes changes made in response to comments received with LB 714. Revisions made by Working Group T1E1.2 at Plano, TX. in December, 1998 are also included.

This version, T1E1.2/99-005R6, does not include revision marks. T1E1.2/99-005R5 is identical, but does include revision marks from –005R4 for use in editing the document.

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T1E1.2/99-005R7
ANSI
T1.403-1999

Revision of
ANSI T1.403-1995

Draft American National Standard
for Telecommunications -

Network and Customer Installation Interfaces-
DS1 Electrical Interface

Secretariat

Alliance for Telecommunications Industry Solutions

Approved Month __, 19__

American National Standards Institute, Inc

Abstract

This standard specifies a DS1-rate electrical interface at the network interface (NI) between the network and a customer installation (CI). Requirements include electrical characteristics, format parameters, and physical characteristics at the NI. This standard provides NI compatibility information and is not meant to be an equipment specification. This standard is a revision of T1.403-1995, and replaces it in its entirety.

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FOREWORD (This foreword is not part of American National Standard T1.403 -199x.)

This American National Standard is one of a series of network and customer installation interface standards developed by Technical Subcommittee T1E1 of Accredited Standards Committee T1, Telecommunications. Committee T1 standards serve the public through improved understanding between carriers, customers, and manufacturers.

This standard specifies a basic DS1 interface, and provides criteria that is common to a set of standards, the T1.403 series, which define specific DS1 applications. The documents which are included in the T1.403 series (at the time that this document is approved) are listed below:

T1.403.01-199x, "Network and Customer Installation Interfaces - Integrated Services Digital Network (ISDN) Primary Rate Layer 1 Electrical Interface Specification".

T1.403.02-199x, "Network-to-Customer Installation Interfaces - Robbed Bit Signaling State Definitions

This standard will be useful to anyone engaged in the provisioning or operation of telecommunications equipment or DS1 services that share a boundary at the interface between the customer installation and the network, designated as the DS1 network interface. This standard establishes the requirements for the interface and connection of a customer installation with the public switched telephone network at the DS1 rate. This standard is intended to be a living document, subject to revision and updating as warranted by advances in network and equipment technology.

Compliance with this standard should provide interface compatibility in most installations, but this standard does not guarantee compatibility or acceptable performance under all operating conditions. In some cases, location-oriented options are needed to ensure compatibility; this need for options is imposed by significant differences between carriers as well as between network elements.

ANSI guidelines specify two categories of requirements: mandatory and recommended. The mandatory requirements are designated by the word "shall" and recommendations by the word "should." Mandatory requirements generally apply to signaling and compatibility by specifying absolute, acceptable limits in these areas; advisory requirements generally refer to optional features.

This standard has eleven annexes. Six are normative and are part of this standard; that is, these annexes include requirements that are a part of the specifications of this standard. Five are informative and are not considered part of this standard; that is, these annexes do not include requirements for the interface, but provide information about the interface specified by this standard.

Suggestions for improvement of this standard are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, Suite 500, 1200 G St NW, Washington, DC 20005.

This standard was processed and approved for submittal to ANSI by Accredited Standards Committee on Telecommunications, T1. Committee approval of the standard does not necessarily imply that all members voted for its approval. At the time it approved this standard, the T1 Committee had the following members:

, Chair

, Vice-Chair

, Director ,

Technical Subcommittee T1E1 on Interfaces, Power and Protection of Networks, which is responsible for the development of this standard, had the following members:

, Chair

, Vice-Chair

, Secretary

Working Group T1E1.2 on Wideband Access Interfaces, which developed this standard, had the following participants:

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Draft American National Standard
for Telecommunications -

Network and Customer Installation Interfaces DS1 Electrical Interface

1. Scope

This standard specifies a DS1-rate electrical interface at the network interface (NI) between the network and a customer installation (CI). It establishes requirements at the NI necessary for compatible operation between a network and the CI. This standard specifies a basic DS1 interface, and provides criteria that is common to a set of standards, the T1.403 series, which define specific DS1 applications. The documents which are included in the T1.403 series (at the time that this document is approved) are listed below:

T1.403.01-199x, "Network and Customer Installation Interfaces - Integrated Services Digital Network (ISDN) Primary Rate Layer 1 Electrical Interface Specification".

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NOTE – The user's attention is called to the possibility that compliance with this standard may require use of an invention covered by patent rights. By publication of this standard, no position is taken with respect to the validity of this claim or of any patent rights in connection therewith. The patent holder has, however, filed a statement of willingness to grant a license under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license. Details may be obtained from the standards developer(s).

The requirements in this standard specify a functional and practical interface; compliance with the requirements provides a satisfactory interface in a high percentage of installations. If cases arise that have not been adequately addressed in this standard, any resulting problems should be resolved through the cooperation of the customer, the carrier, and the equipment supplier.

The signals at the NI that are described in this standard are of two types:

- normal operating signals;
- maintenance signals.

This standard covers a 4-wire DS1 interface based on the various metallic digital facilities currently in use. Physical arrangements, electrical parameters, signal formats, and maintenance protocols are described.

2. Normative references

The following standards contain provisions that, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standard listed below.

– ANSI T1.102-1993, *Telecommunications — Digital hierarchy — Electrical interfaces*

- ITU-T, Recommendation Q.921, *ISDN user ¾ Network interface data link layer specification*.[1]

– ANSI T1.231-1997, *Telecommunications — Digital hierarchy — Layer 1 in-service digital transmission performance monitoring*.

ANSI T1.646-1995, *Broadband ISDN - Physical Layer Specification for User-Network Interfaces Including DS1/ATM.*

3. Definitions, Abbreviations and Acronyms

3.1 Definitions

3.1.1 alarm indication signal (AIS):

A signal transmitted in lieu of the normal signal to maintain transmission continuity and to indicate to the receiving equipment that there is a transmission interruption located either at the equipment originating the AIS signal or upstream of that equipment.

3.1.2 alternate mark inversion (AMI):

A line code that employs a ternary signal to convey binary digits, in which successive binary ones are represented by signal elements that are normally of alternating positive and negative polarity and of equal amplitude, and in which binary zeros are represented by signal elements that have zero amplitude. North American implementations use signal elements representing binary ones that are non-zero for only half the unit interval (50% duty cycle).

3.1.3 bipolar violation (BPV):

A non-zero signal element in an AMI signal that has the same polarity as the previous non-zero signal element.

3.1.4 bipolar with 8-zero substitution (B8ZS):

An AMI line code with the substitution of a unique code to replace occurrences of eight consecutive zero signal elements. Each block of eight successive zeros is replaced by 000VB0VB, where B represents an inserted non-zero signal element conforming to the AMI rule, and V represents an inserted non-zero signal element that is a bipolar violation.

3.1.5 carrier:

An organization that provides telecommunications service to the public.

3.1.6 channelized:

A DS1 frame is said to be channelized if the payload digit time slots are assigned in a fixed pattern to signal elements from more than one source, each operating at a slower digital rate.

3.1.7 channel time slot:

A time slot occupying a specified position in a frame and allocated to a particular time-derived channel containing multiple digit time slots.

[1] Available from the American National Standards Institute, 11 West 42nd Street, New York, NY 10036.

3.1.8 CI/CSU loopback:

A complete, transparent line loopback, located in the NT1 or CSU in the customer installation and immediately in front of the NI, in which the full 1.544 Mb/s bit stream is returned towards the source. The CI/CSU loopback can only be activated from within the CI.

3.1.9 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.

3.1.10 complete loopback:

A loopback which operates on the full bit stream. At the loopback point, the received bit stream shall be transmitted back towards the transmitting station without modification of the logical content of the signal.

3.1.11 customer installation (CI):

The arrangement of equipment and wiring on the customer's premises that is the responsibility of the customer.

3.1.12 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.

3.1.13 channel:

A channel is defined as one or more digital time-slots established to provide a communications path between a message source and its destination. For the case when the 192 payload bits represent 24, 8-bit channel time slots, making up 24 individual 64 kb/s (DS0) bit streams, each DS0 is referred to as a DS0 channel.

3.1.14 digit time slot:

A time slot allocated to a single binary digit.

3.1.15 digital signal level 0 (DS0):

A digital signal transmitted at the nominal rate of 64 kb/s.

3.1.16 digital signal level 1 (DS1):

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

3.1.17 excessive zeros (EXZ):

An EXZ for an AMI-coded signal is the occurrence of any zero-string length greater than 15 contiguous zeros. An EXZ for a B8ZS-coded signal is the occurrence of any zero-string length greater than seven contiguous zeros.

3.1.18 High-level data link control (HDLC):

A very common bit-oriented data link protocol (OSI layer 2) standardized by ISO.

3.1.19 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.

3.1.20 ISDN line loopback:

A complete, transparent loopback, located in the NT2 in the customer installation, in which the signal is returned towards the source. The ISDN line loopback can only be activated from within the CI.

3.1.21 isochronous:

A signal characteristic such that the time intervals between successive significant instants (zero level crossings) either have the same duration or durations that are integral multiples of the shortest duration.

3.1.22 isolated pulse:

A pulse free from the effects of other pulses in the same signal. (A suitable testing signal for DS1 is a pulse preceded by at least four zeros and followed by at least one zero.)

3.1.23 jitter:

The short term variations of the significant instants (e.g. zero level crossings) of a digital signal from their ideal positions in time. Short term implies phase variations of frequency greater than or equal to 10 Hz. Jitter may lead to crosstalk, or distortion, or both, of the original analog signal, and is a potential source of bit errors at the ports of digital switches.

3.1.24 line build-out network (LBO):

An electrical network used to increase the electrical length of a cable section.

3.1.25 line loopback:

A complete loopback in which the signal returned toward the source of the loopback command consists of the full 1.544 Mbit/s signal with (1) bit sequence integrity maintained, (2) no change in framing, and (3) no removal of bipolar violations.

3.1.26 loopback:

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

3.1.27 network:

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

3.1.28 network interface (NI):

The point of demarcation between the network and the Customer Installation.

3.1.29 non-transparent loopback:

A loopback in which the signal transmitted beyond the loopback point (the forward signal), when the loopback is activated, is not the same as the received signal at the loopback point.

3.1.30 partial loopback:

A loopback which operates on one or more specified channel time slot multiplexed within the full bit stream.

3.1.31 path:

A path is a framed digital signal between the two points that originate and terminate the framing.

3.1.32 payload:

The 192 information bits of a DS1 frame.

3.1.33 payload loopback:

A loopback in which the signal returned toward the source of the loopback command consists of the payload of the received signal (with bit sequence integrity retained) and newly-generated SF or ESF framing (not necessarily maintaining the integrity of the channel time-slots, frames, or superframes of the received signal). For ESF, the newly-generated data link contains a valid performance report message with a value of one in every LB-labeled bit position for the duration of the loopback indicating the signal is the result of a payload loopback.

3.1.34 pulse density:

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

3.1.35 quasi-random signal (QRS):

A signal derived from a pseudo-random signal (having length 2^n–1 bits that contains every combination of *n*-bit words except for *n* consecutive zeros). In the QRS, logical ones are inserted to break up sequences of contiguous logical zeros longer than *k* bits. For DS1, *n* equals 20 and *k* equals 13.1.

3.1.36 regenerator:

Equipment that reconstructs and retransmits received pulses.

3.1.37 remote alarm indication (RAI):

A signal transmitted in the outgoing direction when a terminal determines that it has lost the incoming signal. RAI is commonly called the Yellow Alarm signal.

3.1.38 repeatered line:

A full-duplex digital transmission facility that carries one DS1 signal in each direction and is composed of two twisted metallic pairs and regenerators.

3.1.39 significant instant:

The instant at which a signal element (pulse) commences in a discretely-timed signal.

3.1.40 stratum level:

Based on performance, the clocks in the synchronization network are classified into four levels, called stratum levels. Stratum 1 is the highest and Stratum 4 is the lowest level of performance.

3.1.41 terminal equipment (TE):

Equipment that originates or terminates signals at the specified rate.

3.1.42 time slot:

Any cyclic time interval that can be recognized and defined uniquely.

3.1.43 transparent 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.

3.1.44 unit interval (UI):

The nominal difference in time between consecutive significant instants (e.g. zero level crossings)of an isochronous signal, for example, the DS1 rate one UI equals 648 ns.

3.1.45 wander:

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

3.2 Abbreviations and Acronyms

AIS	alarm indication signal
AMI	alternate mark inversion
ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
ATM	asynchronous transfer mode
AWG	American wire gauge
BER	bit error ratio
BPV	bipolar violation
CCC	clear channel capability
CGA	carrier group alarm
CI	customer installation
C/R	command/response
CRC	cyclic redundancy check
CSU	channel service unit
dB	decibel
dBm	power level in decibels relative to 1 milliWatt
DC	direct current
DCS	digital cross-connect system
DL	data link

DSU	data service unit
DTE	digital terminal equipment
EA	extended address
EIA	Electronic Industries Association
EIC	equipment identification code
EMC	electromagnetic compatibility
ESF	extended superframe format
EXZ	excessive zeros
FCC	Federal Communications Commission
FCS	frame check sequence
FDL	facility data link
FE	frame synchronization bit error event
FEXT	far-end crosstalk
FI	facility identification
FIC	frame identification code
FPS	framing pattern sequence
ft	foot
HDLC	high-level data link control
Hz	hertz
ISDN	integrated services digital network
ISID	idle signal identification
ISO	International Standards Organization
ITU-T	International Telecommunications Union - Telephone sector
kb/s	kilobits per second
kHz	kilohertz
LAPD	link access procedure on the D channel
LBO	line buildout network
LIC	location identification code

LOF	loss of frame
LOS	loss of signal
ms	milliseconds
mV	millivolts
NE	network element
NCTE	network channel terminal equipment
NI	network interface
NPRM	network performance report message
NT1	network termination 1
NT2	network termination 2
ns	nanoseconds
OOF	out-of-frame
OSI	open systems interface
PBX	private branch exchange
PID	path identification
ppm	parts per million
PRM	performance report message
PRS	primary reference source
RAI	remote alarm indication
SAPI	service access point identifier
SF	superframe format
SPRM	supplementary performance report message
TE	terminal equipment
TEI	terminal endpoint identifier
TIA	Telecommunications Industry Association
TSID	test signal identification
UI	unit interval
µs	microsecond

USOC	universal service ordering code
V	volt
VT	virtual tributary

4. General information

This standard provides NI compatibility requirements and is not an equipment specification. The NI information in this standard complements the equipment information in Part 68, Subpart D, of the FCC Rules and Regulations that contains requirements for the registration of customer-installation equipment to protect the network from harm. Tariffs, contracts, or regulatory acts in various jurisdictions may contain additional or more stringent requirements than those in this standard.

The physical connection of customer-provided equipment is accomplished by means of jacks and plugs described in Part 68, Subpart F, and T1 Technical Report No. 5.

Codeword Messages and bit assignments, including those designated as reserved, shall be changed only by the formulating committee of this standard.

5. Electrical specifications

5.1 General

These electrical specifications apply to the DS1 signals that appear at the NI. A sketch of the NI is shown in Figure 1. The signal crossing the NI from the network toward the CI is identified as the network signal, and the signal crossing the NI from the CI toward the network is identified as the CI signal. At the NI, some of the electrical requirements for the network signal differ from corresponding requirements for the CI signal. The specifications are formulated in terms of two reference signals, one for the network signal, and one for the CI signal. The signal at the NI is made up of the reference signals transmitted through the appropriate attenuation as discussed in 6.3. Measurement techniques are described in ANSI T1.102.

Exchange cables generally used by the carriers in the loop plant are nonloaded, staggered-twist, paired cables. The characteristic impedance of these cable pairs and the impedance of associated terminations, at 772 kHz, is nominally 100 ohms[2].

Table 1 references clauses containing the detailed requirements for both the network reference signal and the CI reference signal. Each of the reference signals shall simultaneously meet all the requirements pointed to in Table 1.

[2] Annex G contains characteristics of network and CI cables. Network cables are typically 100-ohm cables, but embedded in the carriers' plant is a small amount of low-capacitance type cables. The characteristic impedance of these cables at 772 kHz ranges from 120 to 145 ohms. These cables are not standard for this interface and if used are to be handled on an individual basis to ensure that impedance discontinuities do not result in interface reflections great enough to affect performance.

Table 1 - Requirements for reference signals

Requirement	Network reference signal	CI reference signal
Test termination	5.2.1	5.2.1
Test frequency	5.2.2	5.2.2
Transmission rate	5.2.3	5.2.3
Line codes	5.2.4	5.2.4
Pulse shape	5.2.5	5.2.5
Pulse imbalance	5.2.6	5.2.6
60-Hz variations	5.2.7	5.2.7
Power levels	5.2.8	5.2.8
Pulse density	5.2.9	5.2.9
longitudinal balance	6.1.2	6.1.2
Pulse amplitude	6.1.3	6.1.4

5.2 Detailed specifications for reference signal

5.2.1 Test termination

A resistive termination of 100 ohms ± 5% shall be used at the NI for the evaluation of signal characteristics.

5.2.2 Test frequency

A frequency of 772 kHz shall be used for the evaluation of attenuation characteristics.

5.2.3 Transmission rate

The transmission rate of the DS1 signal shall be in the range of 1.544 Mbit/s ± 32 ppm[3] (± 50 bit/s)

5.2.4 Line codes

The line code shall be AMI or B8ZS. The same line code shall be used for both directions of transmission.

5.2.5 Pulse shape

A normalized and isolated pulse (see 3.1.22) shall fit the pulse template shown in figure 2. In judging conformance of an isolated pulse to the mask, the procedures specified in T1.102 for the DS1 rate shall be used.

