TECHNICAL REPORT

ISO/IEC TR 11802-4

IEEE Std 802.5j

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1994-06-30

Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Technical reports and guidelines —

Part 4:
Token ring access method and physical layer specifications — Fibre optic station attachment

Technologies de l'information — Télécommunications et échange d'information entre systèmes — Réseaux locaux et urbains — Rapports techniques et directives —

Partie 4: Méthode d'accès par anneau à jeton et spécifications pour la couche physique — Liaison de station à fibres optiques

Reference number
ISO/IEC TR 11802-4:1994(E)
IEEE Std 802.5j-1993

Abstract: The functional, electrical, optical, and mechanical characteristics of a fibre optic interface for connecting a 4- or 16-Mbit/s token ring station to the trunk coupling unit of a token ring are specified. This Technical Report is based upon a fibre optic transmitter, a channel of multimode graded-index fibres, and a direct-detection photodiode receiver; and includes signaling provisions for bypass of the station from the ring and self-test capabilities.
Keywords: fibre optic interface (FOI), fibre optic medium interface (FMI), fibre optic station attachment, local area network (LAN), optical receiver (ORX), optical transmitter (OTX), token ring, trunk coupling unit

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Part 4: Token ring access method and physical layer specifications— Fibre optic station attachment

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Technical Report ISO/IEC TR 11802-4 : 1994

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The main task of technical committees is to prepare International Standards. In exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

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ISO/IEC TR 11802-4, which is a Technical Report of type 2, was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology.*

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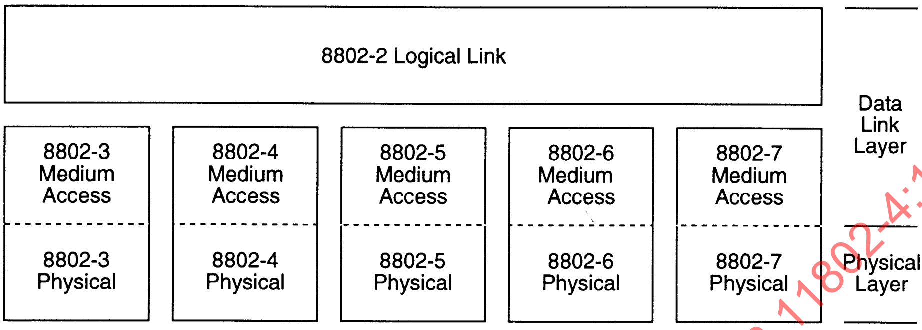
Foreword to Technical Report ISO/IEC TR 11802-4 : 1994

This Technical Report is part of a family of standards for Local and Metropolitan Area Networks. The relationship of the members of the family to each other is shown below. (The numbers in the figure refer to ISO standard numbers.)



This family of standards deals with the physical and data link layers as defined by the ISO Open Systems Interconnection Basic Reference Model (ISO 7498 : 1984). The access standards define five 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 these technologies are as follows:

a) ISO/IEC 8802-3 [ANSI/IEEE Std 802.3, 1993 Edition], a bus utilizing CSMA/CD as the access method.
b) ISO/IEC 8802-4 [ANSI/IEEE Std 802.4-1990], a bus utilizing token passing as the access method.
c) ISO/IEC 8802-5 [ANSI/IEEE Std 802.5-1992], a ring utilizing token passing as the access method.
d) ISO/IEC 8802-6 [ANSI/IEEE Std 802.6, 1994 Edition], a dual bus utilizing distributed queuing as the access method. DQDB subnetworks provide a range of telecommunications services within a metropolitan area.
e) ISO 8802-7, a ring utilizing slotted ring as the access method.

ISO 8802-2 [ANSI/IEEE Std 802.2-1989], Logical Link Control protocol, is used in conjunction with the medium access standards.

ISO/IEC 10038 [ANSI/IEEE Std 802.1D, 1993 Edition], *Media access control (MAC) bridges,* specifies an architecture and protocol for the interconnection of IEEE 802 LANs below the level of the logical link control protocol. ISO/IEC 15802-4 [ANSI/IEEE Std 802.1E, 1994 Edition], 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.

