IEEE Std 802.4h-1997

(Supplement to ISO/IEC 8802-4: 1990
[ANSI/IEEE Std 802.4-1990])

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Alternative Use of BNC Connectors and Manchester-Encoded Signaling Methods for Single-Channel Bus Physical Layer Entities

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IEEE Std 802.4h-1997
(Supplement to ISO/IEC 8802-4: 1990
[ANSI/IEEE Std 802.4-1990])

IEEE Standards for Local and Metropolitan Area Networks:

Supplement to Token-Passing Bus Access Method and Physical Layer Specifications

Alternative Use of BNC Connectors and Manchester-Encoded Signaling Methods for Single-Channel Bus Physical Layer Entities

Sponsor

LAN MAN Standards Committee
of the
IEEE Computer Society

Approved 26 June 1997

IEEE Standards Board

Abstract: This supplement to ISO/IEC 8802-4:1990 [ANSI/IEEE Std 802.4-1990] provides the functional, electrical, and mechanical characteristics of single-channel differential and Manchester-data-encoded bus Physical Layer Entities (PLEs).
Keywords: BNC connectors, differential Manchester encoding, eye pattern, local area network, MAC-Symbol encoding, Manchester-encoded signaling, Physical Layer Entity, single-channel bus, token-passing bus access method

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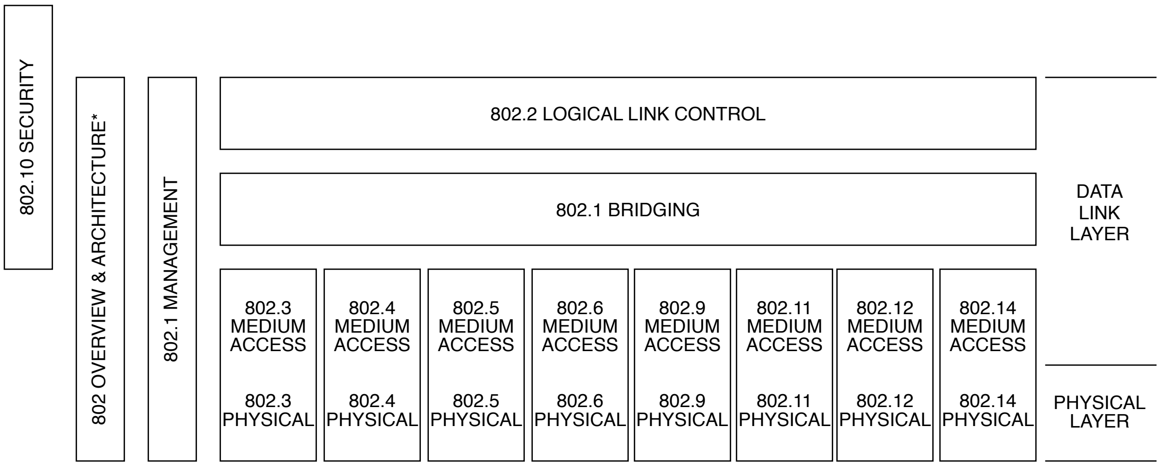
Introduction

(This introduction is not part of IEEE Std 802.4h-1997, IEEE Standards for Local and Metropolitan Area Networks: Supplement to Token-Passing Bus Access Method and Physical Layer Specifications: Alternative Use of BNC Connectors and Manchester-Encoded Signaling Methods for Single-Channel Bus Physical Layer Entities.)

This standard is part of a family of standards for local and metropolitan area networks. The relationship between the standard and other members of the family is shown below. (The numbers in the figure refer to IEEE standard numbers.)



* Formerly IEEE Std 802.1A.

This family of standards deals with the Physical and Data Link layers as defined by the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) Open Systems Interconnection Basic Reference Model (ISO/IEC 7498-1: 1994). The access standards define several types of medium access technologies and associated physical media, each appropriate for particular applications or system objectives. Other types are under investigation.

The standards defining the access technologies are as follows:

• IEEE Std 802	*Overview and Architecture*. This standard provides an overview to the family of IEEE 802 Standards. This document forms part of the 802.1 scope of work.
• ANSI/IEEE Std 802.1B and 802.1k [ISO/IEC 15802-2]	*LAN/MAN Management*. Defines an Open Systems Interconnection (OSI) management-compatible architecture, and services and protocol elements for use in a LAN/MAN environment for performing remote management.
• ANSI/IEEE Std 802.1D [ISO/IEC 10038]	*MAC Bridging*. Specifies an architecture and protocol for the interconnection of IEEE 802 LANs below the MAC service boundary.
• ANSI/IEEE Std 802.1E [ISO/IEC 15802-4]	*System Load Protocol*. Specifies a set of services and protocol for those aspects of management concerned with the loading of systems on IEEE 802 LANs.
• ANSI/IEEE Std 802.2 [ISO/IEC 8802-2]	*Logical Link Control*
• ANSI/IEEE Std 802.3 [ISO/IEC 8802-3]	*CSMA/CD Access Method and Physical Layer Specifications*

- ANSI/IEEE Std 802.4 [ISO/IEC 8802-4] — *Token Passing Bus Access Method and Physical Layer Specifications*
- ANSI/IEEE Std 802.5 [ISO/IEC 8802-5] — *Token Ring Access Method and Physical Layer Specifications*
- ANSI/IEEE Std 802.6 [ISO/IEC 8802-6] — *Distributed Queue Dual Bus Access Method and Physical Layer Specifications*
- ANSI/IEEE Std 802.9 [ISO/IEC 8802-9] — *Integrated Services (IS) LAN Interface at the Medium Access Control (MAC) and Physical (PHY) Layers*
- ANSI/IEEE Std 802.10 — *Interoperable LAN/MAN Security*
- IEEE Std 802.11 — *Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications*
- ANSI/IEEE Std 802.12 — *Demand Priority Access Method, Physical Layer and Repeater Specifications*

In addition to the family of standards, the following is a recommended practice for a common Physical Layer technology:

- IEEE Std 802.7 — *IEEE Recommended Practice for Broadband Local Area Networks*

The following additional working group has authorized standards projects under development:

- IEEE 802.14 — *Standard Protocol for Cable-TV Based Broadband Communication Network*

The reader of this standard is urged to become familiar with the complete family of standards.