5.2.6 Pulse imbalance

In any window of 17 consecutive digit time slots, the maximum variation in pulse amplitude shall be less than 200 mV, and the maximum variation in pulse width at half amplitude shall be less than 20 ns.

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[3] Older equipment may have rate variations up to ± 128 ppm (± 200 bit/s).

5.2.7 60-Hz variations in pulse amplitude

The presence of 60-Hz longitudinal currents in the powering loops of line repeaters may cause the pulse amplitude to vary at a 60-Hz rate. When this occurs, the envelope of pulse amplitudes shall be limited as shown in figure 3. Any pulse amplitude in the specified range (6.1.3 for network signals; 6.1.4 for CI signals) may be used for the 100% point in figure 3.

5.2.8 Power level

When an all-ones signal is transmitted, the power in a 3-kHz ± 1-kHz band centered at 772 kHz shall be in the range of 12.4 dBm to 19.7 dBm, and the power in a 3-kHz ± 1-kHz band centered at 1544 kHz shall be at least 25 dB below that at 772 kHz.

5.2.9 Pulse density[4]

Under normal operating conditions (no maintenance or testing activity), a DS1 signal at the NI shall meet the following constraints:

- no more than 15 consecutive zeros;
- at least *N* ones in each and every time window of 8 (*N*+1) digit time slots with *N* taking on all values of 1 to 23.

Test patterns may be transmitted without meeting these pulse density requirements.[5].

NOTE – Specific test patterns have been developed for maintenance and testing of facilities used for DS1 services. Some patterns, while not meeting pulse density requirements, perform specific evaluations of the facility. Network and CI facility performance may be degraded by the use of test patterns that do not meet pulse density requirements. An example of a commonly-used test pattern not meeting the density requirement is the 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, where the output bit is forced to be a "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:

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

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

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

where:

$Q_n(k)$ = Present state for *n*th stage;
$Q_n(k+1)$ = Next state for *n*th stage;
$RD(k)$ = Present value of output;
$+$ = a logic OR operation;
$\oplus$ = a logic EXCLUSIVE OR; (modulo-two-addition) operation;

$(\overline{})$ = a logic NEGATION operation.

When the QRS is transmitted from a CI to the NI, the signal should be structured with valid framing (see clause 7). In this arrangement, the periodic QRS is transmitted at the 1.536 Mbit/s rate. The network may transmit the QRS to the NI either framed or unframed. In the latter case, the QRS is transmitted at the 1.544 Mbit/s rate.

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[4] In the case of DS0 channelization as described in clause 7, and when clear-channel coding is not provided, the contents of an all-zero channel time-slot may be changed by DS1-terminating equipment.

[5] See Committee T1 Technical Report No. 25 for examples of other DS1 test patterns.

6. Receiver impedance and return loss

6.1.1 The nominal terminating impedance at the receiver shall be 100 ohms excluding any protection devices. The return loss of the interface with respect to 100 ohms, over the frequency band from 100 kHz to 1544 kHz, shall be at least 18 dB.

6.1.2 Longitudinal Balance

The longitudinal balance of the impedance to ground of both transmitters and receivers shall be greater than 35 dB over the frequency range of 50 kHz to 1544 kHz when measured with an applied longitudinal voltage having a longitudinal source impedance of 90 ohms and a metallic impedance of 100 ohms. Figure 8 illustrates an example of a measuring circuit.

6.1.3 Network pulse amplitude

An isolated pulse, either positive or negative, shall have a base-to-peak amplitude between 2.25 V and 3.6 V. Pulse amplitude shall be measured at the zero point on the "x" axis of the pulse template provided in figure 2.

6.1.4 CI pulse amplitude

An isolated pulse, either positive or negative, shall have a base-to-peak amplitude between 2.4 V and 3.6 V. Pulse amplitude shall be measured at the zero point on the "x" axis of the pulse template provided in figure 2.

6.2 Signal characteristics at the NI

6.2.1 Network signal characteristics

The network signal at the NI shall be a reference signal (i.e., a signal meeting all the requirements of 5.2.1 through 5.2.9, 6.1.2, and 6.1.3) that has been transmitted through a cable pair with a loss between 0.0 dB and 16.5 dB. The resulting amplitude of an all-ones signal at the NI shall be at least 0.65 V peak-to-peak.

6.2.2 CI signal characteristics

The CI signal level at the NI is dictated by the arrangement of network facilities. Annex H contains additional descriptive information on the relationship between the network facilities and the CI attenuation. The CI signal at the NI shall be a signal that,

- meets the requirements of 5.2.1 to 5.2.9, 6.1.2, and 6.2.4;

- is attenuated as advised by the carrier, using codes A, B, or C. (See Annex H for information on these codes.)

Code A requires that the customer installation implement an attenuation equivalent to the code A line-build-out (LBO) option, i.e., 0 dB. For code A, the resulting range of CI attenuation at 772 kHz shall be 0 to 5.5 dB.

Code B requires that the customer installation implement an attenuation equivalent to the code B line-build-out (LBO) option, i.e., 7.5 dB. For code B, the resulting range of CI attenuation at 772 kHz shall be:

(0 to 5.5 dB) + 7.5 dB = 7.5 to 13.0 dB.

Code C requires that the customer installation implement an attenuation equivalent to the code C line-build-out (LBO) option, i.e., 15 dB. For code C, the resulting range of CI attenuation at 772 kHz shall be:

(0 to 5.5 dB) + 15 dB = 15 to 20.5 dB.

The total CI attenuation is a result of the combined effect of wire, cable, connectors, and LBO networks.

6.3 Jitter, wander, and phase transients

Jitter is short-term variations of the significant instants (e.g. zero level crossings)of a digital signal from their ideal positions in time. Jitter describes variations that occur at a frequency greater than or equal to 10 Hz. Jitter is specified in two frequency bands (band 1 and band 2) whose characteristic weighting functions are specified in figure 4. The magnitude of jitter is specified in terms of unit intervals (UI).

Wander is long-term variation of the same instants. Wander is further categorized as long term (24 hr) and short term (15 min), and the following specifications apply to wander measured against a primary reference source (PRS), as defined in ANSI T1.101. The magnitude of wander is specified in terms of unit intervals (UI).

Phase transients are relatively short duration step functions of the same instants. The duration of phase transients caused by clock switching depends upon the clock stratum level involved. A stratum 4 may have a transient that has a duration in the range of milliseconds to seconds, while a stratum 2 transient may take hours. The duration of phase transients due to SONET pointer adjustments (see 6.3.1.3) is presently undefined, but is expected to be on the order of seconds. Phase transients are specified by maximum phase deviation (in UIs), and by maximum frequency off-set during the transient.

6.3.1 Network signal at the NI

6.3.1.1 Network signal jitter

The jitter of the network signal shall not exceed the following limits:

- *Band 1:* 5.0 UI, peak-to-peak;
- *Band 2:* 0.1 UI, peak-to-peak.

6.3.1.2 Network signal wander

At the NI, the wander of the network signal shall not exceed 28 UI, peak-to-peak, over any 24-hour period; nor shall it exceed 13 UI, peak-to-peak, in any 15-minute interval.

6.3.1.3 Network signal phase transients

At the NI, during the phase transient, the phase deviation shall not exceed 1.5 UI (1 µs)[6] , and the frequency of the signal shall not be offset from the nominal frequency by more than 61 ppm. Such transients shall be isolated in time. (Phase transients are defined in ANSI T1.101 as occurring at a maximum rate of "81 ns for any period of 1.326 ms". This specification was developed prior to the identification of SONET VT1.5 pointer adjustments as a potential source of phase transients of approximately 8 UI (5.2 µs). The scope and details of network and CI phase transient specifications are expected to evolve in the future. In any case, phase slope characteristics of phase transients due to pointer adjustments will be no greater than 61 ppm.

6.3.2 CI signal at the NI

6.3.2.1 CI signal jitter

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[6] These transients are typically due to network clock rearrangements.

The jitter of the CI signal shall not exceed the following limits:

- *Band 1:* 5.0 UI, peak-to-peak;
- *Band 2:* 0.1 UI, peak-to-peak.

The jitter generated by the source equipment within the CI shall not exceed the following limits:

- *Band 1:* 0.5 UI, peak-to-peak;
- *Band 2:* 0.07 UI, peak-to-peak.

6.3.2.2 CI signal wander

At the NI, the wander of the CI signal shall not exceed 28 UI, peak-to-peak, over any 24-hour period; nor shall it exceed 13 UI, peak-to-peak, in any 15-minute interval.

6.3.2.3 CI signal phase transients

At the NI, the phase transient of the CI signal shall not exceed the requirements in 6.3.1.3.

6.4 Powering arrangements

Direct-current power shall not be delivered to the NI by either the CI or the network. The CI shall not apply voltages to the NI other than those described in this standard.

7. Framing formats

7.1 General

The network signal and the CI signal at the NI shall be framed in either the superframe (SF) format or the extended superframe (ESF) format. The same framing format shall be used in both directions of transmission.

7.2 Frame

A frame is a set of 192 digit time-slots for the information payload preceded by one digit time-slot containing the framing (F) bit, for a total of 193 digit time-slots.

7.3 Superframe format

A superframe consists of twelve consecutive frames (see figure 5). 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 (see table 2):

- terminal framing (F_t) bits that are used to identify frame boundaries;
- signaling framing (F_s) bits that are used to identify superframe boundaries. When the 192-digit time-slots are DS0-channelized, the F_s bits are also used to identify signaling frames.

7.4 Extended superframe format

An extended superframe consists of twenty-four consecutive frames (see figure 5). The ESF uses the F bits for the following functions (see table 3):

- *a 2-kb/s framing pattern sequence (FPS):* The FPS is used to identify the frame and the extended superframe boundaries. When the 192-information-digit time-slots are channelized, the FPS is used to identify the signaling frames;
- *a 4-kb/s data link (DL):* Data link functions are specified in 9.5;
- *a 2-kb/s cyclic redundancy check (CRC) channel:* This channel carries a CRC-6 code. The CRC-6 bits transmitted in an ESF shall be determined as follows:
  - The check bits, c1 through c6, contained in ESF(*N*+1) shall always be those associated with the contents of ESF(*N*), the immediately preceding ESF. When there is no ESF immediately preceding, the check bits may be assigned any value.

  - For the purpose of CRC-6 calculation only, every F bit in ESF(*N*) is set to "one". ESF(*N*) is altered in no other way;

  - The resulting 4632 bits of ESF(*N*) are used, in order of occurrence, to construct a polynomial in X such that the first bit of ESF(*N*) is the coefficient of the term X^{4631} and the last bit of ESF(*N*) is the coefficient of the term X^0;

  - The polynomial is multiplied by the factor X^6, and the result is divided, modulo 2, by the generator polynomial $X^6 + X + 1$. The coefficients of the remainder polynomial are used, in order of occurrence, as the ordered set of check bits, c1 through c6, that are transmitted in ESF(*N*+1). The ordering is such that the coefficient of the term X^5 in the remainder polynomial is check bit c1 and the coefficient of the term X^0 in the remainder polynomial is check bit c6.

8. DS1 applications

Certain DS1 applications have additional requirements.

8.1 Clear channel capability

Clear channel capability (CCC), in which a DS1 signal has unconstrained payload bits, shall be provided using B8ZS.

8.2 Primary rate ISDN

The requirements for the primary rate ISDN application shall be as specified in ANSI T1.403. ISDN.

8.3 Robbed-bit signaling

Robbed-bit signaling is a DS1 application that provides a method of per-DS0-channel signaling. The requirements shall be as specified in ANSI T1.403.02. Robbed bit signaling is used to provide address and supervisory information over the DS0 channel.

8.4 Asynchronous transfer mode (ATM)

The requirements for asynchronous transfer mode applications shall be as specified in ANSI T1.646. Future plans call for adding these requirements to the ANSI T1.403. series.

9. Maintenance

9.1 Remote Alarm Indication (RAI)

The Remote Alarm Indication signal was formerly widely known in the industry as the Yellow Alarm. The RAI designation is used in other ANSI standards and ITU-T Recommendations. An RAI signal shall be transmitted in the outgoing direction when DS1 terminal equipment located in either the network or the CI determines that it has effectively lost the incoming signal. The detailed requirements for sending RAI are contained in ANSI T1.231. An RAI signal shall be transmitted across the NI in the following forms:

- *Superframe format*[7] *:* For the duration of the alarm condition, but for at least one second, bit two in every DS0 channel shall be a zero. This arrangement shall be used even if the payload is not channelized;
- *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-ms per interruption (see 9.5.1.1.1 and 9.6);
- *Both formats:* For either framing format, the minimum time between the end of one transmission of RAI and the beginning of another transmission of RAI shall be one second. Certain services provided by the carrier may require longer time intervals than these minimum values, or may require unequal on and off intervals, or both longer intervals and unequal "on" and "off" intervals.

9.2 Alarm indication signal (AIS)

The AIS shall be generated as an unframed, all-ones signal. The detection of the AIS signal is defined in ANSI T1.231. An AIS is transmitted to the NI upon a loss of originating signal, or when any action is taken that would cause a service disruption (e.g., line loopback). The AIS is removed when the condition triggering the AIS is terminated. (See Annex J for more information.)

9.3 CI/NI trouble sectionalization

The signals and messages described in this clause are intended for application at a point within the network as close as is practicable to the NI so that the sectionalization provided will place trouble within the network or within the CI. The CI shall not generate these signals and messages, and is not required to detect them.

9.3.1 Trouble sectionalization signals

Alarm Indication Signal - Customer Installation (AIS-CI) and Remote Alarm Indication - Customer Installation (RAI-CI) are intended for use in the network, to differentiate whether a trouble exists within the network or within the CI.

Although the two signals may be applied independently, they are intended to be used together to locate trouble in either direction of transmission to either side of the point of application of the signals.

Where clarity requires it in the following clauses, the terms AIS and RAI are used to differentiate AIS and RAI from AIS-CI and RAI-CI.

9.3.1.1 Alarm Indication Signal - Customer Installation (AIS-CI)

AIS-CI is a variant of AIS (see 9.2). AIS-CI is generated within the network and is transmitted toward the network, away from the CI, when either an AIS defect or an LOS defect has been detected in the signal received from the CI. AIS and LOS defects are defined in ANSI T1.231. This signal may transit the NI from the network to the CI as a result of far end action. The CI shall respond to this signal only in as far as it is within the definition of AIS.

Generation of AIS-CI is optional. If provided, AIS-CI shall meet the requirements defined in Annex D.

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[7] It is recognized that some existing unchannelized equipment does not transmit the RAI signal.

9.3.1.2 Remote Alarm Indication - Customer Installation (RAI-CI)

RAI-CI is a variant of RAI (see 9.1). The purpose of RAI-CI is to indicate that RAI has been detected in the signal from the CI and that the defect or failure which caused the origination of that RAI is not found in the signal from the network. RAI-CI may thus be used to determine whether a problem which has been detected, is in the network, or in the CI in the direction of transmission toward the CI. This signal may transit the NI from the network to the CI as a result of far end action. The CI shall respond to this signal only in as far as it is within the definition of RAI.

Generation of RAI-CI is optional. If provided, RAI-CI shall meet the requirements defined in Annex D.

9.4 Loopbacks

Loopbacks are used by carriers and customers as a maintenance tool to aid in problem resolution. The codes and protocols described in this subclause and Annex B (for fractional T1) may be used by the carrier for trouble isolation, the customer for CI-to-CI (end-to-end) testing, or the customer for local CI testing.

Two types of loopbacks are defined in this standard ¾ line and payload. Both are applicable for signals using the ESF format; only the line loopback is applicable for signals using the SF format. Line loopbacks result in a full 1.544 Mbit/s loopback of the signal received by the CI from the NI. Payload loopbacks result in a 1.536 Mbit/s loopback of the payload of the signal received by the CI from the NI maintaining bit-sequence integrity[8] for the information bits.

The following table identifies the subclauses containing information and requirements on loopback definitions and loopback control signals. Figure 7 illustrates the following loopbacks:

	SF format	ESF format
Definitions		
Line loopback	3.1.2.5	3.1.2.5
Payload loopback	—	3.1.33
Control signals	9.4.1	9.4.2
loopback activate	9.4.1.1	9.4.2.1
CI/CSU line loopback activate	—	9.4.2.1
ISDN line loopback activate		T1.403.01
loopback deactivate	9.4.1.2	9.4.2.2
loopback retention	—	9.4.2.3

Observation of a received signal from the CI identical to the signal transmitted from the NI to the CI is confirmation of a line loopback. Observation of a received signal from the CI that contains a payload identical to that in the signal transmitted from the NI to the CI, and ESF framing with a valid performance report message containing the LB bit set to one (see figure 6) is confirmation of a payload loopback.

9.4.1 Loopback control codes in the SF format

The protocol currently used by the carriers for network access to the CI line-loopback feature is an in-band control code. Only the CI shall respond to the in-band control line-loopback codes described in 9.4.1.1 and 9.4.1.2.

Some embedded equipment sends unframed (non-standard) line-loopback-control codes. This standard does not preclude the use of such non-standard line-loopbacks.

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[8] This requires that the timing of the transmitted signal be synchronized with the timing of the received signal.

9.4.1.1 Activation code

The in-band activation code for a line loopback shall be a framed DS1 signal consisting of repetitions of four "zeros" followed by one "one", lasting for at least 5 seconds, with the framing bits replacing bits of the pattern.

9.4.1.2 Deactivation code

The in-band deactivation code for a line loopback shall be a framed DS1 signal consisting of repetitions of two "zeros" followed by one "one", lasting for at least 5 seconds, with the framing bits replacing bits of the pattern [9].