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

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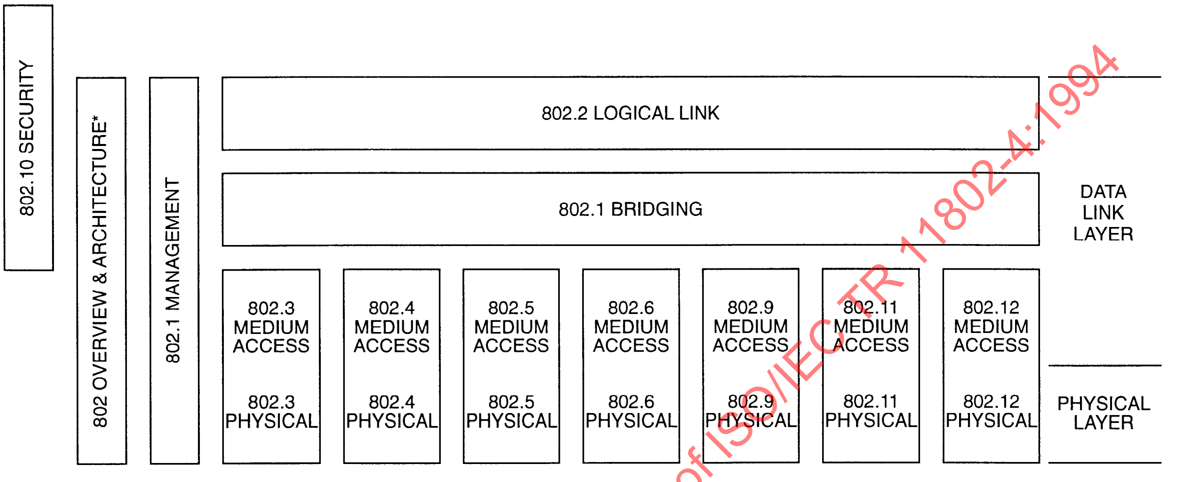
Publication of this trial-use standard for comment and criticism has been approved by the Institute of Electrical and Electronics Engineers. Trial-use standards are effective for 24 months from the date of publication. Comments for revision will be accepted for 18 months after publication. Suggestions for revision should be directed to the Secretary, IEEE Standards Board, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, and should be received no later than December 30, 1995. It is expected that following the 24-month period, this trial-use standard, revised as necessary, shall be submitted to the IEEE Standards Board for approval as a full-use standard.

Introduction to IEEE Std 802.5j-1993

(This introduction is not a part of IEEE Std 802.5j-1993, or of ISO/IEC TR 11802-4: 1994.)

This trial-use standard is part of a family of standards for local and metropolitan area networks. The relationship of the members of the family to each other 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 (ISO) Open Systems Interconnection Basic Reference Model (ISO 7498 : 1984). 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 these 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.
- ISO/IEC DIS 15802-2 [IEEE Std 802.1B and 802.1k]: 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.
- ISO/IEC 10038 (ANSI/IEEE Std 802.1D]: MAC Bridging. Specifies an architecture and protocol for the interconnection of IEEE 802 LANs below the MAC service boundary.

[†]The 802 Architecture and Overview Specification, originally known as IEEE Std 802.1A, has been renumbered as IEEE Std 802. This has been done to accommodate recognition of the base standard in a family of standards. References to IEEE Std 802.1A should be considered as references to IEEE Std 802.

- ISO/IEC 15802-4 [ANSI/IEEE Std 802.1E]: 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.
- ISO 8802-2 [ANSI/IEEE Std 802.2]: Logical Link Control
- ISO/IEC 8802-3 [ANSI/IEEE Std 802.3]: CSMA/CD Access Method and Physical Layer Specifications
- ISO/IEC 8802-4 [ANSI/IEEE Std 802.4]: Token Bus Access Method and Physical Layer Specifications
- ISO/IEC 8802-5 [ANSI/IEEE Std 802.5]: Token Ring Access Method and Physical Layer Specifications
- ISO/IEC 8802-6 [ANSI/IEEE Std 802.6]: Distributed Queue Dual Bus Access Method and Physical Layer Specifications
- IEEE Std 802.10: Interoperable LAN/MAN Security, *Currently Contains* Secure Data Exchange (SDE)

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

- IEEE Std 802.7: IEEE Recommended Practice for Broadband Local Area Networks

The following additional working groups have authorized standards projects under development:

- IEEE 802.9: Integrated Services (IS) LAN Interface at the Medium Access Control (MAC) and Physical Layers
- IEEE 802.11: Wireless LAN Medium Access Control (MAC) and Physical Layer Specifications
- IEEE 802.12: Demand Priority Access Method/Physical Layer Specifications

Conformance test methodology

An additional standards series, identified by the number 1802, has been established to identify the conformance test methodology documents for the 802 family of standards. This makes the correspondence between the various 802 standards and their applicable conformance test requirements readily apparent. Thus the conformance test documents for 802.3 are numbered 1802.3, the conformance test documents for 802.5 will be 1802.5, and so on. Similarly, ISO will use 18802 to number conformance test standards for 8802 standards.

IEEE Std 802.5j-1993

This Technical Report generally satisfied the standards developing working group. However, it was felt that more time is needed for industry experts to review fibre as a media for token ring operation. In the opinion of the working group, publication as a trial-use standard is preferred to widespread distribution of unapproved drafts.

Participants

When the IEEE 802.5 Working Group approved IEEE Std 802.5j-1993, it had the following membership:

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Part 4: Token ring access method and physical layer specifications— Fibre optic station attachment

1. Scope

This Technical Report specifies the functional, electrical, optical, and mechanical characteristics of a fibre optic interface for connecting a 4- or 16-Mbit/s token ring station to the trunk coupling unit (TCU) of a token ring. It is based upon a fibre optic transmitter, a channel of multimode graded-index fibres, and a direct-detection photodiode receiver; and includes signalling provisions for bypass of the station from the ring and self-test capabilities.

2. Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of ISO and IEC maintain registers of currently valid International Standards.

CISPR Publication 22 (1985), Limits and methods of measurement of radio interference characteristics of information technology equipment.[1]

EIA/TIA-455-A-1991, Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components.[2]

[1]CISPR documents are available from the International Electrotechnical Commission, 3 rue de Varembé, Case Postale 131, CH 1211, Genève 20, Switzerland/Suisse. CISPR documents are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[2]EIA publications are available from Global Engineering, 1990 M Street NW, Suite 400, Washington, DC, 20036, USA.

IEC 435:1983, Safety of data processing equipment.[3]

IEC 793-2:1989, Optical fibres—Part 2: Product specifications.

IEC 950:1991, Safety of information technology equipment including electrical business equipment.

ISO 7498:1984, Information processing systems—Open Systems Interconnection—Basic Reference Model.[4]

ISO/IEC 7498-4:1989, Information processing systems—Open Systems Interconnection—Basic Reference Model—Part 4: Management framework.

ISO/IEC 8802-5:1992 [ANSI/IEEE Std 802.5-1992], Information technology—Local and metropolitan area networks—Part 5: Token ring access method and physical layer specification.

ISO/IEC 9314-3:1990, Information processing systems—Fibre Distributed Data Interface (FDDI)—Part 3: Physical Layer Medium Dependent (PMD).

ISO/IEC 9646-1:1991, Information technology—Open Systems Interconnection—Conformance testing methodology and framework—Part 1: General concepts.

ISO/IEC 9646-2:1991, Information technology—Open Systems Interconnection—Conformance testing methodology and framework—Part 2: Abstract test suite specification.

MIL-C-26482, Connector, Electrical, Circular, Miniature, Quick Disconnect, Environment Resisting, Receptacle.[5]

MIL-C-85049, General Specification for Electrical Connector Accessories.

MIL STD MS-3476, Connectors, Plug, Electric, Series 2, Crimp Type, Bayonet Couplings.

3. Definitions

3.1 bypass: The state of the station attachment when the TCU does not route the station signals onto the trunk ring. Instead, the station signals will be returned to the station for lobe testing, and trunk signals will continue along the trunk.

3.2 bypass key: A signalling pattern sent by a fibre optic station to leave the ring and enter the BYPASS state. This pattern consists of a low light-level detected at the FOTCU for greater than 4 ms (see 6.2).

3.3 conformance test interface connector (CTIC): A defined connector for the purpose of conformance testing.

3.4 fibre: A filament-shaped optical waveguide made of dielectric materials.

[3]IEC publications are available from IEC Sales Department, Case Postale 131, 3 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse. IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[4]ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse. ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[5]MIL publications are available from the Director, U.S. Navy Publications and Printing Service, Eastern Division, 700 Robbins Avenue, Philadelphia, PA 19111, USA.

3.5 fibre optic cable: A cable containing one or more optical fibres compatible with the specifications in 7.2.

3.6 fibre optic channel: The data path from any transmitting station's FMIC or transmitting concentrator's FMIC to the next receiving FMIC.

3.7 fibre optic interface (FOI): The interface between a station's PHY and the optical medium. It is bounded on one side by the MIC or PHY-layer I/O interface, and on the other side by the FMIC.

3.8 fibre optic medium interface connection (FMIC): The mechanical and optical interface between the station or FOI and the fibre optic cable. This is a duplex optical port at which conformance testing is performed.

3.9 fibre optic station (FODTE): A compliant token ring station with an FOI as described in this Technical Report.

3.10 fibre optic trunk coupling unit (FOTCU): A physical device that enables a fibre optic station to connect to a trunk cable. The FOTCU contains the means for inserting the fibre optic station into the ring, or conversely, bypassing the fibre optic station. *Syn:* fibre optic concentrator lobe port.

3.11 insert: An action whereby the station transmit signals are routed to the next active downstream station, and input signals are routed from the next active upstream station.

3.12 insertion: A signalling pattern sent by a fibre optic station to request to join the ring (INSERT). This pattern consists of an alternating pattern of normal data signals and low light-level signals (see 6.1).

3.13 insertion key echo: The return of the Insertion Key to the station by the FOTCU (see 6.3).

3.14 lobe: Those elements in the data path between a station's transmitter and its own receiver when it is in Bypass State.