Conformance test methodology

An additional standards series, identified by the number 1802, was established in 1990 to identify the conformance test methodology documents for the 802 family of standards. Thus the conformance test documents for 802.3 are numbered 1802.3.

IEEE Std 802.4h-1997

This supplement to ISO/IEC 8802-4 : 1990 [ANSI/IEEE Std 802.4-1990] provides the functional, electrical, and mechanical characteristics of single-channel differential and Manchester-data-encoded bus Physical Layer Entities (PLEs).

This standard contains state-of-the-art material. The area covered by this standard is undergoing evolution. Revisions are anticipated within the next few years to clarify existing material, to correct possible errors, and to incorporate new related material. Information on the current revision state of this and other IEEE 802 standards may be obtained from

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IEEE Standards for Local and Metropolitan Area Networks:

Supplement to Token-Passing Bus Access Method and Physical Layer Specifications

Alternative Use of BNC Connectors and Manchester-Encoded Signaling Methods for Single-Channel Bus Physical Layer Entities

The contents of this supplement will be incorporated into IEEE Std 802.4 in a future edition. The sections of this supplement are ordered to parallel the order of sections in the base standard. This supplement is intended to be used in conjunction with IEEE Std 802.4-1990. Editing instructions necessary to incorporate this supplement into IEEE Std 802.4 are provided in ***bold italics***. The style of this supplement also matches that of the base document. When the contents of this supplement are incorporated into IEEE Std 802.4 in a future edition, the style will be updated to match current practices.

Add Sections 20 and 21 as follows:

20. Single-Channel Differential Manchester-Encoded Data Bus Physical Layer Entity (PLE)

The functional, electrical, and mechanical characteristics of two forms of PLEs (single-channel differential and Manchester-data-encoded bus) of this standard are specified in this section. The relationship of this section to other sections of this standard and to local area network (LAN) specifications is illustrated in Fig 20-1.

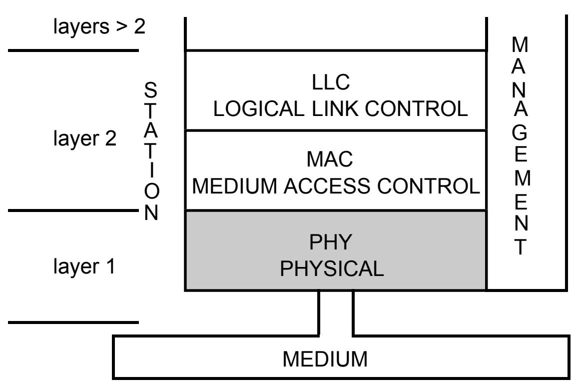


Fig 20-1
Relation to LAN Model

This specification includes two types of PLEs, Type A and Type B, found in stations that can attach to two types of LAN media. One medium that is described in Section 13, and is also used with the PLEs described in Section 12, is commonly known as “carrierband.” The other medium is described in Section 21. The relationship of the PLEs defined in this section to the media types is illustrated in Fig 20-2.

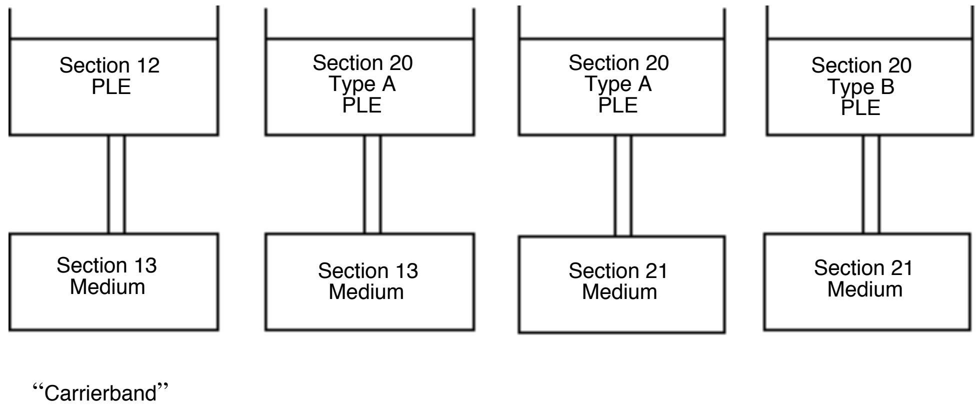


Fig 20-2
PLE and Medium Types

This standard specifies these PLEs only as necessary to ensure
(1) The interpretability of implementations conforming to this specification, and
(2) The protection of the LAN and those using it.

20.1 Nomenclature. Terms used in this section that have meaning within the section that is more specific than that indicated in the glossary of IEEE Std 802. 1B [10] are as follows:

dBmV. A measure of rms signal level on a 75 Ω cable compared to 1 mV. In terms of SI units (International System of Units), dBmV is defined as dB (1 mV, 75 Ω) rms.

detected bit error. An error that is reported as a *bad_signal*. A *bad_signal* reported during the preamble or during the four symbols following the last end delimiter of a transmission is not included.

differential Manchester encoding. A means by which separate data and clock signals are combined into a single, self-synchronized data stream suitable for transmission on a serial channel.

drop cable. The coaxial cable of the medium that connects to a station.

medium. The cable system of a LAN, including a trunk cable, taps, and drop cables.

operating frequency range. That range defined as 2–15 MHz for a 10 Mb/s data rate and 4–30 MHz for a 20 Mb/s data rate.

regenerative repeater. A device used to extend the length or topology of the medium beyond the limits imposed by signal degradation on a single segment on the medium.

single-channel system. A system where at any point on the medium only one information signal at a time can be present without disruption.

trunk cable. The main cable of the medium, which interconnects the taps.

Type A PLE. A PLE capable of working over the medium described in Section 13 or Section 21 of this standard (PLE receiver threshold set to +10 dBmV).

Type B PLE. A PLE capable of working over the medium described in Section 21 of this standard (PLE receiver threshold set to +20 dBmV).

undetected bit error. An error that is not reported as a *bad_signal* by the PLE.

20.2 Object. The object of this specification is to
(1) Provide the physical means necessary for communication between local network stations employing the LAN token-passing bus access method and using the single-channel medium described in Sections 13 and 21 of this standard.
(2) Define a physical interface that can be implemented independently among different manufacturers of hardware and achieve the intended level of compatibility when interconnected to the common bus LAN medium.