9.4.2 Loopback control in the ESF format

9.4.2.1 Activation messages

The activation command for a loopback shall be by means of the ESF data-link bit-patterned ESF Data Link Command and Response messages specified for that purpose in table 4 [10]. Loopback activation messages shall not be returned to the NI (e.g., by the requested loopback) [11]. Accordingly, loopback activation shall be a two-step process as follows:

a) The loopback activation message shall be sent at least 10 times as a contiguous transmission (see 9.5.1.1.2) as a preamble to a loopback activation request;

b) The end of the transmission of the preamble specified in a) shall constitute a request for loopback activation.

9.4.2.2 Deactivation messages

Deactivation messages shall be sent from a source transmitting in the same direction that the activation message was sent.

Loopback deactivation may be accomplished in several ways. First, deactivation shall be initiated by the use of the deactivate message specified for the purpose in table 4. In addition, loopback deactivation shall be initiated by any of the following:

- the universal-loopback-deactivate message specified in table 4;

- AIS;

- a data link signal consisting of two occurrences of a one-per-second performance message separated by uninterrupted idle code.

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[9] Embedded network equipment exists that may react to the line loopback deactivate code and block the code from reaching the CI. When this occurs, manual intervention is required to deactivate the CI line loopback.

[10] Some embedded CI equipment uses either framed or unframed in-band codes as described in 9.4.1 to activate and deactivate ESF line loopbacks.

[11] Some embedded CI equipment for ESF operation activates loopback immediately upon identification of the loopback activation message and does not delay actual loopback until either transmission of the loopback activation message ceases, or is replaced by the loopback retention message.

These three methods of deactivation support the following:

- a formal deactivation message for maintenance procedures;

- prevention of simultaneously sustained loopbacks of any kind that face the same direction;

- deactivation of any inadvertent loopback by the presence of a normal signal containing all components of the ESF framing pattern.

NOTE – Equipment may also exist in CIs that does not respond to the "Universal Deactivate" message, AIS, or the PRM-and-idle-code combination. Loopbacks can be deactivated in such equipment by using the appropriate line or payload deactivate messages from table 4.

9.4.2.3 Loopback retention

Many maintenance test signals are transmitted with framing. To permit these signals to be looped back, the source of the framed test signal shall not generate any of the deactivation messages. One approach to inhibiting the PRM-and-idle-code combination is to apply the priority message from table 4, denoted as a loopback retention message, for the duration of the maintenance activity (see also 9.5.1.1.1). This message, when present in the received signal, is another positive confirmation of the presence of a line loopback. In the case of a payload loopback, the priority message does not appear in the returned signal.

9.5 ESF Data Link

This subclause specifies the use of the ESF data link (DL) for carrying performance information and control messages across the NI. The specification of these messages is the same for both the CI and the network [12]. When idle, the DL shall contain continuous repetitions of the data link idle code, 01111110.

Performance information appearing in one direction of transmission is a quantification of the quality of transmission in the opposite direction.

Two message formats are used on the DL:

- *Bit-patterned* messages;
- LAPD messages.

The bit-patterned messages carry priority messages and command and response messages. Formats of these messages are specified in 9.5.1.2.

The LAPD messages carry path identification and performance monitoring information. The format and protocol of the LAPD message are given in 9.5.2.1. The structure of the information within the message-oriented protocol is bit-assigned. The performance monitoring information is in 9.5.2.2, and the path identification information is in 9.5.2.3.

Operation, administration, and maintenance of the network may cause other messages to appear at the NI (the CI should be able to disregard any such undefined messages). Use of the DL for other terminal-

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[12] Equipment exists that uses the data link for the RAI signal and either an all-ones idle code or terminal-to-terminal communications. Such equipment cannot take advantage of the standard features described in 9.5.. Thus, equipment supporting the all-ones idle code can be connected to equipment that meets the specifications of 9.5, but performance information and control messages appear in one direction only. However, equipment supporting terminal-to-terminal communications cannot be so connected, and further, may not be compatible with the application of the performance message.

to-network communications or for any terminal-to-terminal messages beyond the described set is for future study [13]. Network architecture is such that the DL may be discontinuous relative to the DS1 payload and end-to-end continuity of the DL cannot be guaranteed.

NOTE – CI-to-CI testing using loopbacks is not feasible if the DL is discontinuous relative to the DS1 payload.

9.5.1 Bit-patterned messages

Bit-patterned messages are preemptive. When sent, they overwrite other signals in the DL.

9.5.1.1 Functionality of bit-patterned messages

9.5.1.1.1 Priority messages

Priority messages indicate a service-affecting condition. They shall be transmitted until the condition no longer exists, but not for less than 1 second. These messages may be interrupted for a maximum of 100 ms per interruption with a minimum interval of one second between interruptions.

9.5.1.1.2 Command and response messages

Command and response messages are transmitted to perform various functions. The loopback commands of table 4 activate and deactivate the loopback functions of the CI, as described in 9.4. Command and response messages that are labeled "Reserved for network use" shall not be generated by the CI. Command and response messages that are labeled "Reserved for customer" shall not be generated by the network. The use of the network loopback, protection switching and synchronization message functions described in table 4 are not covered in this standard. Command and response messages shall be repeated at least 10 times as a contiguous transmission.

9.5.1.2 Format of bit-patterned messages

The format of data-link bit-patterned messages shall be

0xxxxxx0 11111111

with the rightmost bit transmitted first. Table 4 lists the two categories of bit-patterned message functions and their associated 16-bit messages. Table 5 lists unassigned messages.

9.5.2 HDLC structured messages

Message-oriented signals are signals conforming to an HDLC protocol as defined below. Two message-oriented signals are defined for the ESF data link. One is a periodic performance report generated by the source/sink DS1 terminals. The other is a path, test (see 9.5.2.3), or idle (see 9.6) signal identification message that may be optionally generated by a terminal or intermediate equipment on a DS1 circuit.

9.5.2.1 Format of message-oriented signals

Message-oriented signals in both the network signal and the CI signal shall use the frame structure, field definitions, and elements of procedure of the LAPD protocol defined in ITU-T Recommendation Q.921 with address values not as defined in the Recommendation [14]. These applications use a subset of the full Q.921/LAPD capabilities. The message structure of the performance report is shown in figure 6,

[13] See Technical Report No. 12, *DS1 ESF data link application guidelines*, 1991.

[14] Recommendation Q.921 associates ranges of address values with functions. The address values in this standard do not correspond to that association.

while the message structure of the identification message(s) is shown in figure 13. In both figures, the following abbreviations are used:

- *SAPI:* Service Access Point Identifier;
- *C/R:* Command/Response;
- *EA:* Extended Address;
- *TEI:* Terminal End point Identifier;
- *FCS:* Frame Check Sequence.

The performance report shall use only the SAPI and TEI values shown in figure 6[15]. The identification message(s) shall use only the SAPI and TEI values shown in figure 13.

The source of either the performance report or an identification message shall generate the frame check sequence (FCS) and the zero stuffing required for transparency. Zero stuffing by a transmitter prevents the occurrence of the flag pattern (01111110) in the bits between the opening and closing flags of a Q.921/LAPD frame by inserting a zero after any sequence of five consecutive ones. (A receiver removes a zero following five consecutive ones.)

NOTE – The data elements in the performance report are arranged so that zero stuffing will never occur in the first twelve octets, but zero stuffing may occur in the FCS. Thus, except for the FCS, the line signal duplicates the list sequence of the report (octets 1 through 12, figure 6), and the message is of constant length from the opening flag to the end of octet twelve.

9.5.2.2 Performance report

The network signal and the CI signal shall include a performance report sent each second using a bit-assigned structure for the message field. The one-second timing may be derived from the DS1 signal or from a separate equally accurate ($\pm$ 32 ppm) source. The phase of the one-second periods with respect to the occurrence of error events is arbitrary; that is, the one-second timing does not depend on the time of occurrence of any error event.

The performance report contains performance information for each of the four previous one-second intervals. This is illustrated in figure 6, octets 5 through 12, and by an example in table 6.

Counts of events shall be accumulated in each contiguous one-second interval. At the end of each one-second interval, a modulo-4 counter shall be incremented, and the appropriate performance bits shall be set in the t_0 octets (octets 5 and 6 in figure 6). These octets and the octets that carry the performance bits of the preceding three one-second intervals form the performance report.

9.5.2.2.1 Error-event reporting

Occurrences of error events indicate the quality of transmission. The occurrences that shall be detected and reported are as follows:

- no events;
- CRC error;
- severely-errored framing.

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[15] The performance report with SAPI 14 should be constructed and inserted on the data link by the source terminal that constructs the information payload of the DS1 signal whether it is a network (C/R = 1) or a CI (C/R = 0) terminal. The performance report with SAPI 14 should be delivered without alteration to the terminal that sinks the information payload of the DS1 signal.

The occurrences that should be detected and, if detected, shall be reported are as follows:

- frame-synchronization-bit error;
- line-code violation;
- controlled slip.

9.5.2.2.2 Error-event definitions

Error events are defined as follows:

– *CRC error event:* A CRC error event is the occurrence of a received CRC code that is not identical to the corresponding locally calculated code;
- *Severely-errored-framing event:* A severely-errored-framing event is the occurrence of two or more framing-bit-pattern errors within a 3-ms period. Contiguous 3-ms intervals shall be examined. The 3-ms period may coincide with the ESF. The severely-errored-framing event, while similar in form to criteria for declaring a terminal has lost framing, is only designed as a performance indicator; existing terminal out-of-frame criteria will continue to serve as the basis for terminal alarms;
- *Frame-synchronization-bit error event:* A frame-synchronization-bit error event is the occurrence of a frame-bit error in the received frame-bit pattern not meeting the severely-errored-framing event criteria;
- *Line-code violation event:* A line-code-violation event for an AMI-coded signal is the occurrence of a received excessive zeros (EXZ) [16] or a bipolar violation. A line-code-violation event for a B8ZS-coded signal is the occurrence of a received EXZ or a bipolar violation that is not part of a zero-substitution code;

- *Controlled-slip event:* A controlled-slip event is the occurrence of a replication, or deletion, of a DS1 frame at the receiving terminal. A controlled slip may occur when there is a difference between the timing of a synchronous receiving terminal and the received signal.

9.5.2.3 Path- and test-signal-ID message(s)

Path- and test-signal-identification messages are optional messages that may be sent on the ESF data link. One is used to identify the path between the source terminal and the sink terminal, and is referred to as a path ID (PID). The other is used by test signal generating equipment and is referred to as a test-signal ID (TSID). If sent, they shall conform to the format and content requirements specified in Annex A.

9.5.2.4 Priority of bit-patterned messages

Bit-patterned messages shall preempt any Q.921/LAPD messages.

9.5.3 Special carrier applications

A carrier may require the use of the ESF data link for provisioning or maintenance of the DS1 facility or circuit. Examples of these applications are:

- communicating performance information within the network;
- providing protection switching control;

[16] Some existing equipment may not detect EXZ.

Such uses may cause interruptions, delays, or reduction of throughput on the ESF data link, but should not impact the timely transmission of the bit-patterned messages and of the performance report . The performance report shall always be passed.

9.6 DS1 idle signal

The idle signal indicates that the normal signal source is not present. The DS1 idle signal is not to be confused with the data link idle code defined in 9.5.

Generation and detection of the DS1 idle signal by the network or CI is optional. If provided, the DS1 idle signal shall meet the requirements defined in Annex C.

9.7 Performance sectionalization messages

Performance sectionalization messages are intended for use in the network, to differentiate whether performance degradations exist within the network, within the CI, or both.

This standard includes two methods for performance sectionalization, SPRM and NPRM. Any combination of SPRM, NPRM or no performance sectionalization can be employed on a DS1 path in either direction.

9.7.1 Supplementary Performance Report Message (SPRM)

In order to locate a source of errors along a DS1 path, supplementary information may be added by a network element to CI or network generated performance report messages. The added information is termed supplementary performance report message (SPRM) information. SPRM is intended for application at a point within the network as close as is practicable to the NI to determine whether errors in the DS1 path originate in the network or in the CI. The R, U1 and U2 bits of the PRMs are used to carry the supplementary information.

Generation of SPRM information by a NE is optional. If provided, SPRM shall meet the requirements of Annex E.

9.7.2 Network Performance Report Message (NPRM)

In order to locate a source of errors along a DS1 path, network performance report messages (NPRM) may be inserted into the data link by a network element. NPRM is intended for application at a point within the network as close as is practicable to the NI to determine whether errors in the DS1 path originate in the network or in the CI. NPRM messages contain information on the quality of transmission on both sides of the network interface.

Generation of NPRM information by a NE is optional. If provided, NPRM shall meet the requirements of Annex F.

9.7.3 Other Maintenance Signals

The following codes, typically used in conjunction with the SF format, may be used within the network to support out-of-service maintenance or protection switch operations. These codes are used in repetitive pulse patterns of more than 5 seconds. Network equipment may block customer transmission of long sequences of these patterns:

11000 (called a 2 in 5 pattern)

11100 (called a 3 in 5 pattern)

10100

10. Connector arrangements

Interconnection at the NI should use one of four Universal Service Ordering Code (USOC) connectors (RJ48C, RJ48X, RJ48M, and RJ48H), as shown in figures 9 through 12. The figures are from T1 Technical Report No. 5. The 8-pin connectors in figures 9 and 10 have the same pin assignments, but the connector in figure 10 provides a physical loopback when unplugged.

NOTE – The RJ48X connector should be used with caution. When the RJ48X plug is removed from the jack, the zero-loss shorting bars of the jack replace the normal LBO and CI-cable attenuations, which may cause signal levels up to 20.5 dB higher than normal to be sent into the network facility increasing crosstalk into other 1.544 Mbit/s channels.

The 50-pin connectors in figures 11 and 12 are physically the same but have different pin assignments. The pin assignments of figure 12 allow for more circuits.

Table 2 - Superframe format

	F bits			Bit use in each 8-bit time slot	
Frame number	**Superframe bit number**	**Terminal framing** (F_t)	**Signaling framing** (F_s)	**Data**	**Robbed-bit signaling** (Note 3)
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
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

NOTES

1 Frame 1 transmitted first. Bit 1 of each 8-bit time slot transmitted first.

2 Frames 6 and 12 are denoted as signaling frames.

3 Multiple-state signaling can be supported (see ANSI T1.107). See ANSI T1.403.02 for definition of robbed-bit signaling states. If robbed-bit signaling is not implemented, all eight bits of an 8-bit time slot may be available for data.

Table 3 - Extended superframe format

	F bits				Bit use in each 8-bit time slot	
Frame number	**Superframe bit number**	**Framing pattern sequence** (FPS)	**Data link** (DL)	**Cyclic redundancy check** (CRC-6)	**Data**	**Robbed-bit signaling** (Note 3)
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
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
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
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

NOTES

1 Frame 1 transmitted first. Bit 1 of each 8-bit time slot transmitted first.

2 Frames 6, 12, 18 and 24 are denoted as signaling frames.

3 Multiple-state signaling can be supported (see ANSI T1.107). See ANSI T1.403.02 for definition of robbed-bit signaling states. If robbed-bit signaling is not implemented, all eight bits of an 8-bit time slot may be available for data.

Table 4 - Assigned bit-patterned ESF data link messages

Function	Message(note 1)
Priority messages	
RAI	00000000 11111111
Loopback retention and acknowledge	00101010 11111111
RAI-CI	00111110 11111111
Command and response messages	
Line loopback activate - see note 1)	00001110 11111111
Line loopback deactivate - see note 1)	00111000 11111111
Payload loopback activate	00010100 11111111
Payload loopback deactivate	00110010 11111111
Reserved for network use (loopback activate)	00010010 11111111
Universal loopback (deactivate)	00100100 11111111
ISDN line loopback (NT2)	00101110 11111111
CI /CSU line loopback(NT1)	00100000 11111111
For network use (indication of NT1 power off)	00011100 11111111
Reserved for protection switch line 1 - see note 2)	01000010 11111111
Reserved for protection switch line 2	01000100 11111111
Reserved for protection switch line 3	01000110 11111111
Reserved for protection switch line 4	01001000 11111111
•	•
•	•
•	•
Reserved for protection switch line 24	01110000 11111111
Reserved for protection switch line 25	01110010 11111111
Reserved for protection switch line 26	01110100 11111111
Reserved for protection switch line 27	01110110 11111111
Reserved for protection switch acknowledge	00011000 11111111
Reserved for protection switch release	00100110 11111111
Do not use for synchronization - see note 3)	00110000 11111111
Stratum 2 traceable	00001100 11111111
SONET Minimum (± 20 ppm) Clock (SMC) traceable	00100010 11111111
Stratum 4 traceable	00101000 11111111
Stratum 1 traceable	00000100 11111111
Synchronization-traceability unknown	00001000 11111111
Stratum 3 traceable	00010000 11111111
Reserved for network synchronization	01000000 11111111
Transmit Node Clock (TNC)	01111000 11111111
Stratum 3E traceable	01111100 11111111
Under study for maintenance	00101100 11111111
Under study for maintenance	00110100 11111111
Reserved for network use	00010110 11111111
Reserved for network use	00011010 11111111
Reserved for network use	00011110 11111111
Reserved for network use	00111010 11111111
Reserved for customer	00000110 11111111
Reserved for customer	00001010 11111111
Reserved for customer	00000010 11111111
Reserved for customer	00110110 11111111

NOTES

1 Rightmost bit transmitted first

1) This loopback is referred to as the I_a loopback in ANSI T1.403.01.