4. Abbreviations

BER	bit error rate
CTIC	conformance test interface connector
DTE	data terminal equipment
FACJ	filtered accumulated correlated jitter
FAPS	filtered accumulated phase slope
FDDI	fibre distributed data interface
FDTE	fibre optic data terminal equipment
FMIC	fibre optic medium interface connection
FODTE	fibre optic data terminal equipment
FOMAU	fibre optic media access unit
FOTCU	fibre optic trunk coupling unit
INIT	initialization
JTOL	jitter tolerance
LAN	local area network
MAC	medium access control (sublayer)
MAU	medium access unit
mDDT	mean data delay time

mFCJ	mean filtered correlated jitter
MIC	medium interface connector
NA	numerical aperture
ORX	optical receiver
OTA	optical transmit asymmetry
OTX	optical transmitter
PHY	physical (layer)
PICS	protocol implementation conformance statement
PMD	physical layer medium dependent
RETS	retiming elements
RX	receive
SMT	station management
SNR	signal-to-noise ratio
TA	transmit asymmetry
TCU	trunk coupling unit
TX	transmit
UJA	uncorrelated jitter alignment error

5. Overview

The use of optical fibres to attach a station to a ring requires a new definition of media interface. In particular, we define a fibre optic medium interface (FMI) to encompass the following functions:

a) Optical signal characteristics on transmit and receive ports (Q1 and Q2 in figure 1) of a fibre optic station (FODTE) which include the electro-optical and opto-electronic conversions of the original station's electrical signals
b) Cable medium (fibre) reference for specification of the FMI signals
c) Remote signalling requirements of both the station and the channel, including the FOTCU, to facilitate station insertion and removal on the ring
d) Physical attachment of the station to the medium, via a fibre optic medium interface connector (FMIC)

The FMI specified in this Technical Report contains two ports, an optical transmitter and an optical receiver, and uses a separate fibre for each path. The following clauses specify characteristics of the transmit and receive active interfaces, as measured through a reference channel, as well as mechanical, environmental, and system behavior characteristics. Parameters are specified to promote interoperability and conformance testability of both the baseband data channel (including critical timing attributes) and the Insert/Bypass command signalling. Specifications for both data and Insert/Bypass command signalling are based on the FMI operating into a pair of characterized 62.5/125 μ multimode optical fibres acting as a reference fibre optic cable medium.

The fibre optic lobe cabling and the FOTCU are indirectly specified by the requirement to interoperate with an attaching fibre optic station (DTE) whose FMI signalling characteristics conform to the specifications in this Technical Report.

Since the fibre media cannot pass the station phantom dc ring access signals specified in 7.4 of ISO/IEC 8802-5:1992[6], an out-of-band signalling method compatible with fibre is defined for the access control functions. The signalling method specifies on/off "keying" or toggling of the optical signal from the station to the FOTCU. The FOTCU is required to recognize this keying for station insertion and removal, and convey the keyed signal back to the station; this keyed signal may then be used by the station as an acknowledgment. Beyond this keying function and the requirement to support data traffic in INSERT and BYPASS states, the FOTCU is not further defined.

It should be noted that this Technical Report allows for stations with a single exposed interface at the FMIC, as well as devices with both exposed MIC and exposed FMIC interfaces (i.e., modem-like wire to fibre converters). For devices with both MIC and FMIC, the signal characteristics at the MIC shall meet the specifications set forth in 7.5 of ISO/IEC 8802-5:1992, while the signalling requirements at the FMIC shall meet the specifications set forth in this Technical Report. However, a manufacturer may want to consider restricting the lobe length conditions under which the unit is used. If so, the basic requirement to be met is interoperability with all other stations on the ring when the units are operating within the specified restrictions. It should be noted that a manufacturer could not claim general conformance to the Technical Report in such a case, but only conformance under the specified conditions of usage.

It may be necessary to implement a jitter reduction device between media domains (e.g., shielded twisted pair to fibre) to ensure interoperability with some older equipment. In figure 1 the PHY/MIC cable is optional and unspecified.

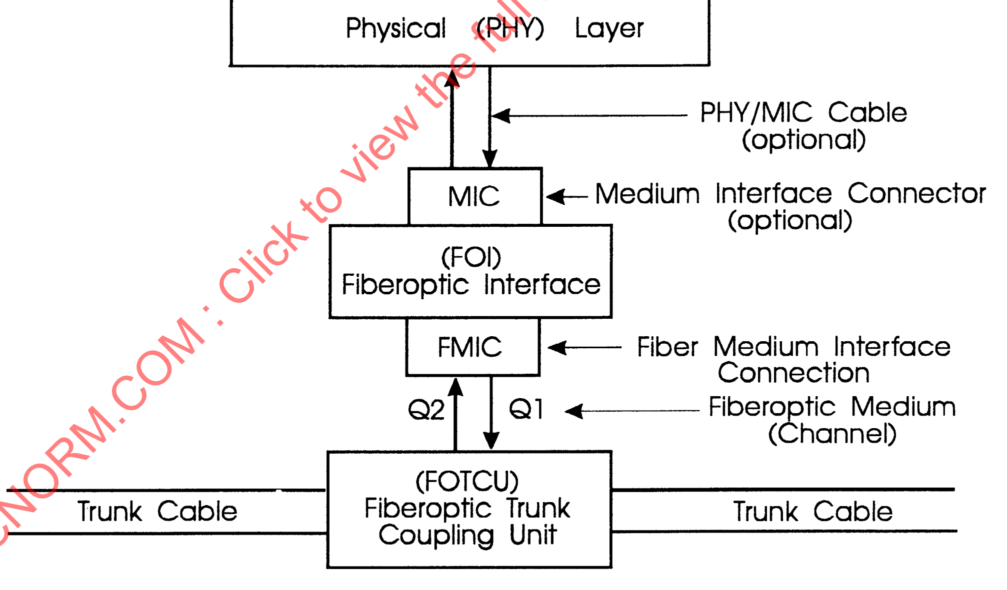


Figure 1—Partitioning of PHY and fibre optic elements

[6]Information on references can be found in clause 2.