(3) Provide a communications channel capable of high bandwidth and low bit error rate.
(4) Provide for ease of installation and service in a wide range of environments.
(5) Provide for high network availability.
(6) Facilitate low-cost implementations.

20.3 Compatibility Considerations. This standard applies to PLEs that are designed to operate on a 75 Ω coaxial cable configured in a trunk and drop cable structure as defined in Sections 13 and 21. The compatibility between the two types of PLEs and the two types of media is shown in Fig 20-2. Compatibility is determined at the medium interface. Compatible physical entities shall use the same signaling rate.

20.4 Medium Overview. The two types of media usable with the PLE are summarized below. The communications medium specified in Sections 13 and 21 consists of a trunk and drop structure. The media trunk cable is connected to the drop cables by nondirectional impedance-matching networks (taps), and the drop cables are connected to the stations. The medium described in Section 13 delivers a signal of at least +10 dBmV to receiving stations. The medium described in Section 21 delivers a signal of at least +20 dBmV to receiving stations. Extensions of the topology or size of the medium are accomplished by active regenerative repeaters.

20.5 PLE Overview

20.5.1 General Description of Functions. The functions performed by the single-channel differential Manchester-encoded data bus PLE are described informally here. Jointly, these functions provide a means whereby Medium Access Control (MAC) symbols presented at the MAC interface of the PLE can be conveyed to all of the PLEs on the bus for presentation to their respective MAC interfaces.

20.5.1.1 Symbol Transmission and Reception Functions. Successive MAC-symbols presented to the PLE at its service interface are applied to a differential Manchester encoder that produces as output a three PHY-symbol code: {H}, {L}, {off}.

This encoded signal is then ac-coupled to the single-channel bus medium and conveyed by the medium to one or more receivers.

Each receiver is also ac-coupled to the bus medium. The receiver bandpass-filters the signal to reduce received noise, and infers the transmitted PHY-symbols. It recovers the timing of the transmitted PHY-symbols, decodes the inferred PHY-symbols by an inverse of the encoding process, and presents the decoded MAC-symbols at its MAC service interface.

For all MAC-symbols except *pad_idle*, this decoding process is an exact inverse of the encoding process in the absence of errors. The *pad_idle* symbols, which are referred to collectively as “preamble,” are transmitted at the start of each MAC frame, both to provide a training signal for receivers and to provide a nonzero minimum separation between consecutive frames. Since each transmission begins with *pad_idle* symbols, it is expected that some of these initial symbols may be “lost in transit” between the transmitter and the receiver. Additionally, in this differential Manchester-encoded data system, the MAC-symbols for successive *pad_idle* symbols are identical to the encoding of an alternating series of *ones* and *zeros*. Receivers are permitted to decode the transmitted representations of successive *pad_idle* symbols as an alternating series of *ones* and *zeros* and report it as such to the MAC entity.

20.5.1.2 Regenerative Repeater Functions. Regenerative repeaters may be used to extend the network size beyond the maximum signal loss or distortion budget of a single medium segment. They do so by connecting two or more medium segments and repeating anything “heard” on one segment to the other segments. For the purposes of this standard, regenerative repeaters are considered stations, whether or not they have functionality beyond that of a repeater.

20.5.1.3 Jabber Inhibit Functions. To protect the LAN from most faults in a station, each station contains a jabber-inhibit function. This function serves as a “watchdog” on the transmitter; if the station does not turn off its transmitter after a prolonged time (approximately 0.5 s), then the transmitter output shall be automatically disabled for at least the remainder of the transmission.

20.5.1.4 Local Administrative Functions (OPTIONAL). These functions are activated either manually or by way of the PLE management interface, or both. They include

(1) Enabling or disabling each transmitter output (a redundant medium configuration has two or more transmitter outputs).
(2) Selecting the received signal source (any medium, if redundant media are present, of any available loopback point).

NOTE: If a loopback point is selected, then all transmitter output to the medium shall be inhibited.

20.5.2 Basic Functions and Options. Symbol transmission and reception functions and jabber-inhibit functions are required in all implementations. All other functions are optional.

20.6 Application of Management. The following constraints are imposed on the parameters and actions specified in Section 9:

(1) In the capabilities group, the dataRate parameter sequence shall specify one or both of the values 10 and 20.

(2) In the local management information, the value of minPostSilencePreambleLength shall be 6.

20.7 Functional, Electrical, and Mechanical Specifications. Unless otherwise stated, all voltage and power levels specified are in rms and dBmV, respectively. Specifications shall be met by the fundamental frequency component during the continuous transmission of either all *one* symbols, all *zero* symbols, or alternating *one* and *zero* symbols.

20.7.1 Data Signaling Rates. The standard signaling rates for differential Manchester-encoded data systems are 10 Mb/s and 20 Mb/s. The permitted tolerance for each signaling rate is ±0.01% for originating stations and ±0.015% for a repeater station while repeating. When a composite PLE is embodied in a regenerative repeater, it shall originate signaling on all media at exactly the same data rate.

20.7.2 Symbol Encoding. The PLE transmits symbols presented to it at its MAC interface by the MAC sublayer entity. The possible input MAC-symbols are *zero*, *one*, *non-data*, *pad_idle,* and *silence*. The possible MAC-symbols are differential Manchester-encoded into the PHY-symbols {off}, {H}, and {L}. The encoding action to be taken for each of the MAC-symbols is

(1) *Silence*. Each *silence* symbol shall be encoded as the sequence {off}{off}.

(2) *Pad_idle*. *Pad_idle* symbols are always originated in octets. Each pair of consecutive *pad_idle* symbols shall be encoded as {LH}{HL} with {LH} as the first transmitted symbol.

With the exception of a regenerative repeater, when sending *pad_idle* MAC-symbols immediately after *silence* MAC-symbols, the MAC sublayer entity shall send at least 6 octets of *pad_idle* MAC-symbols. This minimum post-*silence* preamble is composed of the following two parts:

(a) The first part, of 3 octets, is a delay to compensate for possible receiver blanking at remote stations as described in 20.7.6.3.

(b) The final 3 octets of *pad_idle* MAC-symbols are provided for receiver synchronization. A regenerative repeater shall repeat *silence* during the receiver blanking period. This may cause the preamble of the succeeding transmission to be shortened by up to 3 octets.

(3) *Zero*. Each *zero* symbol shall be encoded as the sequence {HL}.