2) The "protection switch line" codes of the form 01*XXXXX* 0 11111111 use the five bits designated *X* to contain the binary representation of the number of the line, 1 through 27, to be switched to a protection line. (e.g., the code for line 25 is a 1 followed by 11001 which is the binary representation of 25.)

3) Use of this block of messages is described in T1 Technical Report No. 33.

Table 5 - Unassigned ESF data link messages

Message
00111100 11111111
01111010 11111111
01111110 11111111[1)]
NOTE – Rightmost bit transmitted first.
1) Assignment of this message should be avoided due to its similarity to the DL idle code described in 9.5.

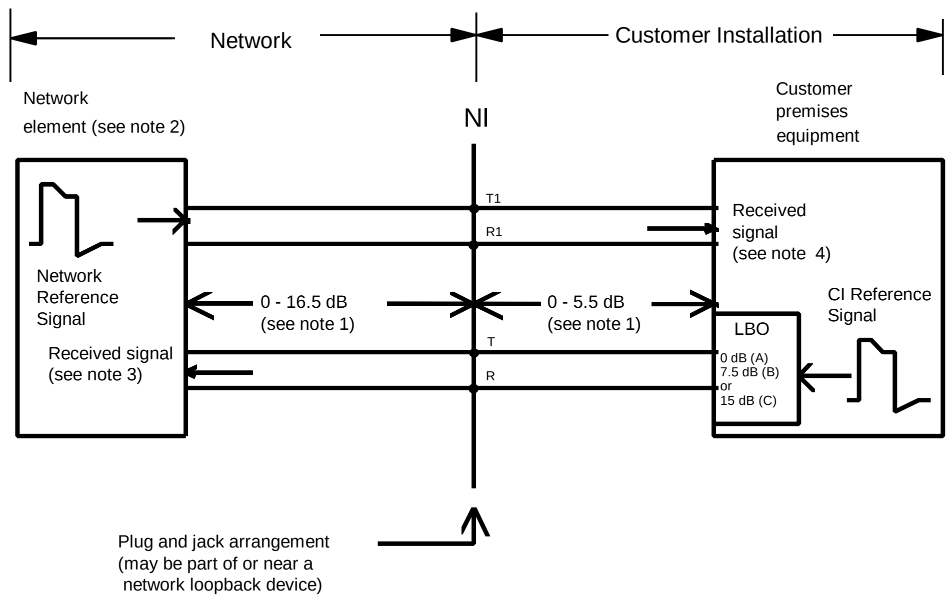
Table 6 - Example of performance report messages

Message Content	Specific octets	Msg sent at $t = T_0$	Msg sent at $t = T_0 + 1$	Msg sent at $t = T_0 + 2$	Msg sent at $t = T_0 + 3$
Overhead	Flag	01111110	01111110	01111110	01111110
	Address 1	00111000	00111000	00111000	00111000
	Address 2	00000001	00000001	00000001	00000001
	Control	00000011	00000011	00000011	00000011
Most recent second	msg octet 1	00000001	00000000	10000000	00100000
	msg octet 2	00000000	00000001	00000010	00000011
1st previous second	msg octet 3	00000000	00000001	00000000	10000000
	msg octet 4	00010011	00000000	00000001	00000010
2nd previous second	msg octet 5	00000000	00000000	00000001	00000000
	msg octet 6	01000010	00010011	00000000	00000001
3rd previous second	msg octet 7	00000010	00000000	00000000	00000001
	msg octet 8	00000001	01000010	00010011	00000000
Error check[1)]	FCS octet 1	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
	FCS octet 2	xxxxxxxx	xxxxxxxx	xxxxxxxx	xxxxxxxx
	Flag	01111110	01111110	01111110	01111110

NOTE — Performance and counter value data appearing in this example:

T_0–3 → NmNl= 01; slip = 1; all other parameters = 0
T_0–2 → NmNl = 10; severely errored framing = 1; all other parameters = 0
T_0–1 → NmNl = 11; CRC error = 1; all other parameters = 0
T_0 → NmNl = 00; CRC error = 320; all other parameters = 0
T_0+1 → NmNl = 01; all parameters = 0
T_0+2 → NmNl = 10; CRC error = 6; all other parameters = 0
T_0+3 → NmNl = 11; CRC error = 40; all other parameters = 0

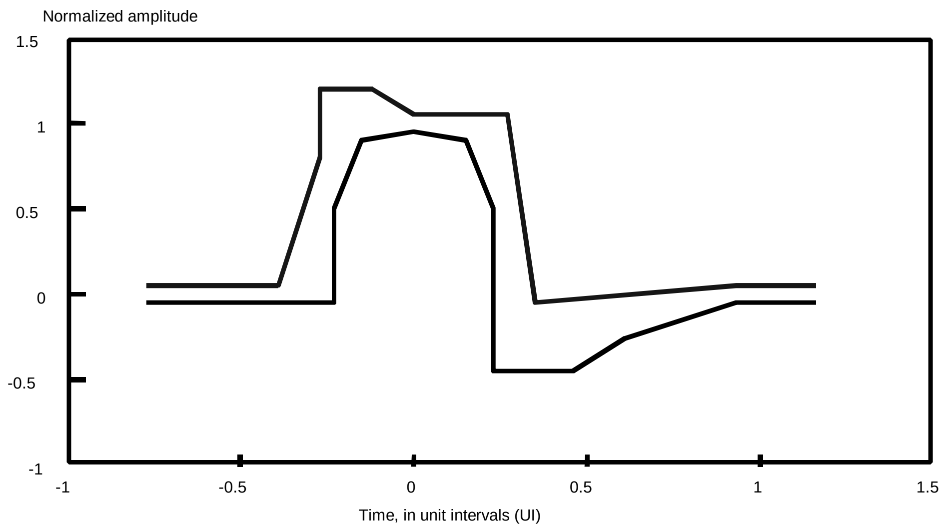
1) Values not pertinent to example



Notes

1. Loss values apply at 772kHz.
2. An example of a network element is a final span line repeater.
3. The received signal is the CI reference signal attenuated by cable and LBO.
4. The received signal is the network reference signal attenuated by 0 - 22 dB of cable

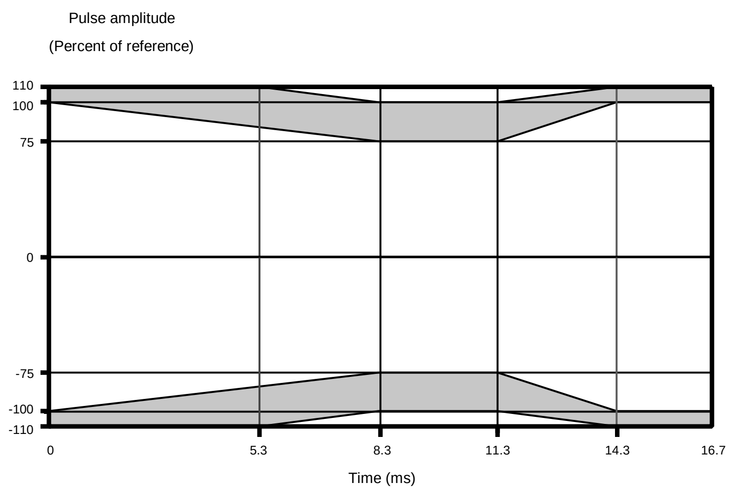
Figure 1 – Network interface



Minimum curve		Maximum curve	
Time	**Normalized amplitude**	**Time**	**Normalized amplitude**
–0.77	–0.05	–0.77	0.05
–0.23	–0.05	–0.39	0.05
–0.23	0.50	–0.27	0.80
–0.15	0.90	–0.27	1.20
0.0	0.95	–0.12	1.20
0.15	0.90	0.0	1.05
0.23	0.50	0.27	1.05
0.23	–0.45	0.34	–0.05
0.46	–0.45	0.77	0.05
0.61	–0.26	1.16	0.05
0.93	–0.05		
1.16	–0.05		

NOTE – 1 Unit Interval = 648 nanoseconds

Figure 2 – Isolated pulse template and corner points



NOTES

1 1 / 60 Hz = 16.7 ms

2 Envelope of pulse amplitude shall lie within shaded area.

3 Reference (100%) may be any amplitude in the specific range of pulse amplitudes (see text).

Figure 3 – Pulse amplitude envelope with 60 Hz longitudinal currents

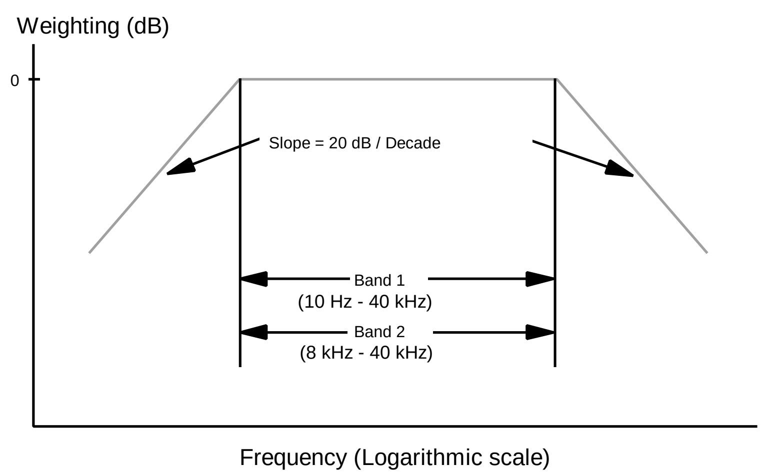
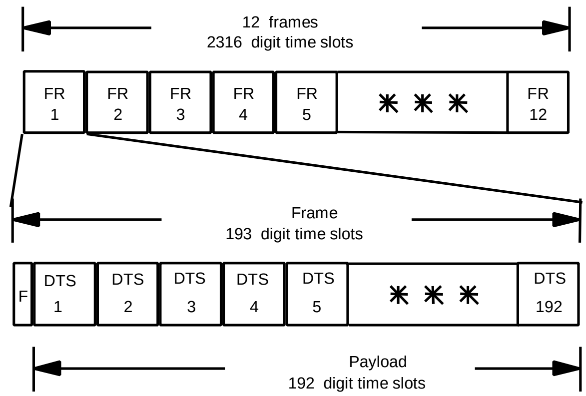


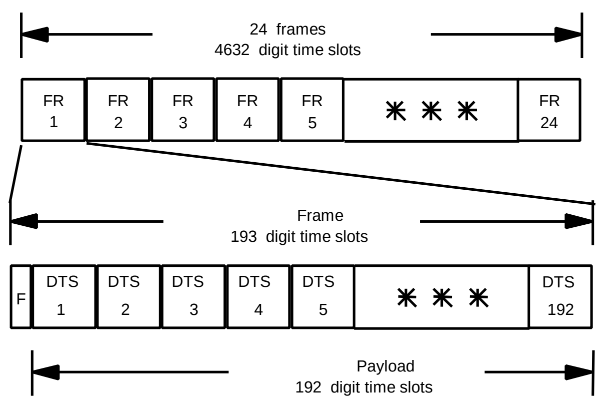
Figure 4 – Frequency weighting functions for jitter specifications

Superframe



NOTE - Time slots transmitted leftmost (bit 1) first.

Extended superframe



NOTE - Time slots transmitted leftmost (bit 1) first.

Figure 5–Bit assignments

Octet structure

Octet No.	Bit Number 8	7	6	5	4	3	2	1
1	FLAG							
2	SAPI						C/R	EA
3	TEI							EA
4	CONTROL							
5	G3	LV	G4	U1	U2	G5	SL	G6
6	FE	SE	LB	G1	R	G2	Nm	Nl
7	G3	LV	G4	U1	U2	G5	SL	G6
8	FE	SE	LB	G1	R	G2	Nm	Nl
9	G3	LV	G4	U1	U2	G5	SL	G6
10	FE	SE	LB	G1	R	G2	Nm	Nl
11	G3	LV	G4	U1	U2	G5	SL	G6
12	FE	SE	LB	G1	R	G2	Nm	Nl
13	FCS							
14								
15	FLAG							

Octet no.	Octet contents	Interpretation
1	01111110	Opening LAPD flag
2	00111000	From CI: SAPI=14, C/R=0, EA=0
	00111010	From carrier: SAPI=14, C/R=1, EA=0
3	00000001	TEI=0, EA=1
4	00000011	Unacknowledged frame
5,6	Variable	Data for latest second (Ti)
7,8	Variable	Data for previous second (Ti-1)
9,10	Variable	Data for earlier second (Ti-2)
11,12	Variable	Data for earlier second (Ti-3)
13,14	Variable	CRC16 Frame Check Sequence
15	01111110	Closing LAPD flag

Bit value	Interpretation
G1=1	CRC error event=1
G2=1	1<CRC error event ≤ 5
G3=1	5<CRC error event ≤ 10
G4=1	10<CRC error event ≤ 100
G5=1	100<CRC error event ≤ 319
G6=1	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, 0 – May be modified by SPRM (See Annex E)
R	0 – May be modified by SPRM (See Annex E)
NmNl=00,01,10,11	One-second report modulo 4 counter

NOTE - The rightmost bit (bit 1, lsb) is transmitted first for all fields except the two bytes of the FCS that are transmitted leftmost bit (bit 8, msb) first. CAUTION: For the FCS bytes only, the bit numbering is different from that of Q.921.

Figure 6 – Performance report message structure and contents

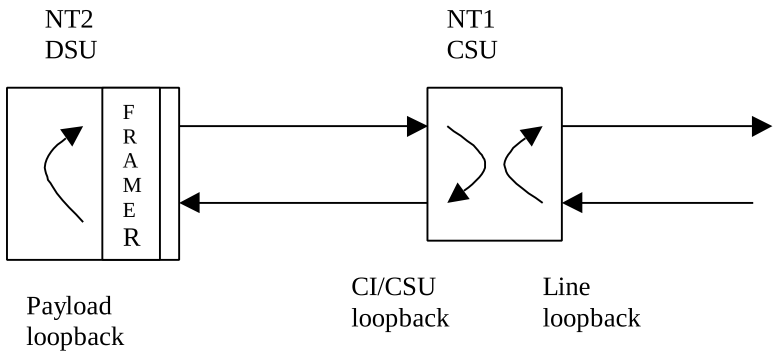
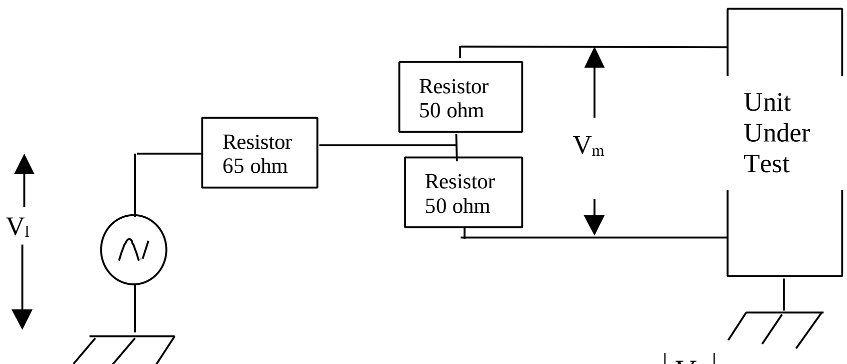


Figure 7 - Customer Installation Loopbacks



$$Longitudinal\ Balance = 20Log_{10}\left|\frac{V_l}{V_m}\right|$$

Where: V_m = Metallic voltage, and V_l = longitudinal voltage

Figure 8 Longitudinal balance measuring circuitry

Universal service order code (USOC):	RJ48C
Electrical network connection:	Tip/Ring and Tip1/Ring1
Mechanical arrangement:	8 position miniature modular jack
Usage:	1.544 Mbit/s access lines
Interface codes:	04DU9 (all)

Wiring diagram:

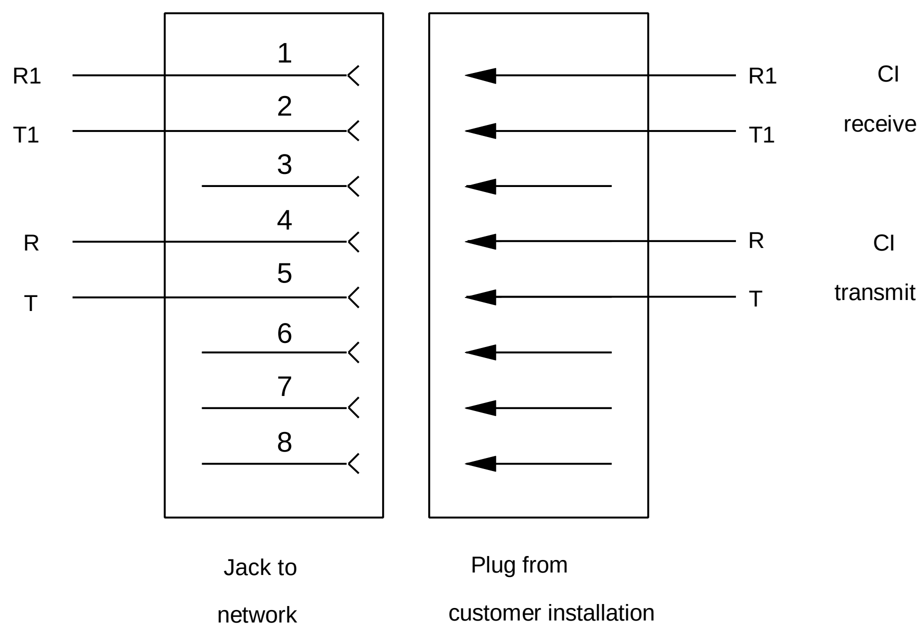
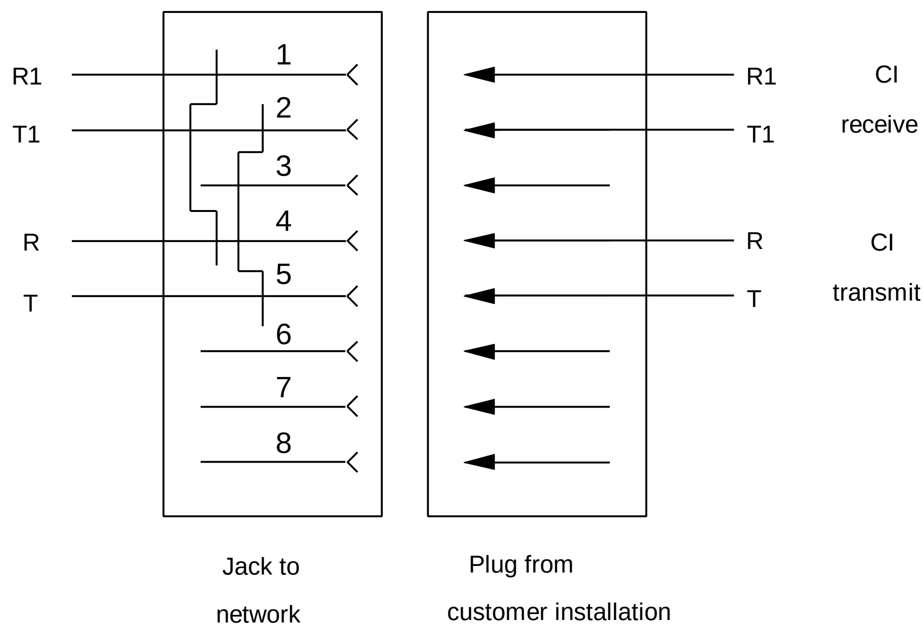