6. Coupling of the station to the ring

Connection of the FOI to the lobe fibre optic medium shall be via an FMIC. The fibre is a waveguide suitable for direct-detected baseband data transmission at 4 or 16 Mbit/s (Manchester-encoded) using optical sources at 850 nm nominal center wavelength. Using the reference fibre, channel lengths (Q1 and Q2) of 0–2000 m are supported. See 7.2 and annex A.

When devices are used in the channel between two adjacent stations, the active devices shall meet the delay and distortion limits of the Insertion Key, Bypass Key, and Insertion Key Echo functions defined in 6.1, 6.2, and 6.3.

The insertion of the station into the ring at the trunk and the removal of the station from the ring are requested by the station. The mechanism for effecting the insertion or bypass of the station resides in the TCU. The station exercises control of the mechanism via the fibre optic cabling using an "insertion key" signal and a "bypass key" or low light-level signal. A mechanism is also provided to echo the insertion key to the station FOI to allow key acknowledgment. The method of activating the bypass function for passive FOTCUs is shown in annex B.

6.1 Insertion key

The insertion key is a specific pattern presented to the FOI's transmitter enable function when a station desires to attach to the ring. (SMT presents "TokenRingPHYAction = insert" to the PHY interface; see 6.4.2.1 of ISO/IEC 8802-5:1992.) The transmitter, when enabled, converts the continuous input stream from the medium access control sublayer (MAC) to suitable optical waveforms with average optical power, Po, as defined in 7.1. The maximum time that the input stream remains at either logic state without a transition during keying will not exceed 2 bit times (see 5.2 of ISO/IEC 8802-5:1992). When disabled, the transmitter emits a low light-level, less than or equal to Po_OFF. The insertion key, therefore, is an envelope of optical power that shall meet the signal level specifications of 7.1 and the timing specifications of figure 2, as controlled by the transmitter enable function.

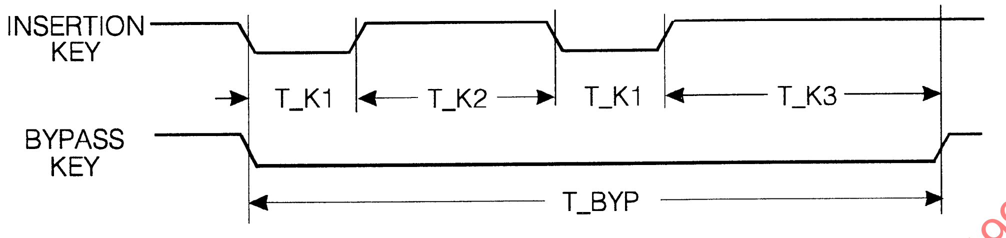
The insertion key pattern, measured at the Po_OFF threshold crossings of the average optical power at the FMIC-TX port, shall maintain the typical values of figure 2 parameters T_K1, T_K2, and T_K3 within the accuracy specified. The optical averaging time constant shall be approximately 1 µs.

The optical data stream with its blanked or disabled regions is delivered via the channel to a detector at the FOTCU, which decodes the envelope via a receive signal detect function. The detector yields an electrical logic signal representing true for received signals above an optical power detection threshold, Pr_DET, and false for signals of weaker power. Pr_DET is derived from signal-to-noise ratio (SNR) and error performance, but is always greater than Po_OFF.

When the insertion key is recognized, the FOTCU shall effect the switching action that causes the insertion of the station into the ring. The attachment enters the INSERT state.

6.2 Bypass key

When a fibre optic station decides to leave the ring ("Token Ring PHYAction = remove"), it signals the FOTCU via the outbound optical fibre using the "break" key. In this function the FOI transmitter is disabled and an average power of less than or equal to Po_OFF is presented to the FMIC-TX port. This condition is maintained for a sufficient time (T_BYP) to force the FOTCU to detect loss of signal (no signal detected for a time > T_BYPDET) and revert to the BYPASS state. This loop state should be used by the station for off-line self-testing ("Lobe Test") purposes. The bypass key shall meet the level specifications of 7.1 and the timing specifications shown in figure 2.