(4) *One*. Each *one* symbol shall be encoded as the sequence {LH}.

(5) *Non_data*. *Non_data* symbols are transmitted by the MAC sublayer entity in pairs. Each such pair of consecutive *non_data* symbols shall be encoded as the sequence {LL} {HH} when the immediately preceding PHY-symbol is an {L} and shall be encoded as the sequence {HH} {LL} when the immediately preceding PHY-symbol is an {H}. Thus, the start delimiter subsequence

non_data non_data zero non_data non_data zero

shall be encoded as the sequence

{LL}{HH}{HL}{LL}{HH}{HL}

and the end delimiter subsequence

non_data non_data one non_data non_data one

shall be encoded as the subsequence

{LL}{HH}{LH}{HH}{LL}{LH}

after an immediately preceding {L}, and as the subsequence

{HH}{LL}{LH}{HH}{LL}{LH}

after an immediately preceding {H}.

Fig 20-3 shows representative encodings of the MAC-symbols.

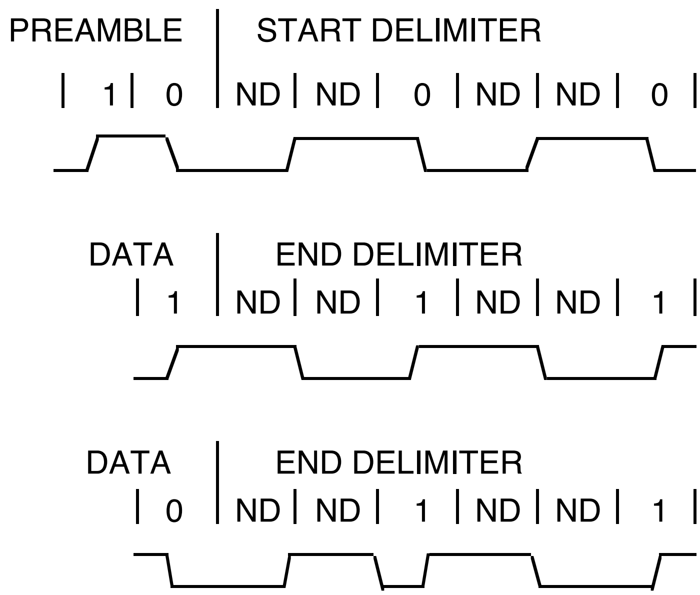


Fig 20-3
MAC-Symbol Encoding

20.7.3 Transmitted Signals. The PHY-symbols resulting from the encoding of 20.7.2 shall be converted directly to their line representations, as described in 20.7.3.1, and the resultant signaling shall be coupled to the medium, as described in 20.5.1 and 20.7.5. The polarity of the signal at the start of the frame does not imply specific information about the signal. The PLE shall be able to receive signals of either polarity.

20.7.3.1 Signal Representation. The signal representations of the {off}, {H}, and {L} PHY-symbols shall be as follows:

(1) An {off} symbol shall be represented by no signal for a period equal to one-half of the period of MAC-symbol delivery for the MAC entity at the MAC interface.
(2) An {L} symbol shall be represented by a voltage level for a duration of one-half of the MAC-symbol time.
(3) An {H} symbol shall be represented by a voltage level of opposite polarity to that of preceding {L} for a duration of one-half of the MAC-symbol time.

20.7.3.2 Jitter. The maximum jitter in the period of {L} or {H} shall be no more than ±1% of the MAC-symbol time.

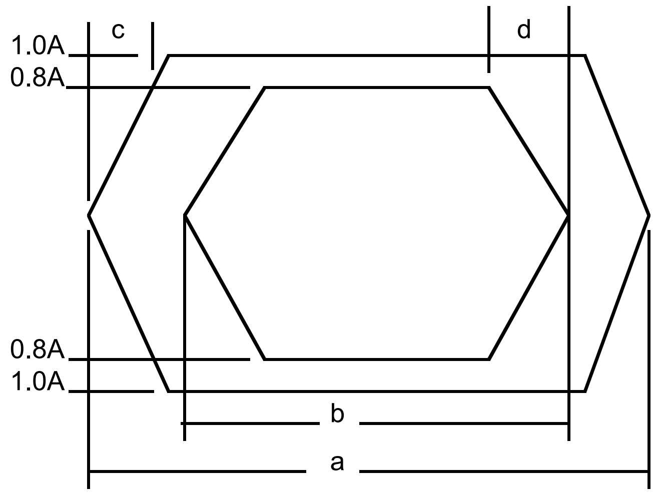
20.7.3.3 Output Level. The output level of the transmitted signal into a 75 Ω resistive load shall be between +63 dBmV and +66 dBmV, inclusive.

20.7.3.4 Leakage. The residual leakage transmitter-off output shall be no more than –20 dBmV in the operating frequency range.

20.7.3.5 Transition Times. The transmit signal of {H} and {L} PHY-symbols shall fit within the shaded portion of the eye pattern shown in Fig 20-4.

(1) The signal rise time, measured from the –80% to +80% signal points (10% to 90% of peak-to-peak signal amplitude), and the fall time, measured from the +80 to –80% signal points (90% to 10% of peak-to-peak signal amplitude), shall be greater than 7. 5% of the MAC-symbol_time. That is, the rise and fall times of the transmitted signal shall be no less than 15 ns for the 10 Mb/s data rate and no less than 7.5 ns for the 20 Mb/s data rate. In addition, the rise and fall times of the transmit signal, measured as above, shall be no greater than 70 ns for the 10 Mb/s data rate and no greater than 35 ns for the 20 Mb/s data rate.

NOTE: The intent of this specification is to allow a transmitted waveshape anywhere between a slew-rate-limited square wave and a sinusoidal wave. If the slew rate {H} and {L} PHY-symbols are equal, the slew rate should not exceed 12% of the nominal MAC symbol_time in order to meet the output level requirements of 20.7.3.3.



10 Mb/s				20 Mb/s			
a	b	c	d	a	b	c	d
102	98	7.5	35	51	49	3.75	17.5

NOTE: Values in nanoseconds.