Figure 9 – Connector pin assignments (8-position RJ48C)

Universal service order code (USOC):	RJ48X
Electrical network connection:	Tip/Ring and Tip1/Ring1
Mechanical arrangement:	8 position miniature modular jack with shorting bars
Usage:	1.544 Mbit/s access lines
Interface codes:	04DU9 (all)

Wiring diagram:

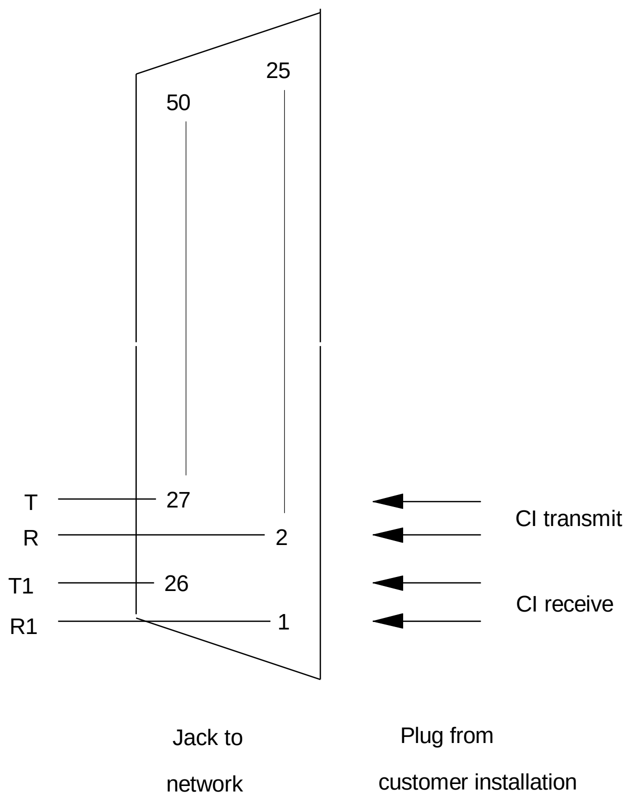


CAUTION - Use of this connector may cause crosstalk into other 1.544 Mbit/s channels. (See clause 10)

Figure 10 – Connector pin assignments (8-position RJ48X with shorting bars)

Universal service order code (USOC):	RJ48M
Electrical network connection:	8 Tip/Ring and 8 Tip1/Ring1 connections
Mechanical arrangement:	50 position miniature ribbon jack
Usage:	Multiple 1.544 Mbit/s access lines
Interface codes:	04DU9 (all)

Wiring diagram:



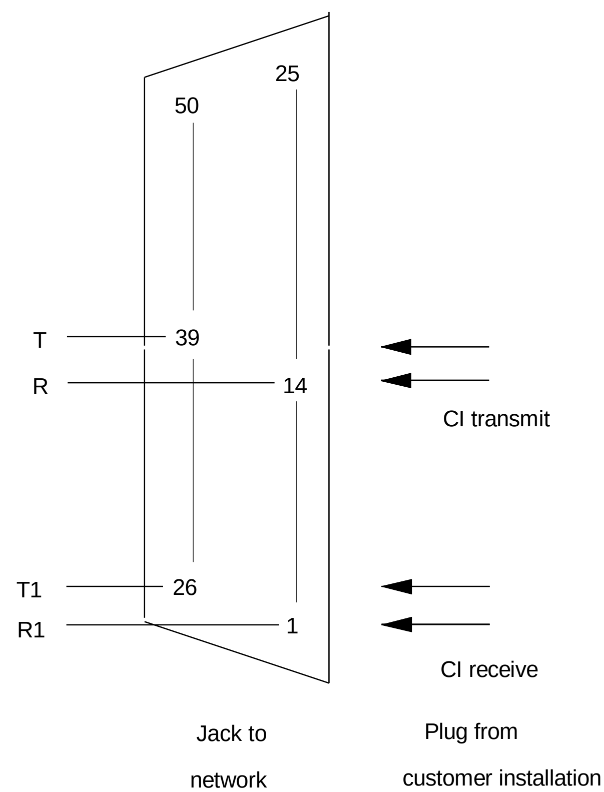
Line	T1	R1	T	R
1	26	1	27	2
2	29	4	30	5
3	32	7	33	8
4	35	10	36	11
5	38	13	39	14
6	41	16	42	17
7	44	19	45	20
8	47	22	48	23

NOTE - The exchange carrier will wire the lines to the connector in the sequence designated by the customer

Figure 11 – Connector pin assignments (50-position RJ48M)

Universal service order code (USOC):	RJ48H
Electrical network connection:	12 Tip/Ring and 12 Tip1/Ring1 connections
Mechanical arrangement:	50 position miniature ribbon jack
Usage:	Multiple 1.544 Mbit/s access lines
Interface codes:	04DU9 (all)

Wiring diagram:



Line	T1	R1	T	R
1	26	1	39	14
2	27	2	40	15
3	28	3	41	16
4	29	4	42	17
5	30	5	43	18
6	31	6	44	19
7	32	7	45	20
8	33	8	46	21
9	34	9	47	22
10	35	10	48	23
11	36	11	49	24
12	37	12	50	25

NOTE - The exchange carrier will wire the lines to the connector in the sequence designated by the customer.

Figure 12 – Connector pin assignments (50-position RJ48H)

Annex A
(normative)

Path and test signal identification message requirements

A.1 DS1–ESF ID messages

DS1–ESF ID messages are optional messages. The DS1–ESF ID messages use the LAPD protocol and are one of two types. One is used to identify a path from the terminal equipment (TE) source to the TE sink, and is referred to as a path ID (PID). The other is used by test signal generating equipment, and is referred to as a test signal ID (TSID).

The PID shall originate from the same DS1 source and share the same data link as the performance report. The PID shall be sent at least once every ten seconds, but not more often than once per second (to minimize data link occupancy), and be separated from the performance report by at least one flag.

The TSID shall originate from test equipment, and is of particular use in test equipment associated with digital cross-connect equipment (DCS). The TSID shall be sent once a second (to minimize test time) and separated from the performance report by at least one flag.

A.2 Format of the ID messages

The format of the ID messages is that of an unnumbered and unacknowledged frame using the frame structure, field definitions and elements of procedure of the LAPD protocol defined in ITU-T Recommendation Q.921 with address values not as defined in the Recommendation. To differentiate the ID message from the performance report message, the ID message shall use a SAPI value of 15 and a TEI value of 0. The structure of the ID message is shown in figure 13. The content of the 76-octet information field is shown in figure 14, and is discussed in the following clause.

A.3 DS1 Path identification and test signal identification messages

The DS1 path identification (PID) and test signal identification (TSID) messages use the same 76 octet structure made up of six data elements. Each data element is allocated a fixed length field; however, the entire field is not always filled with element data. The first data element is one byte long and defines the type of identification message being transmitted. The next four data elements identify the type of terminal equipment and the equipment location that sourced the identification message. The final data element identifies a specific DS1 signal or test-signal identification.

The first five data elements have the same meaning for both messages. The sixth data element is different for each of the messages (see figure 14). The data elements are designed to accommodate codes that are widely used in North American facility networks.

The contents of the first five data elements are defined as follows:

- *TYPE:* The type code is a one octet code used to identify a particular type of identification message. Specific values are shown in figure 14;
- *EIC:* The equipment identification code (up to ten characters) describes a specific piece of equipment;
- *LIC:* The location identification code (up to eleven characters) describes a specific location;
- *FIC:* The frame identification code (up to ten characters) identifies where the equipment is located within a building at a given location;
- *UNIT:* A code (up to 6 characters) that identifies the equipment location within a bay.

The final data element for the DS1 path identification message is the facility identification (FI) code. The facility identification code (up to 38 characters) identifies a specific DS1 path.

The final data element for the test signal identification message is the generator number (GEN No.). The GEN No. is the number of the signal generator sending the test signal.
For a given data element, the maximum length is not needed in all cases. The ASCII NUL character (00000000) shall be used to indicate the end of the string when the full length of the data element is not needed for a given word. The remaining bit positions of the data element may contain ones, zeros, or any combination of ones and zeros.

In those cases where all the data elements are not needed for a given message, the first octet of the data element shall contain the ASCII NUL character. The remaining bit positions of the data element may contain ones, zeros, or any combination of ones and zeros.

Octet no.	Octet label (bits 8 7 6 5 4 3 2 1)			Octet content
1	Flag			01111110
2	SAPI	C/R	EA	00111100 or 00111110
3	TEI		EA	00000001
4	Control			00000011
	76 octet information field			PID or TSID
81	FCS			
82				Variable
83	Flag			01111110

Name	Value	Interpretation
Flag	01111110	Interframe fill octet sequence
SAPI,C/R,EA	00111100 00111110	SAPI=15, C/R=0 (CI), EA=0 SAPI=15, C/R=1 (carrier), EA=0
TEI,EA	00000001	TEI=0, EA=1
Control	00000011	Unacknowledged information transfer
76 octet information field	PID TSID	Circuit/facility identifier Test signal generator identifier
FCS	Variable	CRC16 frame check sequence

NOTE – The rightmost bit (bit 1, lsb) is transmitted first for all fields except for the two bytes of the FCS that are transmitted leftmost bit (bit 8, msb) first.

CAUTION: For the FCS bytes only, the bit numbering is different from that of Q.921.

Figure A.1 Identification signals - Q.921/LAPD structure

DS1 path identification

Data elements	Binary value	
Type	0011 1000	Path ID
EIC	xxxx xxxx xxxx	10 octets
LIC	xxxx xxxx xxxx	11 octets
FIC	xxxx xxxx xxxx	10 octets
Unit	xxxx xxxx xxxx	6 octets
FI	xxxx xxxx xxxx	38 octets

Test signal identification

Data elements	Binary value	
Type	0011 0010	Test ID
EIC	xxxx xxxx xxxx	10 octets
LIC	xxxx xxxx xxxx	11 octets
FIC	xxxx xxxx xxxx	10 octets
Unit	xxxx xxxx xxxx	6 octets
GEN No.	xxxx xxxx xxxx	38 octets

Figure A.2 Path identification and test signal identification

Annex B
(normative)

In-band signaling for fractional-T1 (FT1) channel loopbacks

B.1 General

Two in-band signaling conventions are used for FT1-channel-loopback control:

– a signaling convention for requesting loopback activation;

– a signaling convention for requesting loopback deactivation.

This annex addresses signaling conventions only and is not an equipment specification. This annex does not preclude the use of methods other than in-band signaling that might be implemented either separately, or jointly with the in-band control. The codes and conventions specified in this annex may be used by the carrier for section testing, and by the CI for CI-to-CI testing.

B.2 Channelization

For the purpose of the specifications in this annex, a fractional T1 (FT1) channel is one that uses *N* (where *N* = 1 to 24) channel time slots (octets) within a DS1 frame (see clause 7 and figures 5) and does not include the DS1 frame bit. A DS1 frame may transport more than one FT1 channel. An FT1 channel may be used either for *N* x 64 kb/s transport or *N* x 56 kb/s transport. In *N* x 64 kb/s transport, all bits of the channel time slots are occupied by the transported signal. In *N* x 56 kb/s transport, bit eight of the channel time slot is always assigned the value "one". The remaining seven bits are occupied by the transported signal. For *N* x 64 kb/s signals transported by networks capable of clear channel operation, the *N* channels used for an FT1 channel shall be contiguous. For *N* x 64 kb/s signals transported by networks not capable of clear channel operation, the FT1 channel data shall be bit-mapped sequentially into alternate *N* x 64 kb/s octets assigned for the FT1 channel (e.g., for a 384 kb/s FT1 channel, octets 1, 3, 5, 7, 9, 11). The alternate unused octets in every frame (e.g., octets 24, 2, 4, 6, 8, 10, 12) shall be filled with a pattern containing at least two ones with a preferred pattern of all-ones.

The in-band signaling conventions and codes for FT1-channel-loopback control are specified below. The signaling may be used with either *N* x 64 kb/s transport or *N* x 56 kb/s transport subject to the conventions above.

B.3 Loopback activation code

The signal used to request FT1-channel-loopback activation (see B.5) shall be a repeated periodic sequence (with a period equal to 127 bit intervals – PN127) as generated by an autonomous, linear sequential circuit such as represented in figure 15. The feedback polynomial for the circuit shall be $X^7 \oplus X^3 \oplus 1$, with the operation "⊕" representing modulo 2 addition. The loopback-activation-request signal is generated whenever the value of input "A" in the circuit is set to zero and the initial state of the circuit values stored by the delay elements is other than all zeros. The request signal may begin with any element (bit) of the periodic sequence, and may end with any element of the periodic sequence.

B.4 Loopback deactivation code

The signal used to request FT1-channel-loopback deactivation (see B.6) shall be the complement (logical inversion) of the repeated periodic sequence specified in B.3 (i.e., the value of the input at "A" is set to one). The request signal may begin with any element of the periodic sequence, and may end with any element of the periodic sequence.

B.5 Loopback activation

Loopback activation in the FT1 channel shall be requested (see figure 16) by transmitting to the NI the loopback request signal sequence specified above for a period of not less than 2.0 seconds immediately followed by transmission of an all-ones signal for not less than 2.0 seconds. The responding device should activate a loopback within the 2.0 second interval immediately following the end of the loopback-activation-code sequence[17], i.e., during the first 2.0 seconds of the succeeding all-ones signal.

B.6 Loopback deactivation

Loopback deactivation in the FT1 channel shall be requested (see figure 17) by transmitting the loopback-deactivation-signal sequence specified above for a period of not less than 2.0 seconds, immediately followed by transmission of an all-ones signal for not less than 2.0 seconds. The responding device should remove the loopback within the 2.0 second interval immediately following the end of the loopback-deactivation-code sequence, i.e., during the first 2.0 seconds of the succeeding all-ones signal.

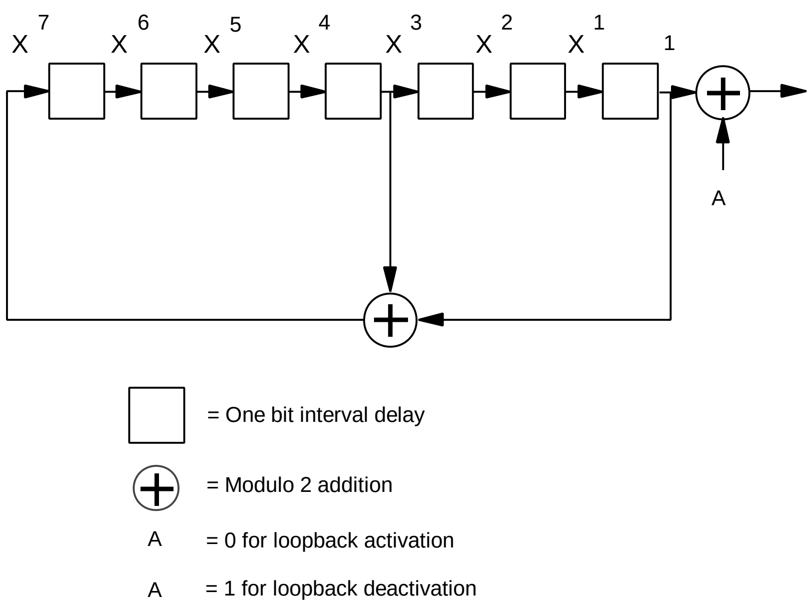


Figure B.1 Code sequence generator

[17] Some embedded equipment activates loopback immediately upon recognition of the PN127 codeword rather than waiting the minimum of two seconds.