Parameter	Description	Minimum	Typical	Maximum	Units
T_K1[a]	Key element #1 (avg Po < Po_OFF)	808	833	858	µs
T_K2[a]	Key element #2 (avg Po > Po_OFF)	1616	1667	1717	µs
T_K3[a]	Key element #3 (avg Po > Po_OFF)	1616	1667		µs
T_BYP[a]	Bypass element (avg Po < Po_OFF)	4850	5000		µs
T_BYPDET	Time of Pr < PrDET,Min before detecting Bypass Key	4000	4500		µs
T_E1[b]	Key echo at FMIC-RX (from T_K1)	766	833	900	µs
T_E2[b]	Key echo at FMIC-RX (from T_K2)	1533	1667	1800	µs
T_E3[b]	Key echo at FMIC-RX (from T_K3)	1533	1667		µs

[a]The transmitted envelope at the FMIC-TX port consists of the Typical T_Kn or T_BYP values, plus the Key time base uncertainty of the transmit enable function (due to source clock inaccuracies for the electrical keying signal), and asymmetries of the optical enable function (due to distortions in converting the electrical keying signals into an optical envelope). The total envelope timing asymmetry measured optically at the TX port (at the Po_OFF transitions of average power) is about ± 3%.

[b]The optical envelope as seen at the FMIC-RX port may contain the original transmitted asymmetry plus distortions of the envelope due to the channel, including the FOTCU. The total allowed envelope timing asymmetry measured optically at the RX port (also at the Po_OFF transitions of average power) is ± 8%. This is derived from an estimated ± 2% timing asymmetry in detecting the optical envelope's average power transition between Pr > Pr_DET,Min and Pr < Pr_DET,Min, and a total allowable key asymmetry (end-to-end, electrical) of ± 10%.

Figure 2—Insertion and bypass keying patterns

6.3 Insertion key echo

The attachment is designed such that the station may detect faults in the optical connection path. An "insertion key acknowledge" function is accomplished by receiving the insertion key back at the station that sent it (via the path from Q1 to Q2 in figure 1.) The transitions that mark the beginnings of the T_En intervals shall not glitch for more than 20 µs. Failure to receive the insertion key at Q2 via a receiver signal detect function indicates a problem in the optical interconnection or FOTCU. If the acknowledgment fails, the station may assert the bypass key to ensure that the FOTCU is in fact in the BYPASS state.

In order to allow full interoperability between stations that do and do not implement acknowledgments, the channel and FOTCU shall provide echo of the envelope keying pattern while in the BYPASS state. The total optical envelope Key Timing parameters T_En of figure 2 shall be provided at the station input FMIC-RX port under all transmit conditions at FMIC-TX, thus satisfying the parameters of figure 2.

6.4 Operational (system) timing

Figure 3 summarizes the system operational timing requirements of the keying, detection, and insert/bypass switching of the lobe. The propagation delay limit is large to accommodate active devices such as repeaters in the link, or state machine logic in the FOTCU.

The detection of the INSERTION KEY at the FOTCU, within the timing parameters of figure 2 (T_Kn), shall cause the station to be inserted in the ring within T_INSERT,Max of the receipt of the end of the INSERTION KEY. The INSERTION KEY shall return to the FOI within T_ECHO,Max, within the timing parameters of figure 2 (T_En).

The detection of the BYPASS KEY at the FOTCU, i.e., loss of signal for greater than T_BYPDET,Max, shall cause the station to be de-inserted from the ring, or BYPASSED, within T_BYPASS,Max of the receipt of the beginning of the BYPASS KEY.

The maximum time that the ring trunk circuit is open, including the break caused by the bypass key, shall not exceed 10 ms.

See annex B for operational timing of a passive FOTCU system.