Fig 20-4
Eye Pattern

(2) The rise and fall times for all {H}s shall be within 10% of each other. The rise and fall times of all {L}s shall be within 10% of each other.
(3) The spectral envelope of the signaling shall be such that the harmonic content relative to the rms transmitted power is as follows:
(a) 2nd and 3rd harmonic are at least 10 dB below the fundamental frequency power.
(b) 4th and 5th harmonic are at least 20 dB below the fundamental frequency power.
(c) 6th and 7th harmonic are at least 25 dB below the fundamental frequency power.
(4) The transmitted signal ripple within each PHY-symbol shall be no greater than 20% of the peak amplitude of the transmitted signal.
(5) The physical signal of the transmitter shall turn on (i.e., go between *silence* and full PHY-symbols) in two or less MAC-symbol_times. The symbols corresponding to the third and subsequent MAC-symbols shall be as specified in the eye pattern. With a 6-octet preamble, there shall be at least 92 full PHY-symbols before the start delimiter for a nonrepeater station and at least 44 full PHY-symbols for a repeater station.

The PHY-signal of the transmitter shall turn off (i.e., go between full PHY-symbols and the receive silence level of +4 dBmV as specified in 20.7.6.2) in two or less MAC-symbol_times; and shall go to the transmitter off level of –20 dBmV as specified in 20.7.3.4 in eight or less MAC-symbol_times. The 9th and subsequent *silence* symbols shall meet the transmitter-off specification.

20.7.4 Jabber Inhibit. Each PLE shall have a self-interrupt capability to inhibit modulation from reaching the LAN medium. Hardware within the PLE (with no external message other than the prolonged detection of an output-on condition within the transmitter) shall provide a nominal window of 0.5 s ± 25% during which time a normal data link transmission may occur. If a transmission is in excess of the duration, the jabber-inhibit function shall operate to inhibit any further output from reaching the medium. Reset of this jabber-inhibit function is implementation-dependent.

20.7.5 Coupling to the Medium. The PLE functions are intended to operate satisfactorily over a medium consisting of a 75 Ω bidirectional coaxial trunk cable, nondirectional impedance-matching taps with a 20 dB trunk to drop loss, and 75 Ω drop cables. The mechanical coupling of the station to the medium shall be via a drop cable as specified in Sections 13 and 21 through either a 75 Ω F-series connector or a BNC connector on the station.

When transmitting, the station shall present an impedance resulting in a voltage standing wave ratio (VSWR) of 3:1 or less at the station connector when terminated with a 75 Ω resistive load or when driven from a 75 Ω resistive source, over the operating frequency range. At all other times, the station shall present an impedance resulting in a VSWR of 1.5:1 or less at the station connector, when driven from a 75 Ω resistive source, over the operating frequency range. The specifications of this paragraph shall also be met by inactive and unpowered PLEs.

Both the transmitter and the receiver shall be ac-coupled to the center conductor of the drop cable of the 75 Ω medium and the breakdown voltage of the ac-coupling means shall be at least 500 V ac at 50/60 Hz. In addition to this coupling, the shield of the coaxial cable medium shall be connected to chassis ground, and the dc impedance of that connection shall be less than 0.1 Ω.

20.7.6 Receiver Characteristics

20.7.6.1 Receiver Sensitivity. Both the Type A PLE and the Type B PLE shall be capable of providing an undetected equivalent bit error rate of 10^{-9} or lower, and a detected bit error rate of 10^{-8} or lower when

(1) The received signals are transmitted according to 20.7.3.

NOTE: This implies that a preamble following silence may be as short as 22 MAC-symbols.

(2) The received signals are conveyed by either the medium defined in Section 13 or the medium defined in Section 21.

(3) The receiver shall report the presence of received signaling, perhaps as *bad_signal*, and shall not report *silence* to the MAC sublayer when the received signal is greater than +10 dBmV for Type A PLE and +20 dBmV for Type B PLE.

In summary, for the medium described in Section 13, the specified signal range is +10 dBmV to +66 dBmV and the maximum noise is –10 dBmV in the operating frequency range for both 10 Mb/s and 20 Mb/s receivers. For the medium described in Section 21, the specified signal range is +20 dBmV to +66 dBmV and the maximum noise is 0 dBmV in the operating frequency range for both 10 Mb/s and 20 Mb/s receivers.

NOTE: When measuring bit error rate, multiple errors in a frame may be counted as a single error.

20.7.6.2 Minimum Receiver Off Level. A Type A PLE receiver shall report *silence* within two MAC-symbol_times of the receiver going below +4 dBmV. A Type B PLE receiver shall report *silence* within two MAC-symbol_times of the receiver going below +14 dBmV. The intention of this specification is to prevent the PLE from reporting reflections on the medium as nonsilence to the MAC sublayer entity.

20.7.6.3 Receiver Blanking. The PLE receiver function shall recognize the end of each transmission and report *silence* to the MAC sublayer entity for a period thereafter. This period of silence, or blanking, shall begin no later than four MAC-symbol_times after reporting the last MAC-symbol of the last end delimiter of the transmission. This period of silence shall continue to a point at least 24 MAC-symbol_times but no more than 32 MAC-symbol_times after the reporting of the last MAC-symbol of the end delimiter. Subsequent to this blanking period, silence or nonsilence, corresponding to the received signal, shall be reported to the MAC sublayer entity. Fig 20-5 shows the receiver blanking function.

Therefore the minimum slot-time of a network is 4 octets.

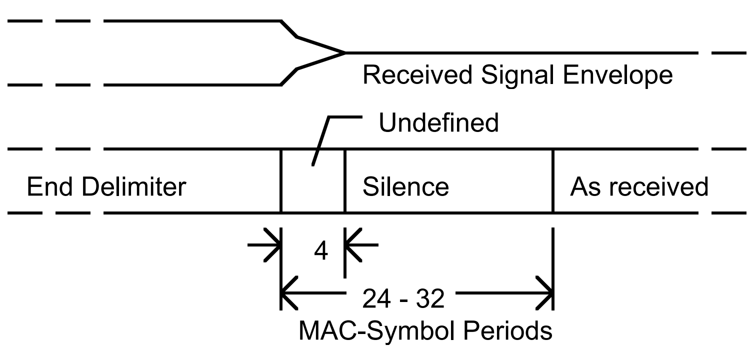


Fig 20-5
Receiver Blanking

20.7.7 Symbol Timing. During the recovery of *pad_idle* and *silence* symbols, it is permissible to vary the MAC-symbol reporting period by up to one nominal MAC-symbol_time. The period of each reported MAC-symbol shall nonetheless be within 90–210% of the nominal MAC-symbol_time at all times. Further, the period of each reported MAC-symbol after *pad_idle* symbol recovery and until either *silence* or *bad_signal* is reported shall be within 90–110% of the nominal MAC-symbol_time.