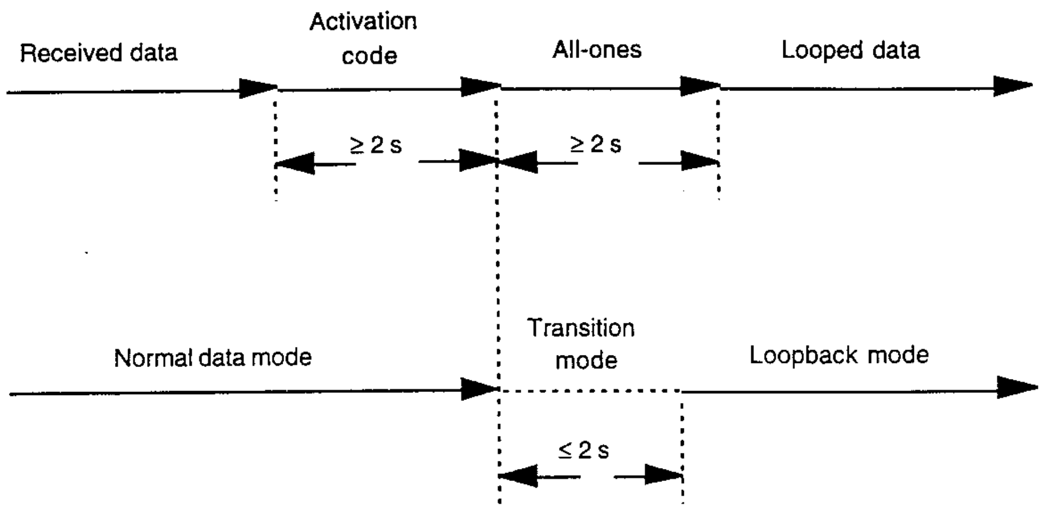


Figure B.2 Loopback activation

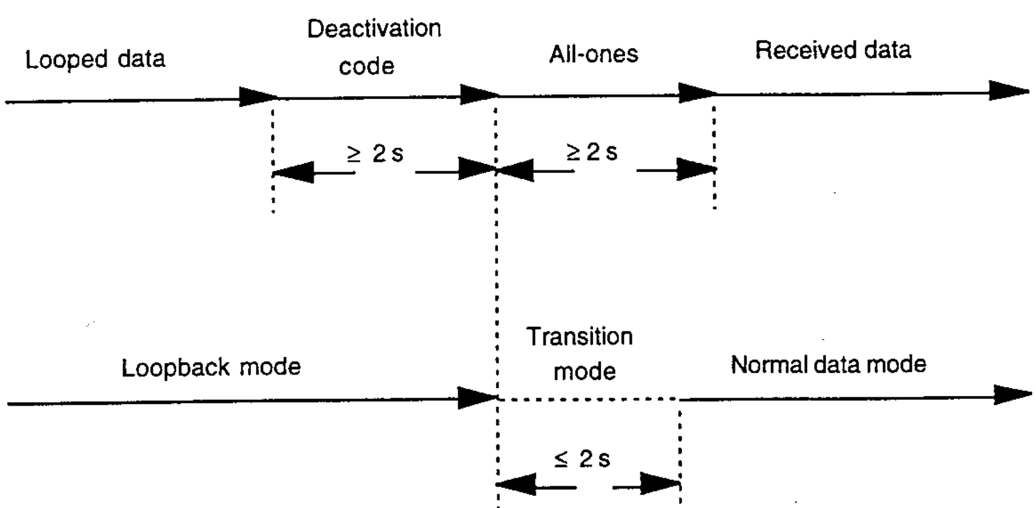


Figure B.3 Loopback deactivation

Annex C
(normative)

DS1 idle signal

C.1 DS1 idle signal

The DS1 idle signal defined in this annex is optional. When a DS1 idle signal is implemented it shall meet the requirements defined in this annex.

The idle signal is transmitted when the normal signal source is not present. Conditions for application of the idle signal within the CI are under study. Two examples for activating this idle signal are:

– the idle signal being present at the CI when the DTE signal is not present;

– the idle signal being used in an unassigned DS1 of a DCS.

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C.2 SF format - DS1 idle signal

When a DS1 is configured to operate in the SF format, the DS1 Idle Signal shall be comprised as follows:

Each of the 24 channel time-slots shall consist of 0001 0111 (left-to-right).

C.3 ESF format - DS1 idle signal

When a DS1 is configured to operate in the ESF format, the DS1 Idle Signal shall be comprised as follows:

- Each of the 24 channel time-slots shall consist of 0001 0111 (left-to-right);
- The ESF FDL shall contain the ESF RAI signal as defined in 9.1;
- Once each second, the RAI signal shall be interrupted for not less than 90 ms nor more than 100 ms with one of the following idle signatures:
  - The interruption period shall consist of all LAPD idle code as defined in 9.4;
  - The interruption period shall consist of the DS1 Idle Signal Identification (ISID) message shown in figure 18. The message format of the ISID is the same as the Test Signal Identification (TSID) defined in annex A, except that ISID uses a 42 octet information structure made up of 6 data elements as shown in figure 19. All other aspects of the signal are the same.

The first data element is one byte long and defines the type of identification message being transmitted. The next four data elements identify the type of equipment and the equipment location that originated the identification message. Finally, because the equipment can source more than one DS1 signal, the final data element identifies a specific DS1 signal.

The data elements are defined as follows:

– *TYPE:* The Type Code is a one octet code (0011 0100) used to identify the idle signal identification message.

– *EIC:* The Equipment Identification Code (up to 10 characters) describes a specific piece of equipment.

– *LIC:* The Location Identification Code (up to 11 characters) describes a specific location.

– *FIC:* The Frame Identification Code (up to 10 characters) identifies where the equipment is located within a building at a given location.

– *UNIT:* A code (up to 6 characters) that identifies the equipment location within a bay.

– *PORT:* The number (up to 4 characters) of the port that initiates the idle signal.

The ASCII null character shall be used to indicate the end of the string when the full length of the data element is not needed for a given word. The remaining bit positions of the data element may contain ones, zeros, or any combination of ones and zeros.

Octet no.	Octet label (bits 8 7 6 5 4 3 2 1)			Octet content
1	Flag			01111110
2	SAPI	C/R	EA	00111100 or 00111110
3	TEI		EA	00000001
4	Control			00000011
	42 octet information field			ISID
47	FCS			
48				Variable
49	Flag			01111110

Name	Value	Interpretation
Flag	01111110	Interframe fill octet sequence
SAPI,C/R,EA	00111100 00111110	SAPI=15, C/R=0 (CI), EA=0 SAPI=15, C/R=1 (carrier), EA=0
TEI,EA	00000001	TEI=0, EA=1
Control	00000011	Unacknowledged information transfer
42 octet information field	ISID	Circuit/facility identifier Test signal generator identifier
FCS	Variable	CRC16 frame check sequence

NOTE – The rightmost bit (bit 1, lsb) is transmitted first for all fields except for the two bytes of the FCS that are transmitted leftmost bit (bit 8, msb) first.
CAUTION: For the FCS bytes only, the bit numbering is different from that of Q.921.

Figure C.1 DS1 Idle Signal – Q.921/LAPD structure

Idle signal identification

Data elements	Binary value	
Type	0011 0100	Idle ID
EIC	xxxx xxxx xxxx	10 octets
LIC	xxxx xxxx xxxx	11 octets
FIC	xxxx xxxx xxxx	10 octets
Unit	xxxx xxxx xxxx	6 octets
Port no.	xxxx xxxx xxxx	4 octets

Figure C.2 DS1 idle signal identification

Annex D
(normative)

AIS-CI and RAI-CI

D.1 Application of AIS-CI and RAI-CI

AIS-CI and RAI-CI are intended to be recognized as AIS and RAI, as specified in ANSI T1.231 respectively, by NEs, which cannot recognize the signatures of the former signals. AIS-CI, like AIS, is an unframed signal and is therefore applicable to DS1 paths without regard to frame format.

D.2 Definition of AIS-CI

The AIS-CI signal is a repetitive pattern with a period of 1.26 seconds. The pattern is formed by sequentially interleaving 1.11 seconds of an unframed all ones pattern and 0.150 ±0.002 seconds of all ones modified by the AIS-CI signature. The AIS-CI signature is defined as a pattern which recurs at 386 bit intervals in the DS1 signal. The pattern comprising the AIS-CI signature is 01111100 11111111 (right-to-left). This results in a repetitive pattern 6176 bits in length in which, if the first bit is numbered bit 0, bits 3088, 3474 and 5790 are logical zeroes and all other bits in the pattern are logical ones. AIS-CI is declared when a signal meeting the definition of AIS in 6.1.2.2.3 also contains 99.9% of the logical zeroes that define the AIS-CI signature.

Since AIS-CI meets the definition of AIS, it may be detected and used for alarm suppression, the initiation of carrier group alarm (CGA) trunk processing and the development of DS1 performance parameters exactly as is AIS. The longer period of time required to detect AIS-CI will not therefore affect its use for functions which require AIS.

The purpose of AIS-CI is to indicate that a defect or failure has been detected in the signal from the customer installation (CI) which would normally lead to the transmission of AIS. AIS-CI may thus be used to determine whether a problem which has been detected, is in the network, or in the CI in the direction of transmission toward the network.

An alternative interpretation of the AIS-CI signature, which may be helpful in detecting the pattern, is that the AIS signal modified by the AIS-CI signature is equivalent to an ESF signal in which the FPS bits, the CRC-6 bits, and the payload are set to all ones and the DL is overwritten by the pattern 01111100 11111111 (right-to-left).

D.3. Definition of RAI-CI - ESF format

The RAI-CI signal is a repetitive pattern with a period of 1.08 seconds. RAI-CI is formed by sequentially interleaving 0.990 ±0.002 seconds of the unscheduled message 00000000 11111111 (right-to-left), which represents RAI in the DL, with 90 ±2 milliseconds of the message 00111110 11111111 (right-to-left) to flag the signal as RAI-CI.

Since RAI-CI meets the definition of RAI, it may be detected and used for alarm suppression, the initiation of carrier group alarm (CGA) trunk processing and the development of DS1 performance parameters exactly as is RAI. The longer period of time required for detection of RAI-CI will not therefore affect its use for functions which require RAI.

In order to accomplish this, RAI-CI shall be transmitted toward the network when two conditions are simultaneously true at the point from which RAI-CI is originated:

RAI is received from the CI;

No LOF, LOS, or AIS failure is detected in the signal received from the network.

The transmission of RAI-CI shall be terminated within 500 µs of the detection of either one or both:

1) The cessation of RAI from the CI;

2) The declaration of LOF, LOS, or AIS in the signal from the network.

To prevent the transmission of RAI-CI during the failure clearing interval of a network failure the transition from RAI to RAI-CI shall be delayed for 20 seconds following the detection of conditions in items 1 and 2 above.

D.4 Definition of RAI-CI - SF format

When the RAI-CI signal is transmitted in the SF format, each of the 24 channel time-slots shall consist of 1000 1011 (left-to-right).

Since RAI-CI meets the definition of RAI, it may be detected and used for alarm suppression, the initiation of carrier group alarm (CGA) trunk processing, and the development of DS1 performance parameters exactly as is RAI.

In order to accomplish this, RAI-CI shall be transmitted toward the network when two conditions are simultaneously true at the point from which RAI-CI is originated;

1) RAI is received from the CI, and one or more of the following exist;

2) No LOF, LOS, or AIS failure is detected in the signal received from the network.

The transmission of RAI-CI shall be terminated within 500 μs of the detection of either one or both:

1) The cessation of RAI from the CI;

2) The declaration of LOF, LOS, or AIS in the signal from the network.

To prevent the transmission of RAI-CI during the failure clearing interval of a network failure, the transition from RAI to RAI-CI shall be delayed 20 seconds following the detection of conditions in items 1), and 2) above.

Annex E

(normative)

Supplementary Performance Report Message (SPRM)

E.1 Application of SPRM

PRMs are normally transmitted by DS1 path terminations and are inserted in the data link at the points of generation of the ESF frame structure. The PRMs transmitted by each DS1 path termination present a view of the received DS1 signal as “seen” by the path terminating network element. The PRMs contain no information which might be used to sectionalize trouble at points along the DS1 path.

Supplementary performance information may be added to the PRMs as they pass points along a DS1 path. The resulting SPRM may be used to locate trouble conditions to one side or the other of the point of insertion of the SPRM. The SPRM may be applied within the network as close as appropriate to the NI or network to network interface. SPRMs may cross the NI from the network. The supplemental information may be ignored by the CI.

E.2 SPRM insertion - application guidelines

The SPRM shall originate in a network element and may share the ESF data link with the NPRM and other CI originated messages. The SPRM shall be applied based on one of the two cases defined below. Case 1 defines the case in which a PRM is present. Case 2 defines the case in which a PRM is not present.

E.2.1 Case 1: CI originated PRMs present in the ESF data link

The R, U1 and U2 bits of the PRM are modified to add the SPRM information to the PRM. The R bit channel is used to flag whether or not SPRM information has been added to the PRMs and, if so, what mode of SPRM is in use. The U1 and U2 bits are used to multiplex the additional intermediate monitoring point performance information into the PRMs. Requirements for the use of R, U1, and U2 bits are given below.

E.2.2 Case 2: CI originated PRMs not present in the ESF data link

The network element shall generate a PRM with the C/R bit = 1. This PRM shall be modified to create a SPRM that includes the information in the R, U1, and U2 bits. Requirements for the use of the R, U1, and U2 bits are given below.

For this case, one-second intervals shall be derived from either the DS1 signal or from a separate equally accurate (±32 ppm) source. The phase of the one-second intervals with respect to the occurrence of errors is arbitrary; that is, the one-second intervals do not depend on the time of occurrence of any error event. SPRM and CI data link traffic contention shall be resolved as follows:

The scheduled SPRM shall be inserted in the ESF data link during the one-second interval when the CI originated data link traffic (if present) permits.

If CI originated data link traffic does not permit the insertion of the scheduled SPRM within the one-second interval, that SPRM shall not be sent.

E.3. Format of the SPRM message

E.3.1 R Bit

Data shall be written to the R bits at a rate of 1 bit per PRM (or one bit per second). Each new bit shall be written into the R bit associated with the message for second t = T_o (Table 6). The R bit then shifts, second by second, along with the other bits in the PRM until it is last seen in the R bit position for second t = T_0+ 3. The 1 bit per second patterns sent in the R bit channel shall have the following meanings:

00000000	PRM
11111111	SPRM inserted and frame format conversion ongoing within the network
10101010	internal hardware fault detected at point of insertion of SPRM
10001000	supplementary performance information added to the PRM

E.3.2 U1 Bit

The U1 bit is used to indicate network performance anomalies. The signal passing towards the CI is monitored for CRC, line code violations, or framing errors at the SPRM insertion point. If any of these errors are detected the U1 bit of the SPRM towards the network shall be set to a logical one. In all other cases the U1 bit shall be set to logical zero.

E.3.3 U2 Bit

The U2 bit is used to indicate CI performance anomalies. The signal passing from the CI is monitored for CRC, line code violations, or framing errors at the SPRM insertion point. If any of these errors are detected the U2 bit of the SPRM towards the network shall be set to a logical one. In all other cases the U2 bit shall be set to logical zero.

Annex F

(normative)

Network Performance Report Message (NPRM)

F.1 Application of NPRM

PRMs are normally transmitted by DS1 path terminations and are inserted in the data link at the points of generation of the ESF frame structure. The PRMs transmitted by each DS1 path termination present a view of the received DS1 signal as “seen” by the path terminating network element. The PRMs contain no information which might be used to sectionalize trouble at points along the DS1 path.

Network Performance Report Message (NPRM) information is written into the data link to further sectionalize trouble along the DS1 path. When added to the data link, NPRM information may be used to indicate trouble conditions on either the Near-end or Far-end side of the NI. NPRM is intended for application at a point within the network as close as is practicable to the NI so that the sectionalization provided will place trouble within the network or within the CI. NPRMs may cross the NI from the network. These messages may be ignored by the CI.

F.2 NPRM insertion - application guidelines

The NPRM shall originate in a network element and share the ESF data link with the PRM and other CI originated messages. The NRPM shall be applied based on one of the two cases defined below. Case 1 defines the case in which a PRM is present. Case 2 defines the case in which a PRM is not present.

F.2.1 Case 1: CI originated PRMs present in the ESF data link

Each NPRM is associated with a PRM that contains the same modulo-4 count.

The NPRM shall be sent once per second and shall follow its associated PRM with a separation of at least one flag. NPRM and CI data link traffic contention shall be resolved as follows:

The NPRM shall be inserted prior to the occurrence of the next PRM when the CI originated data link traffic permits.

If CI originated data link traffic does not permit the insertion of a NPRM prior to the occurrence of the next PRM, that NPRM shall not be sent.

F.2.1 Case 2: CI originated PRMs not present in the ESF data link

NPRM information may also be inserted in the data link when CI generated PRM information is not present. For this case, one-second intervals shall be derived from either the DS1 signal or from a separate equally accurate (±32 ppm) source. The phase of the one-second intervals with respect to the occurrence of errors is arbitrary; that is, the one-second intervals do not depend on the time of occurrence of any error event. NPRM and CI data link traffic contention shall be resolved as follows:

The scheduled NPRM shall be inserted in the ESF data link during the one second interval when the CI originated data link traffic (if present) permits.

If CI originated data link traffic does not permit the insertion of the scheduled NPRM within the one second interval, that NPRM shall not be sent.

F.3 Format of the NPRM messages

The format of the NPRM messages is that of an unnumbered and unacknowledged frame using the frame structure, field definitions and elements of procedure of the LAPD protocol defined in ITU-T Recommendation Q.921 with address values not as defined in the Recommendation. To differentiate the NPRM message from the performance report message, the NPRM message shall use a SAPI value of 16, a TEI value of 0 and the C/R bit shall be set to 1. The structure of the NPRM message is shown in figure 20. The content of the information field is also shown in figure 20, and is discussed in the following clauses.