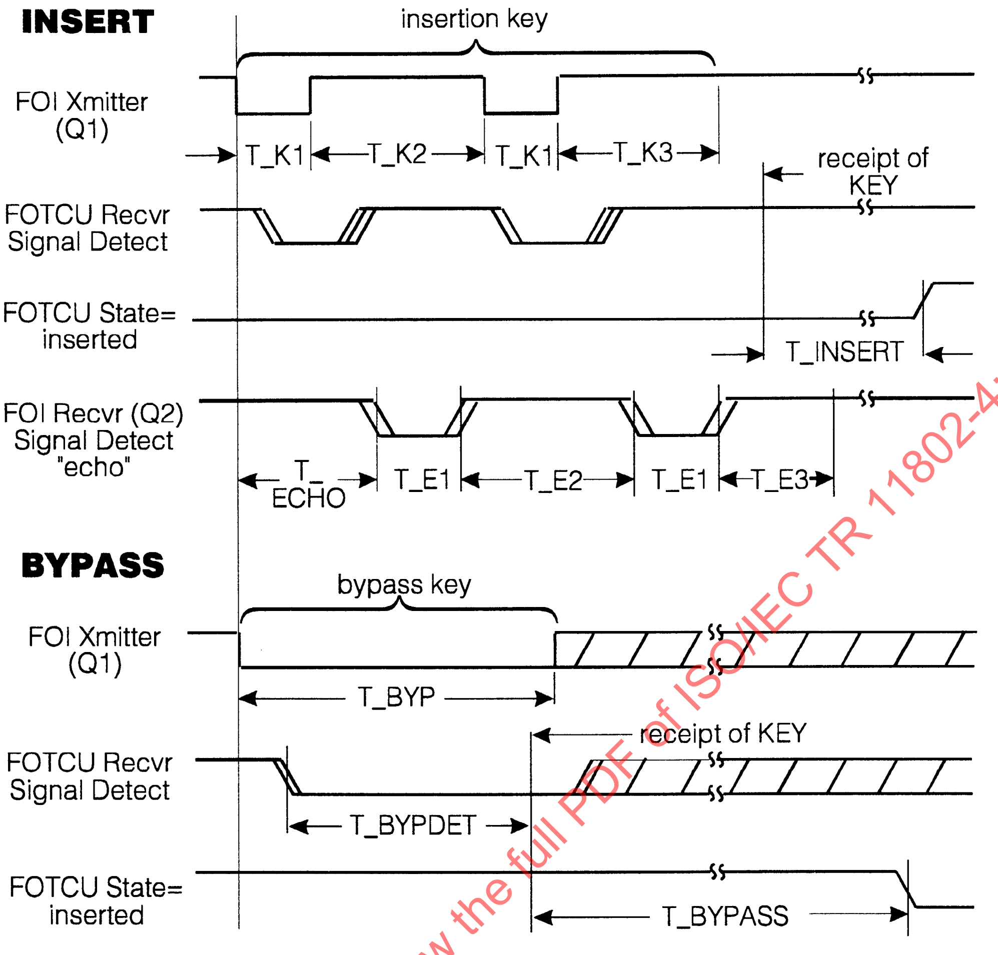
7. Signal characteristics

There are three segments associated with each PHY: the transmitter, including all components in the transmission path up to the FMIC transmitter; the channel, including all components between FMICs; and the receiver, including all components following the FMIC receiver. Each segment is specified independently to ensure compatibility among different implementations.

Several specifications are derived from limits on the total ring accumulation of error and not from any single lobe. Statistical limits have been used for these specifications to allow greater freedom of design.

7.1 The optical transmitter (OTX)

All parameters are specified at the fibre optic medium interface connection with a maximum baseband signalling rate, and 50% duty-cycle signal applied to the transmitter (e.g., all ZEROs.)



Parameter	Description	Minimum	Maximum	Units
T_INSERT	Entering of ACTIVE from receipt of end of Insertion Key at FOTCU	5	100	ms
T_BYPASS	Entering of BYPASS from receipt of beginning of Bypass Key at FOTCU	4	5	ms
T_ECHO	Propagation delay from FOI transmit enable to echo at Q2 (through FOTCU)	<1	100	ms

Figure 3—Keying operational time lines

The transmitted signal shall have the optical characteristics shown in table 1. The optical signal will track the input electrical signal from the PHY whenever the transmitter is enabled. When the transmitter is disabled, the light from the transmitter source is brought to a level less than or equal to Po_OFF.

Data-path asymmetry requirements are a function of the entire link, but are budgeted among the various elements in the interest of interoperability.

Optical transmit asymmetry (OTA) is defined with respect to any valid Manchester data stream. The stream consists of periods of high optical power (greater than the average optical power) alternating with periods of low optical power (less than the average optical power), with the high and low times each nominally one or two unit intervals long. OTA, defined only where adjacent up and down times are the same number of unit intervals, is one half the maximum time difference between the adjacent high and low periods measured at the average power (ac zero) crossings.

Optical Transmit Asymmetry

Data rate	=	4	16	Mbit/s
|OTA|	≤	4.0	1.5	ns

The transmitter waveform shall have the characteristics of a square wave transmitter, as described above.

Table 1—Transmitted signal optical characteristics

Parameter	Minimum	Maximum	Units
Center wavelength	800	910	nm
Spectral width, FWHM		75	nm
Average power, Po, lifetime[a, b]	–19	–12	dBm
Average power, Po_OFF, disabled[b]		–38	dBm
Extinction ratio (data)	13		dB
Rise/fall time, 10–90% at 4 Mbit/s		25	ns
Rise/fall time, 10–90% at 16 Mbit/s		6	ns
Rise/fall time skew (abs Tr–Tf) at 4 Mbit/s		12	ns
Rise/fall time skew (abs Tr–Tf) at 16 Mbit/s		3	ns
Overshoot		25	%

[a]The minimum average power (Po) lifetime specification includes approximately 3 dB for end-of-life degradation.
[b]Measured using optical output power test procedure (see EIA/TIA-455-A-1991) with a calibrated fibre optic power meter at the end of 10 m of reference fibre (see 7.2), terminated with the FMIC specified in clause 11.

7.2 The fibre optic channel

Requirements on the fibre optic channel are defined by the FMIC transmit and receive port characteristics. In practice, the fibre optic channel may include sections of multimode fibre, connectors, splices, and passive or active trunk coupling units. The fibre optic channel is defined from the FMIC's transmitter port (Q1) to the downstream FMIC's receiver port (Q2). Active and passive devices within the channel may be a source of link jitter and other signal impairments, requiring allocation in the link budget.