20.7.8 Symbol Decoding. After determination of each received PHY-symbol, MAC-symbols shall be decoded by the process inverse to that described in 20.7.2, and decoded MAC-symbols shall be reported at the MAC interface. (As stated in 20.5.1.1, receivers are permitted to decode the transmitted representation of *pad_idle* symbols as an alternating sequence of *ones* and *zeros*.) Whenever a PHY-symbol sequence is received for which the encoding process has no inverse, those PHY-symbols shall be decoded as an appropriate number of *bad_signal* MAC-symbols and reported as such at the MAC interface. In such cases, the receiving PLE should resynchronize the decoding process as rapidly as possible.

The polarity of the signal from the medium at the start of the frame does not imply specific information about the signal. The PLE shall be able to receive signals of either initial polarity.

20.7.9 Transmitter Enable/Disable and Received Signal Source Selection (OPTIONAL). The ability to enable and disable transmission onto the medium as directed by management is recommended but optional.

The ability to select the source of received signaling, either a loopback point within the PLE or one of the possibly redundant media, as directed by management, is recommended but optional. When such an option is invoked and the selected source is not one of the media, transmission to all connected media shall be disabled automatically while such selection is in force.

20.7.10 Redundant Media Considerations (OPTIONAL). Embodiments of this standard that can function with redundant media are not precluded, provided that the embodiment, as delivered, functions correctly in a nonredundant, single-cable environment. Where redundant media are employed, the provisions of 20.7.4 and 20.7.9 apply separately and independently to each single medium interface, and much of 20.7.9 shall be mandatory. Specifically, separate jabber-inhibit monitoring shall exist for each medium (although common inhibition is permissible), receiver signal source selection shall be provided and it shall be capable of selecting any one of the redundant media, and it shall be possible to enable or disable each single transmitter independently of all other redundant transmitters when the source of the receiving signaling is one of the redundant media.

20.7.11 Reliability. The PLE shall be designed so that its probability of causing a communication failure among other stations connected to the medium is less than 10^{-6} per hour of continuous (or discontinuous) operation. For regenerative repeaters this requirement is relaxed to a probability of 10^{-5} per hour of operation. Connectors and other passive components comprising the means of connection of the station to the coaxial cable medium shall be designed to minimize the probability of total network failure.

20.7.12 Regenerative Repeated Considerations. The PLE of a regenerative repeater can be considered to be a composite entity, with separate electrical and mechanical transmit and receive functions for each connected trunk segment (i.e., in each port), that all work under a common encoding, decoding, timing-recovery, and control function.

In performing repeating functions, the regenerative repeater serves as a relay station. When a PHY-symbol other than *off* is received, the composite PLE determines which trunk carried the PHY-symbol, and it then selects that trunk as the source of reported PHY-symbols. When a collision or noise is detected (e.g., *bad_data* is reported), the repeater's MAC entity sends data that cannot be interpreted as a valid frame by any receiving station.

The basic mode of operation, originating or repeating, shall be determined by the superior MAC entity and conveyed by the PHY-MODE invoked primitive (see 8.2.3). When originating, the repeater PLE shall originate the symbol timing provided to the MAC entity and transmit the encoded MAC-symbols onto all connected trunk segments. The repeater PLE shall use either loopback or any one of the attached trunks as the source of PHY-symbols that are decoded and report by way of the PHY-DATA indicate primitives.

When repeating and when switching to repeating, the repeater PLE shall delay for the equivalent of the receiver blanking period (see 20.7.6.3) from the end of the most recent transmission to prevent the reflection of the just-prior transmission, and shall then scan the connected ports for one on which signaling is being received. During the delay period, and while this scan for signal is unsuccessful, the repeater PLE shall indicate *silence* symbols to its MAC-entity using its locally originated symbol timing. Upon detecting signaling at one or more ports, the repeater entity shall select one of those active ports as the source of its received signaling, retime that signaling before or after decoding, and indicate the decoded MAC-symbols to its associated MAC entity. It should then vary the frequency of the MAC-symbol timing, within the bounds of this subsection (20.7), as necessary to maintain the proper relationship with the frequency of the received PHY-symbol timing. Regenerative repeaters also prefix enough *pad_idle* symbols to a transmission to provide a minimum of 3 octets of preamble following the receiver blanking period.

20.8 Environmental Specifications

20.8.1 Electromagnetic Emanations. Equipment shall comply with local and national requirements for limitation of electromagnetic interference. Where no local or national requirements exist, equipment shall comply with CISPR Publication 22 (1985) [3].

20.8.2 Safety Requirements. All stations meeting this standard shall comply with relevant local, national, and international safety codes and standards such as IEC Publication 950 (1986) [7].

20.8.3 Electromagnetic Environment. Sources of interference from the environment include electromagnetic fields, electrostatic discharge, transient voltages between earth connections, etc. Several sources of interference contribute to voltage buildup between coaxial cable and the earth connection, if any, of the station.

The PLE embodiment shall meet this specification when operating in an ambient plane wave field of

(1) 2 V/m from 10 kHz to 30 MHz.
(2) 5 V/m from 30 MHz to 1 GHz.

20.9 Labeling. It is recommended that each embodiment (and supporting documentation) of a PLE conformant to this standard be labeled in a manner visible to the user with at least the following parameters:

(1) Data rata capabilities in megabits per second.
(2) Worst-case round trip delay (for nonrepeaters) or one-way delay (for repeaters) that this equipment induces on a two-way transmission exchange between stations, as specified in 6.1.9.
(3) Operating modes and selection capabilities as defined in 20.7.9 and 20.7.10.

Additionally, when a station has multiple connectors (e.g., redundant media), the role of each such connector shall be designated clearly by markings on the station in the vicinity of that connector.

21. Single-Channel Type B Bus Medium

The functional, electrical, and mechanical characteristics of one specific form of the medium are specified in this section. This specification includes the medium embodiments suitable for use by a Type B single-channel differential Manchester-encoded data LAN PLE defined in Section 20. The relationship of this section to other sections of this standard and to LAN specifications is illustrated in Fig 21-1.