F.3.1 Near-end Bits

Bits N1 through N4 are used to indicate Near-end error events. When ESF framing is present on the CI side of the Network Interface the near-end bits will indicate the range of CRC error events over the preceding one-second interval. When SF framing is present on the CI side of the Network Interface the near-end bits will indicate the range of FE error events over the preceding one-second interval.

F.3.2 Far-end Bits

Bits F1 through F4 are used to indicate Far-end error events. The far-end bits will indicate the range of CRC error events over the preceding one-second interval that were detected on the network side of the NI.

F.3.3 NSE and FSE Bits

The NSE and FSE bits are used to report the detection of severely-errored framing events over the preceding one-second interval. The NSE bit shall be set to a logical one when a Near-end severely-errored framing event is detected and the FSE bit shall be set to a logical one for a Far-end severely-errored framing event.

F.3.4 PA Bit

When a Performance Alert (PA) occurrence has been detected over the preceding one-second interval, the PA bit shall be set to a logical one. A Performance Alert is declared when either the Near-end or Far-end path has exceeded a preset performance threshold. The performance threshold limit is defined by the network provider.

F.3.5 FC Bit

When SF is received from the CI, the FC bit is set to a logical one to indicate that the N1 through N4 bits contain FE error events and that the SF to ESF framing format conversion process is ongoing. (see figure 20).

Octet No.	Bit 8	7	6	5	4	3	2	1
1	Flag							
2	SAPI						C/R	EA
3	TEI							EA
4	CONTROL							
5	N1	N2	NSE	R	N3	N4	PA	FC
6	F1	F2	FSE	R	F3	F4	Nm	Nl
7	N1	N2	NSE	R	N3	N4	PA	FC
8	F1	F2	FSE	R	F3	F4	Nm	Nl
9	N1	N2	NSE	R	N3	N4	PA	FC
10	F1	F2	FSE	R	F3	F4	Nm	Nl
11	N1	N2	NSE	R	N3	N4	PA	FC
12	F1	F2	FSE	R	F3	F4	Nm	Nl
13	FCS-lsb							
14	FCS-msb							
15	FLAG							

Octet	Octet contents	Interpretation
1	01111110	Opening LAPD flag
2	01000010	SAPI=16[1], C/R=1 (Carrier), EA=0
3	00000001	TEI=0, EA=1
4	00000011	Unacknowledged information transfer
5,6	t_0	Data for latest second
7,8	t_{0-1}	Data for previous second
9,10	t_{0-2}	Data for earlier second
11,12	t_{0-3}	Data for earlier second
13,14	Variable	CRC16 frame check sequence
15	01111110	Closing LAPD flag

Bit value - One-second report	Interpretation: ESF - From the CI (FC = 0)	SF - From the CI (FC = 1)
NSE =1	SEF ≥ 1, Near-end	SEF ≥ 1, Near-end
N1 = 1	CRC error event = 1, Near-end	FE error event = 1, Near-end
N2 = 1	1 < CRC error events ≤ 100, Near-end	Not used, set to 0
N3 = 1	100 < CRC error events ≤ 319, Near-end	1 < FE error events ≤ 3 or 7[2], Near-end
N4 = 1	CRC error event ≥ 320, Near-end	FE error event ≥4 or 8[2], Near-end
FSE =1	SEF ≥ 1, Far-end	SEF ≥ 1, Far-end
F1 = 1	CRC error event = 1, Far-end	CRC error event = 1, Far-end
F2 = 1	1 < CRC error events ≤ 100, Far-end	1 < CRC error events ≤ 100, Far-end
F3 = 1	100 < CRC error events ≤ 319, Far-end	100 < CRC error events ≤ 319, Far-end
F4 = 1	CRC error event ≥ 320, Far-end	CRC error event ≥ 320, Far-end
PA	Performance Alert (Defined by network provider)	
FC	Frame Format Conversion Flag	
R	Reserved (Default value = 0)	
NmNl = 00, 01, 10, 11	One-second report modulo 4 counter	

Notes:

1 SAPIs greater than 16 are reserved for T1E1 assignment.

2 The smaller value is used when F_t bits are monitored, the larger value is used when F_t and F_s bits are monitored - see T1.231.

3 The rightmost bit (bit 1, lsb) is transmitted first for all fields except for the two bytes of the FCS that are transmitted leftmost bit (bit 8, msb) first. CAUTION: For the FCS bytes only, the bit numbering is different from that of Q.921.

Figure F.1 Network performance report message structure

Annex G
(informative)

Cable characteristics

G.1 Customer installation cables

Specifications for CI cables may be found in ANSI/EIA/TIA-568. That standard contains specifications for both "backbone" and "horizontal" cables. Within each category, the following metallic cables with their characteristic impedances are referenced:

- 100-ohm unshielded twisted pair;
- 150-ohm shielded twisted pair;
- 50-ohm coaxial.

Only 100-ohm (nominal) cable is suitable for the Network-to-CI interface. If shielding in the CI is necessary, a shielded cable with a characteristic impedance of 100 ohms should be used.

The specifications for 100-ohm cable in the above-referenced standard are based on 24 AWG conductors. The maximum attenuation of "backbone" cable is limited in that standard to 6.7 dB per 1000 ft at 772 kHz. This standard limits the attenuation of the cabling from the NI to the customer premises equipment to a maximum of 5.5 dB at 772 kHz. Assuming that all the attenuation is a result of "backbone" cable, the resultant cable length limitation is

$$\{ 5.5 \text{ dB} \}/\{ 6.7 \text{ dB/Kft} \} \approx 820 \text{ ft.}$$

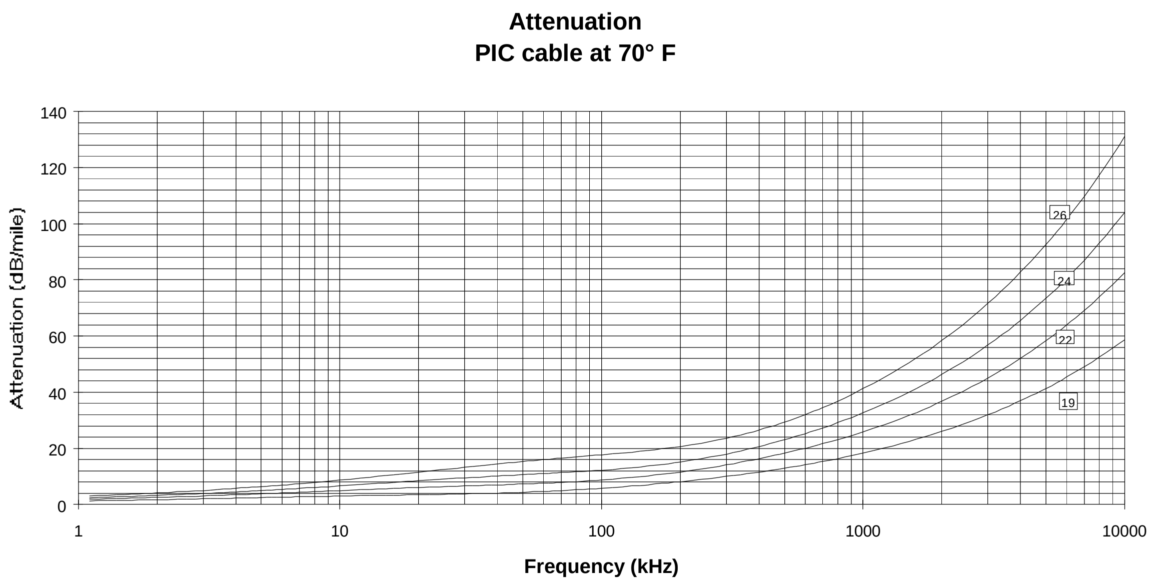
To be compliant with this standard, longer lengths of CI cable require one of the following:

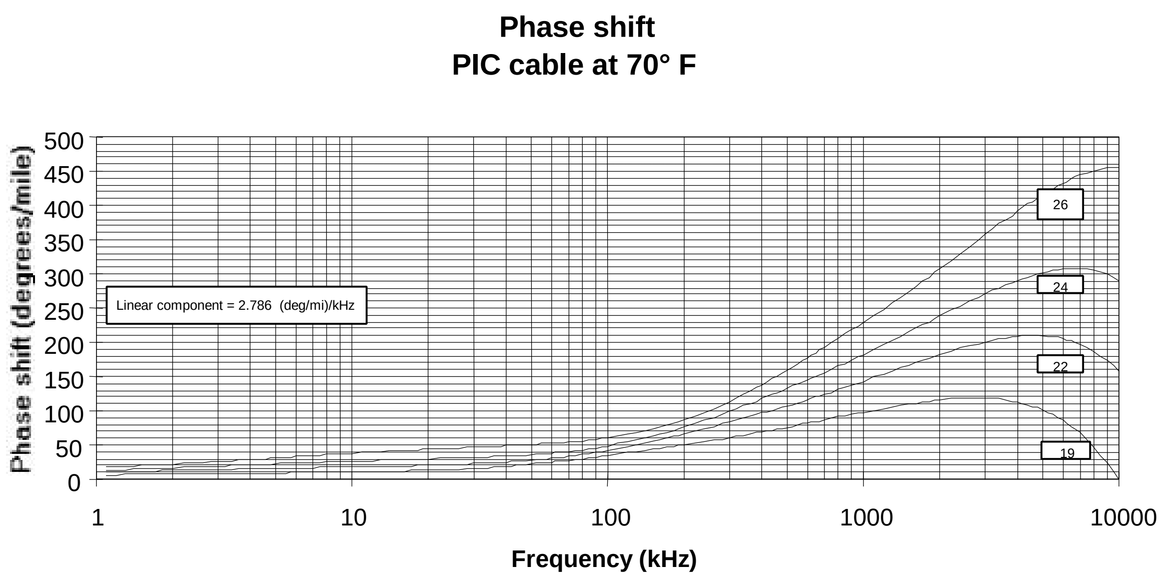
- CI cable with less loss;
- CI repeater(s).

G.2 Carrier cables

This annex contains graphs of two transmission-line parameters for cables generally deployed in the carrier's plant. The transmission-line parameters are the propagation constant, λ, and the characteristic impedance, Z_0. Both parameters are plotted as a function of frequency in figures 21 and 22. In general, both parameters have complex values. The real component of λ is attenuation. It is expressed in units of dB/mile. The imaginary component of λ is phase shift. It is expressed in units of degrees/mile.

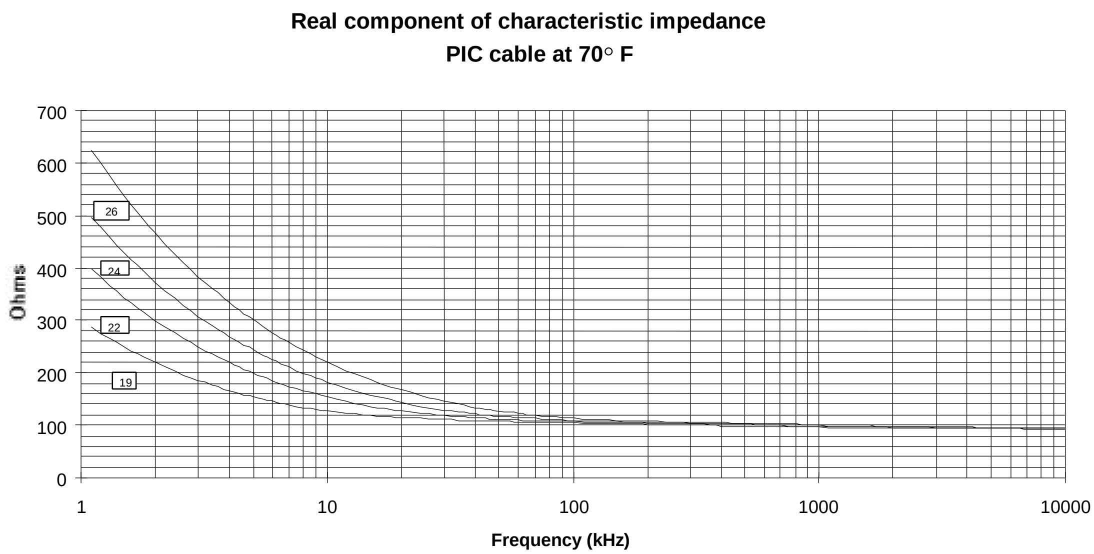
The graphs portray values for four conductor sizes (19, 22, 24, and 26 AWG) of Polyethylene Insulated Conductor (PIC) cable at 70º F.





Note: the graph represents the nonlinear portion of the phase shift characteristics.

Figure G.1 Attenuation and phase shift of PIC cable



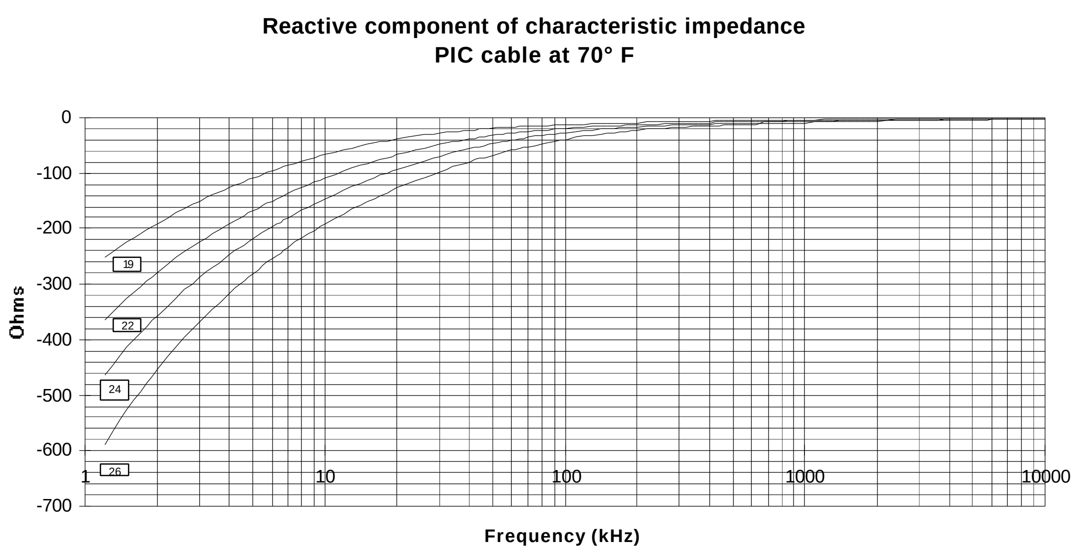


Figure G.2 Real and reactive components of characteristic impedance

Annex H
(informative)

Line build-out

H.1 Repeatered line end-section design

In the design of a repeatered line, the last section ¾ known as the "end-section" ¾ transmits and receives pulses between the final span-line repeater and the CI network channel terminating equipment (NCTE). The target loss range for an end-section is 0 to 22.0 dB [18]. This loss has been partitioned into the following ranges:

- 0 to 16.5 dB from the last repeater to the NI;

- 0 to 5.5 dB from the NI to the NCTE.

H.2 Description of LBO

A line build-out (LBO) attenuates the signal from the CI transmitter. The LBO does not produce simple (resistive) flat loss, but rather simulates cable loss so that the resulting signal can be handled properly by the receiver equalizer at the other end.

H.3 Need for LBO

Some regenerators require that input signals be attenuated by at least 7.5 dB below a nominal 3 V pulse. LBO in the CI is needed to limit the signal amplitude at the input to the regenerator in installations where the attenuation between the regenerator and the NCTE is less than this amount.

LBO may also be needed to control signal level differences at repeatered-line route junctions where there is no repeater at the junction. Such junctions are referred to as non-repeatered route junctions (NRRJs). A NRRJ is illustrated in figure 23. There is a far-end crosstalk (FEXT) coupling path between circuits A and B, as shown in the figure. This coupling occurs between the NRRJ and repeater location #1. If the loss, LR, is significantly less than the sum of L1 and L2, the crosstalk from circuit B may cause such a high noise level at repeater location #1 that errors are created. To control this noise, the maximum signal level difference at NRRJs, denoted as Δ, is limited to 7.5 dB [19], where

$$\Delta = | L1 + L2 - LR |$$

LR may have values ranging from 7.5 to 22.0 dB. The sum of L1 and L2 may range from 0 to 22.0 dB. When these values are not within 7.5 dB of each other, LBO is needed to maintain an acceptable signal level difference.

H.4 FCC requirements for LBO

FCC Part 68 Rules require that network channel terminating equipment (NCTE) for DS1 include LBO networks in 7.5 dB steps. Three values of LBO options, with specific labels as shown below, are required.

---

[18] All values of attenuation are specified at 772 kHz.

[19] This assumes that the value of L2 is known. In practice, this is not usually the case. This standard allows it to have any value between 0 and 5.5 dB. To account for this variation in signal level, it may be necessary to limit the difference between L1 and LR to a value much less than 7.5 dB.

Option label	Attenuation at 772 kHz (dB)
A	0
B	7.5
C	15.0

Part 68 stipulates that a 7.5 dB LBO network (option B) have the following transfer function:

$$\frac{V_{out}}{V_{in}} = \frac{n_2 S^2 + n_1 S + n_0}{d_3 S^3 + d_2 S^2 + d_1 S + d_0}$$

Where:

n_0 = 1.649×10^6
n_1 = 7.9861×10^{-1}
n_2 = 9.2404×10^{-8}
d_0 = 2.1612×10^6
d_1 = 1.7223
d_2 = 4.575×10^{-7}
d_3 = 3.8307×10^{-14}
S = $j\,2\,\pi\,f$
f = frequency (Hz)

FCC Part 68 Rules also address the administration of LBO. When L2 of figure 23 is negligible, and the value of L1 is known, the customer is instructed to set the value of LBO so that:

$$L1 + LBO = 18 \text{ dB} \pm 4 \text{ dB}$$

This approach fails to address DS1 signals delivered from a multiplexer instead of a metallic repeatered line. In this instance, L1 $\approx$ 0. That value of L1 requires 15 dB of LBO using the above equation. The multiplexer, however, requires a nominal 3 V signal that corresponds to 0 dB of LBO. For this reason, this standard requires that the carrier advise the customer of the total signal attenuation involved, using LBO codes A, B, or C.