The relationship of this section to a single-channel differential Manchester-encoded data PLE and medium is illustrated in Fig 21-2. This standard specifies the medium only insofar as necessary to ensure

(1) The interoperability of Type B PLEs conforming to Section 20 specifications when connected to a medium conformant to this section, and
(2) The protection of the LAN medium itself and those using it.

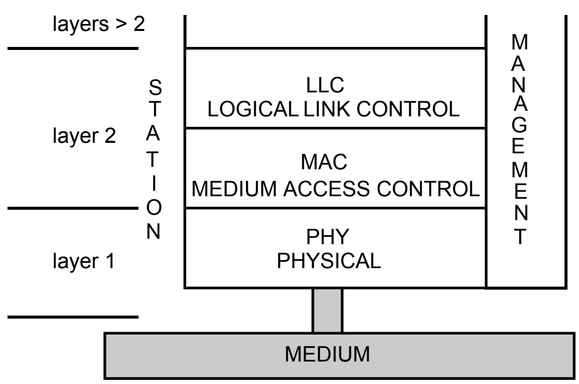


Fig 21-1
Relation to LAN Model

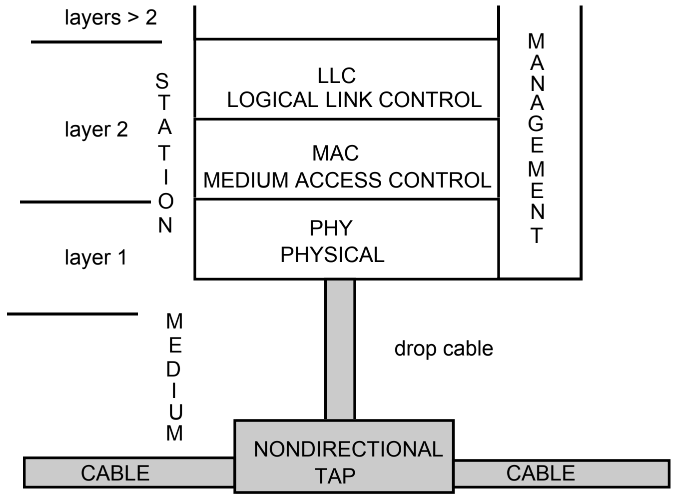


Fig 21-2
Physical Hardware Partitioning

21.1 Nomenclature. Terms used in this section that have meaning within the section that is more specific than that indicated in the glossary of IEEE Std 802.1B [10] are as follows:

dBmV. A measure of rms signal level on a 75 Ω cable compared to 1 mV. In terms of SI units (International System of Units), dBmV is defined as dB (1 mV, 75 Ω) rms.

differential Manchester encoding. A means by which separate data and clock signals are combined into a single, self-synchronized data stream suitable for transmission on a serial channel.

drop cable. The coaxial cable of the medium that connects to a station.

medium. The cable system of a LAN, including a trunk cable, taps, and drop cables.

operating frequency range. That range defined as 2–15 MHz for a 10 Mb/s data rate and 4–30 MHz for a 20 Mb/s data rate.

regenerative repeater. A device used to extend the length or topology of the medium beyond the limits imposed by signal degradation on a single segment on the medium.

single-channel system. A system where at any point on the medium only one information signal at a time can be present without disruption.

trunk cable. The main cable of the medium, which interconnects the taps.

Type B PLE. A PLE defined in Section 20 capable of working over the medium described in this section of the standard (PLE receiver threshold set to +20 dBmV).

21.2 Object. The object of this specification is to

(1) Provide the physical medium necessary for communication between local network stations employing the token-passing bus access method and the Type B differential Manchester-encoded data PLE defined in Section 20.
(2) Provide for high network availability.
(3) Provide for ease of installation and service in a wide range of environments.

21.3 Compatibility Considerations. All implementations of media conformant to this standard shall be compatible at their drop cable station interfaces. Specific implementations based on this standard may be conceived in different ways provided that compatibility at the station interfaces is maintained.

21.4 Overview

21.4.1 General Description of Functions. The functions performed by the Type B bus medium entity are described informally here. Jointly, these functions provide a means for signals generated by a station at the medium interface to be conveyed to all of the other stations on the medium. Thus, stations connected to these drop cables can communicate with each other.

21.4.1.1 Operational Overview. Stations are connected to the trunk coaxial cable(s) by drop cables and impedance-matching taps. These taps are nondirectional (i.e., omnidirectional) with regard to signal propagation. The nondirectional characteristics of the taps permit signals from a station to propagate in both directions along the trunk cable.

The topology of the bus system is that of a highly branched tree without a root, with stations connected as leaves to the trees branches. Branching is accomplished in the trunk itself by way of regenerative repeaters (described below) that provide nondirectional coupling of the signaling carried on the trunk cables similar to that of the taps described above.

21.4.1.2 Regenerative Repeater Functions. In a single-channel bus system, regenerative repeaters may be used to connect trunk segments into a highly branched topology, to extend the length of the medium, or to increase the number of taps on a trunk. The regenerative repeater is connected to the trunks by way of taps and drop cables. Regenerative repeaters are discussed in detail in 20.7.12.

21.4.2 Basic Characteristics and Options. All signal-conveyance characteristics and station-interface characteristics are mandatory. All other characteristics are optional.

21.5 Functional, Electrical, and Mechanical Specifications. The bus medium is an entity whose sole purpose is signal transport between the stations of the bus network. Consequently, only those characteristics of the medium that impinge on station-to-station signal transport, or on human safety, are specified in this standard. An implementation of the medium shall be deemed conformant to this standard if it provides the specified signal transport service and characteristics for the stations of the bus medium, and if it meets the relevant safety and environmental codes. Unless otherwise specified, all measurements are made at the point of station or regenerative repeater connection to the medium. Unless otherwise stated, all voltage and power levels are in rms and dBmV, respectively, based on measuring the fundamental signal content of continuous transmissions of either all *one* symbols, all *zero* symbols, or alternating *one* and *zero* symbols.

21.5.1 Connection to the Station. The connection of the Type B bus medium to the station shall be by way of a 75 Ω drop cable not to exceed 50 m in length. At the station, the drop cable shall have either a male F-series 75 Ω connector or a male BNC connector. This connector shall mate with an appropriate female connector mounted on the station. In addition to this coupling, the shield(s) of the coaxial drop cable shall be connected to the shell of the terminating male connector and the dc impedance of that connection shall be less than 0.001 Ω. The dc impedance of the connection between the shell of that male connector and the outer barrel of the mated female connector shall be less than 0.001 Ω.