NOTE – Certain NCTE may provide the option to automatically select the LBO setting as a function of received level. Automatic LBO selection may be used when the carrier has advised the use of LBO code B or C. It should not be used if the carrier has advised the use of LBO code A.

H.5 Substitution of customer cable loss for LBO

The total CI attenuation will be composed of the customer cable loss and one of the three LBO attenuations. Three loss ranges result:

– *Case 1:* 0 to 5.5 dB (carrier advises LBO code A)

– *Case 2:* 7.5 to 13.0 dB (carrier advises LBO code B)

– *Case 3:* 15.0 to 20.5 dB (carrier advises LBO code C)

When the carrier advises an LBO code of A, the CI cable loss is presumed to be in the range of 0 to 5.5 dB as shown in figure 23. When the carrier advises an LBO code of B, it indicates that the overall CI attenuation is presumed to be 7.5 to 13.0 dB. The customer has the option of positioning the NCTE further from the NI, and utilizing LBO code A, as long as the cable loss is in the range 7.5 to 13.0 dB. When the carrier advises LBO option code C, the customer has even more flexibility. The following table summarizes the tradeoff options between LBO and customer cable loss.

Customer options

Carrier-advised code	Cable Loss (dB)	NCTE LBO option label
A	0.0 - 5.5	A
B	0.0 - 5.5	B
	7.5 - 13.0	A
C	0.0 - 5.5	C
	7.5 - 13.0	B
	15.0 - 20.5	A

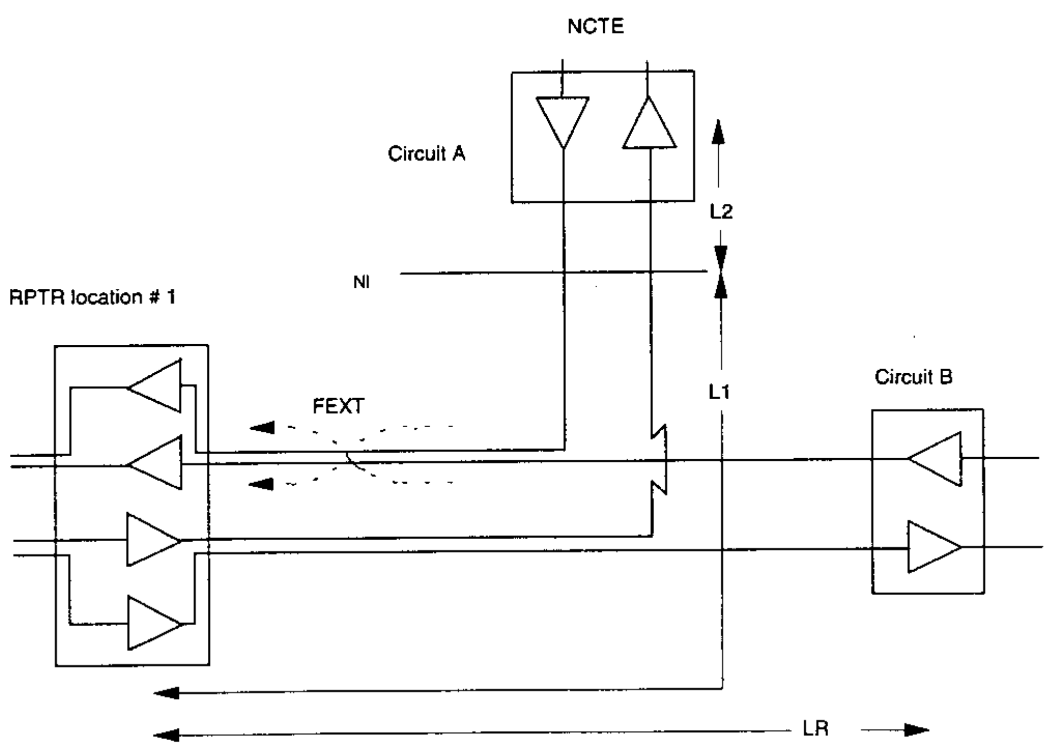


Figure H.1 Non-repeated route junctions

Annex I
(informative)

ESF data link message comparison with other standards

Table 7 compares the wording used for specifying ESF data link messages in other ANSI standards and various ITU-T recommendations involving ISDN. The column labeled T1.403 contains the assignments in table 4. The messages are listed in increasing order of decimal value of the *xxxxxx* component in the message structure 0*xxxxxx*0 11111111. The table is accurate as of the approval date of this standard. It is an objective to further harmonize the various standards that refer to the message functions to minimize the opportunity for confusion.

Table I.1– Comparison of messages specifications in various standards

Message	T1.403	I.431	G.963	G.704
00000000 11111111	RAI alarm	RAI	RAI	LFA(also ca
00000010 11111111	Reserved for customer	Reserved for user	-	-
00000100 11111111	Stratum 1 traceable	-	-	-
00000110 11111111	Reserved for customer	Reserved for user	-	-
00001000 11111111	Sync traceability unknown	-	-	-
00001010 11111111	Reserved for customer	Reserved for user	-	-
00001100 11111111	Stratum 2 traceable	-	-	-
00001110 11111111	Line loopback activate	Line loopback 3 activate	Loopback 2 activate	CI type A LE
00010000 11111111	Stratum 3 traceable	-	-	Synch.-for fu
00010010 11111111	Rsvd for netwk (LB activate)	-	Loopback 1A activate	Netw'k type
00010100 11111111	Payload loopback activate	Payload LB 3 activate	-	Payload loo
00010110 11111111	Reserved for network use	-	-	-
00011000 11111111	Protection switch ack	-	-	Ack. prot. sv
00011010 11111111	Reserved for network use	-	-	-
00011100 11111111	ISDN (international)	-	NT1 power off (Opt 2)	-
00011110 11111111	Reserved for network use	-	-	-
00100000 11111111	ISDN line loopback (I_b)	Loopback C activate	-	CI type B LE
00100010 11111111	±20 ppm clock traceable	-	-	Synch.-for fu
00100100 11111111	Universal LB deactivate	Universal LB deactivate	Universal LB deactivate	Universal LE
00100110 11111111	Protection switch release	-	-	Release pro
00101000 11111111	Stratum 4 traceable	-	-	Synch.-for fu
00101010 11111111	Loopback retention	Loopback retention	Loopback retention	Loopback re
00101100 11111111	Under study - maintenance	-	-	-
00101110 11111111	CI loopback	Reserved for user	-	CI type C LE
00110000 11111111	Don't use for synch	-	-	Synch.-for fu
00110010 11111111	Payload LB deactivate	Payload LB 3 deactivate	-	Payload LB
00110100 11111111	Under study - maintenance	-	-	-
00110110 11111111	Reserved for customer	Reserved for user	-	-
00111000 11111111	Line loopback deactivate	Line LB 3 deactivate	Loopback 2 deactivate	CI type A LE
00111010 11111111	Reserved for network use	-	-	-
00111100 11111111	Unassigned	-	-	-
00111110 11111111	Unassigned	-	-	-
01000000 11111111	Reserved for network synch	-	-	-
01000010 11111111	Rsvd prot. switch line 1	-	-	Prot. Sw. op
through	through			
01110110 11111111	Rsvd prot. switch line 27	-	-	Prot. Sw. op
01111000 11111111	Unassigned	-	-	-
01111010 11111111	Unassigned	-	-	-
01111100 11111111	Unassigned	-	-	-

01111110 11111111	Not recommended for use	-	-	-

Annex J
(informative)

Alarm Indication Signal (AIS)

J.1 AIS description

The DS1 AIS is an all-ones, unframed signal transmitted in place of the normal signal under specified conditions. It satisfies all line format specifications (AMI or B8ZS, and pulse density), and can readily be differentiated from a normal framed signal by the receiving equipment.

J.2 AIS generation

AIS is generated at the DS1 level by equipment detecting a loss-of-signal (LOS) defect, or by equipment placed in a maintenance state, such as a loopback. A DS1 AIS is also generated by demultiplexing equipment that has detected signal defects in the digital hierarchy above DS1. See figure 24.

When AIS is the result of signal defects, the AIS is transmitted from the time the defect is detected until the defect ends. For example, an LOS could be detected and then terminated in as little as 9 µs. An AIS signal would be generated for the same period. On the other hand, there is no maximum length for an AIS, as the duration of a signal failure or a maintenance state can be of any length. Therefore, the duration of an AIS is equal to or greater than a few microseconds.

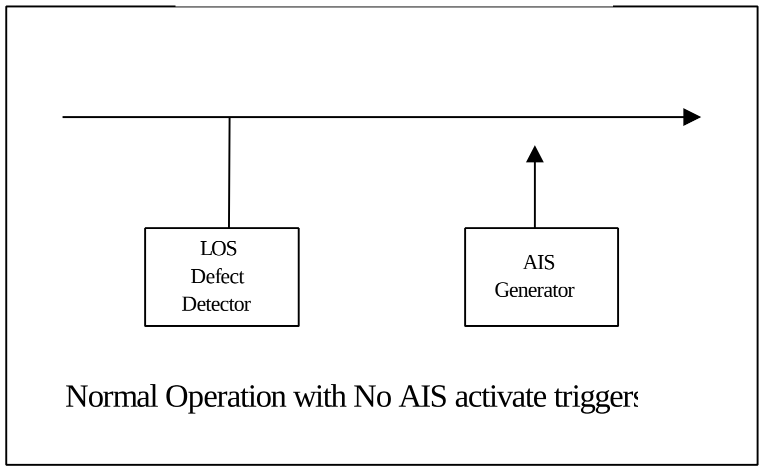
J.3 AIS detection

The detection of AIS is a necessary function in receiving equipment. Criteria for detection appear in ANSI T1.231 as observation of a signal with a 99.9% ones density for a period equal to or greater than *T*, where *T* lies between 3 ms and 75 ms. Criteria for recognizing the disappearance of the AIS include observing a framed signal with a ones density less than 99.9% for a period equal to or greater than *T*, where *T* lies between 3 ms and 75 ms.

The 3 ms minimum time was chosen as the minimum time an AIS, corrupted by errors at a BER of 1×10^{-3}, could be reliably differentiated from a normal (framed) signal containing an "all-ones" in the payload. To reliably detect an AIS in 3 ms, it is necessary to test for the simultaneous occurrence of an out-of-frame (OOF) defect and the 99.9% ones density. It is possible to detect an AIS defect without checking for OOF, but a longer observation interval is required.

A valid DS1 AIS can be shorter than that required for reliable detection. However, for a DS1 signal in the ESF format, the receipt of a "short" AIS would cause, at a minimum, a CRC error event.

Loss of Signal Configuration



Line Loopback Configuration

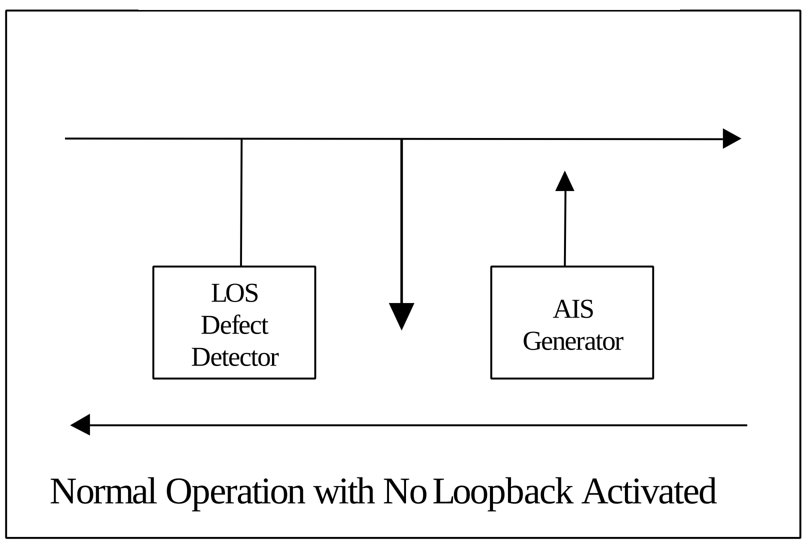
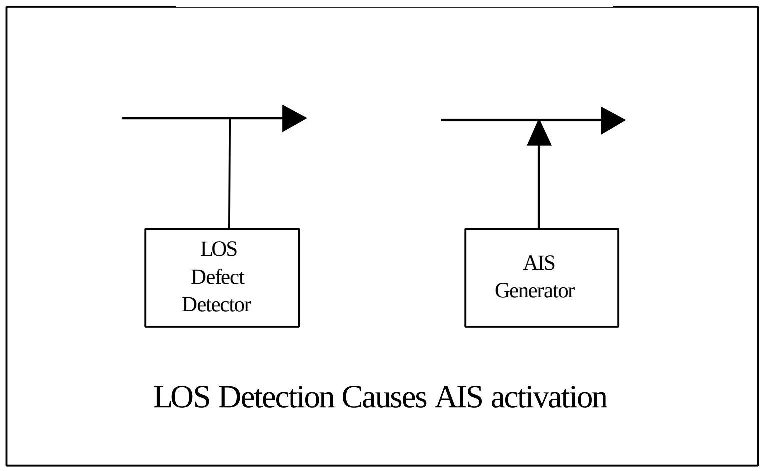


Figure J.1 Examples of Normal Operation

Loss of Signal Configuration



Line Loopback Configuration

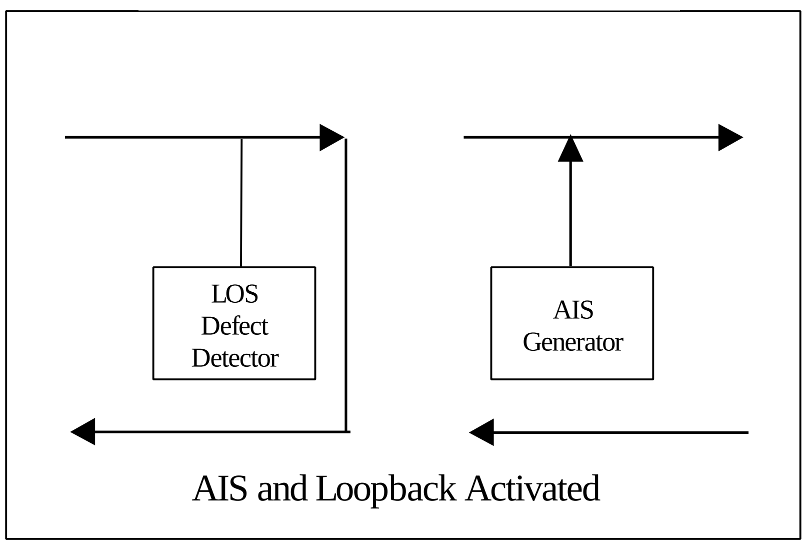
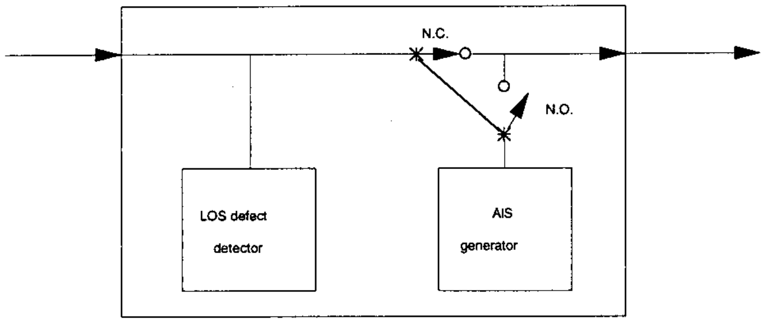


Figure J.2 Examples of AIS and Loopback Activated

To be deleted

Loss of signal configuration



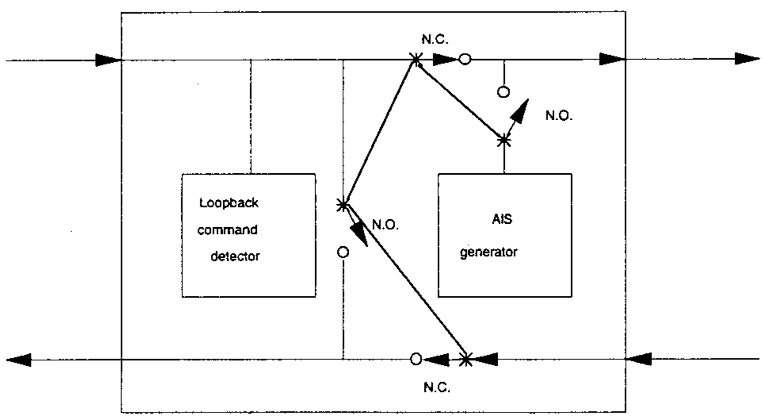
NOTES

1 LOS detection causes change of switch state.

2 N.O. = Normally open contact

3 N.C.= Normally closed contact

Line loopback configuration



NOTES

1 Loopback activation causes change of switch state.

2 Loopback deactivation returns switch to state shown.

3 N.O. = Normally open contact

4 N.C.= Normally closed contact

Annex K

(informative)

Bibliography

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