21.5.2 Cable Characteristics

21.5.2.1 Characteristic Impedance. The characteristic impedance of the bus medium shall be 75 ± 3 Ω.

21.5.2.2 Trunk Return Loss Requirement. Unidirectional reflected signal energy (i.e., reflected from one direction on the trunk cable) shall be less than –22 dB below the incident energy level at any point on the trunk cable over the operating frequency range. This reflection is the sum of the reflections caused by the structural return loss of the cable itself and all the taps and other components on the trunk cable.

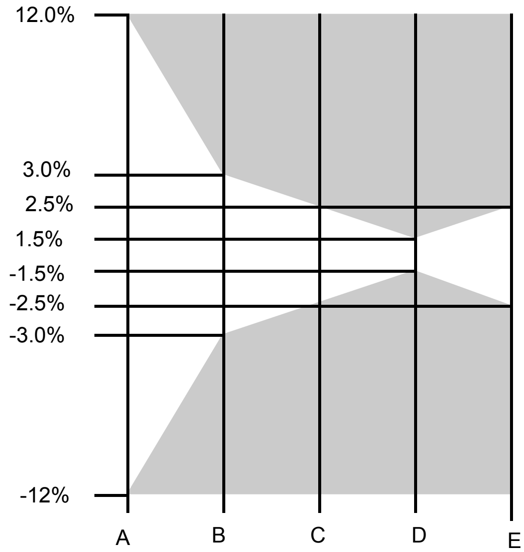
21.5.2.3 Medium Interface Return Loss. The medium as seen at any drop cable to station connection point shall present an impedance resulting in less than –14 dB return loss (VSWR of 1.5:1) when driven from a 75 Ω resistive source as measured over the operating frequency range.

21.5.3 Signal Characteristics. When conveying the signal of a single station or regenerative repeater whose transmit level is as specified in 20.7.3.3, the Type B bus medium shall present that signal to any connected station or regenerative repeater with the following characteristics.

21.5.3.1 Amplitude. The signal amplitude at the connector to any station shall be between +20 dBmV and +66 dBmV for either a 10 Mb/s or a 20 Mb/s data rate system.

21.5.3.2 Tilt. The signal amplitude of the two fundamental signaling frequencies due to media attenuation (corresponding to a transmitted sequence of all *one* symbols and to a transmitted sequence of alternating *one* and *zero* symbols) at any receiving station shall differ by no more than 3.5 dB.

21.5.3.3 Distortion. The maximum percent phase delay distortion (PDD) shall fall within the mask specified in Fig 21-3, which consists of a straight line mask defined by break points.



Point	10 Mb/s network frequency (MHz)	20 Mb/s network frequency (MHz)	Maximum PDD %
A	2.5	5	± 12
B	5	10	± 3
C	7.5	15	0%, reference
D	10	20	± 1.5
E	12.5	25	± 2.5

Fig 21-3
Limits for Percent PDD

NOTE: The PDD limits described above are for the total signal path including trunk cable, taps, and drop cables.

21.5.4 Received Signal Reflection Component. Excluding noise, the signal received by any station is composed of two parts: the nonreflected component of the signal, and the reflected component. The nonreflected component is that part of the signal that would be received from a perfect medium. The reflected component is due to impedance mismatches in the medium, both on the trunk cable and on the drop cable. The transmitting station and the receiving stations are expected to operate as required in Section 20 in the presence of these reflections. As a consequence of the station and the medium impedance mismatch characteristics defined in this section and in Section 20, the maximum reflected signal components are as follows.

At a transmitting station, the reflected component of the signal from the medium, during transmission and 1 µs subsequent to the end of transmission, will be at least 14 dB below the transmit level. From 1 µs to 2 µs following a transmission, the reflected component of a signal will be at least 60 dB below the end of transmission transmit level. After 2 µs, the reflection will be below +4 dBmV. These reflection levels are a consequence of the 14 dB return loss permitted by the interface to the medium (21.5.2.3), the isolation between drop ports of the same tap (21.5.7), and the 50 m maximum length of the drop cable.

21.5.5 Noise Power. The in-band noise power shall be 0 dBmV or less in the operating frequency range as measured at any point that a station or regenerative repeater is connected to the medium.

21.5.6 Power Handling Capability. The total power over the entire cable spectrum, as presented to the station or regenerative repeater, shall be less than 0.25 W.

21.5.7 Tap Requirements. The loss between any trunk port and any drop cable port shall be 20 ± 0.5 dB. For taps with multiple drop cable ports, the isolation between drop ports on the same tap shall be at least 30 dB.

21.5.8 Compatibility with the Stations and Regenerative Repeaters. An embodiment of a Type B bus medium entity is deemed to support a specific bus LAN if the requirements of 21.5.1 through

21.5.7 (inclusive) are met when measured from each point of station connection to the medium, independent of which one of the points of station connection is chosen for test origination.

21.5.9 Redundancy Considerations. As stated in 20.7.10, redundant bus media are not precluded by this standard. Where redundant media are employed, the provisions of 21.5.1 through 21.5.7 shall apply separately and independently to each medium interface.

21.5.10 Reliability. Connectors and other passive components connecting the station to the coaxial cable medium shall be designed to minimize the probability of total network failure.

21.6 Environmental Specifications

21.6.1 Electromagnetic Emanations. LAN cable systems shall comply with local and national requirements for limitation of electromagnetic interference. Where no local or national requirements exist, equipment shall comply with CISPR Publication 22 (1985) [3].

21.6.2 Safety Requirements. All media meting this standard shall comply with relevant local, national, and international safety codes and standards.

21.6.3 Electromagnetic Environment. Sources of interference from the environment include electromagnetic fields, electrostatic discharge, transient voltages between earth connections, etc. Several sources of interference contribute to voltage buildup between coaxial cable and the earth connection, if any, of the station.

The medium embodiment shall meet its specification when operating in an ambient plane wave field of

(1) 2 V/m from 10 kHz to 30 MHz.

(2) 5 V/m from 30 MHz to 1 GHz.

NOTE: Operating in this environment implies that quad-shielded cable or comparable shielding measures may be required.