Active devices may also be a source of accumulated jitter requiring allocation against the maximum allowable station count. In principle, manufacturers are free to regenerate data anywhere in the system if they also make it clear to the user how it affects the station count and clearly specify its effect.

The channel is treated as a two-port device, the ports being at the station FMIC and the FOTCU. The fibre used in the test for transmitter and receiver operation is described as follows. The optical fibre is 62.5 μ nominal core diameter, 125 μ nominal cladding diameter, multimode graded-index optical waveguide media. This optical fibre is also utilized by the fibre distributed data interface (FDDI) physical layer medium dependent (PMD) (see ISO/IEC 9314-3:1990). It complies with the IEC 793-2:1992 type A1b specification with the following modifications to table III (transmission parameters at 850 nm):

Max theoretical NA	=	0.31
Nominal NA	=	0.275 ± 0.015
Modal bandwidth	=	160 MHz × km min

The cabled fibre transmission performance specification at 850 nm center wavelength shall be:

Attenuation	=	3.75 dB/km max
Modal bandwidth	=	160 MHz × km min

Alternative fibre types may be used (e.g., 50/125 μ core/cladding). Care should be exercised in the maintenance of system bandwidth and loss budgets. See annex A for more details on alternate fibre.

7.3 The optical receiver (ORX)

All parameters are specified at the fibre optic medium interface connector RX port. The received signal shall have the optical characteristics shown in table 2. The output electrical signal to the PHY shall track the input optical signal as long as the signal detect threshold is exceeded and shall output a constant polarity signal when the signal detect threshold is not exceeded. The bit error rate (BER) shall be less than 10^{-10} when measured between two FMICs for all combinations of valid optical transmit and receive parameters.

For signal detect to be asserted the BER of the receiver outputs shall be less than 0.01. Signal detect shall be asserted for any power level of Pr, minimum or higher. The minimum allowed power level for signal detect deassertion shall be the power that gives a 0.01 BER on the receiver outputs or PrDET,min whichever is greater. The signal detect function shall respond within the timing constraints imposed by the Insertion and Bypass Keys as described in clause 6.

Table 2—Received signal optical characteristics

Parameter	Minimum	Maximum	Units
Average received power, Pr, operating	–31	–11	dBm
Signal detect threshold	–38	–32	dBm
Signal detect hysteresis	0.3		dB
Input extinction ratio, operating	10		dB
Input rise/fall time, 10–90%, operating at 4 Mbit/s		60	ns
Input rise/fall time, 10–90%, operating at 16 Mbit/s		27	ns

7.3.1 Station jitter specifications

The receiver jitter specifications consist of three requirements. The first, jitter tolerance (7.3.1.1), tests the capability of the stations to receive error-free data in the presence of accumulated jitter. The second, uncorrelated jitter (7.3.1.2), tests the amount of uncorrelated or random noise added by a station. The third, noise tolerance (7.3.1.3), tests the receiver budget in the presence of the maximum phase slope. All jitter figures are peak-to-peak.

7.3.1.1 Jitter tolerance

Jitter tolerance (JTOL) is the ability of a receiver to receive frame data in the presence of a data rate frequency error caused by accumulated jitter. Interoperability requires that JTOL exceeds the filtered accumulated phase slope (7.3.2) value with enough margin to account for uncorrelated jitter.

JTOL is measured for a station receiving frames containing worst-case data patterns from an active monitor station using a clock source with a controlled frequency error. A conforming transmitter on the active monitor station is utilized, with nominal optical characteristics as defined in 7.1. The test channel is a short length (approximately 10 m) of the referenced 62.5/125 multimode graded-index glass fibre. The frequency error deviation (ns/ns) of the active monitor clock source is increased until frame or token errors occur on the ring. The JTOL specified minimum values shall be:

Data rate	=	4	16	Mbit/s
|JTOL|	>	0.014	0.015	ns/ns

7.3.1.2 Uncorrelated jitter

Uncorrelated jitter output is defined as the average of two measurements of peak-to-peak jitter, one with an input data stream of all zeros, and the other with all ones. Both measurements are made with zero transferred jitter. The channel shall not contain any active devices during the measurements. The average of the two measurements shall be less than the uncorrelated jitter alignment error (UJA). The parameter values are:

Data rate	=	4	16	Mbit/s
UJA	≤	8.4	3.4	ns

7.3.1.3 Noise tolerance

The station shall transfer data from the FMIC receive port to the FMIC transmit port with an error rate of less than 10^{-9}. This error rate shall be maintained over the input power range and rise/fall times specified in 7.3 and in the presence of broadband jitter. The broadband jitter shall have a Gaussian density function with zero mean and 3.4 ns for 4 Mbit/s and 0.9 ns for 16 Mbit/s standard deviation. The spectral density of the broadband jitter shall be equivalent to white noise passed through a single-pole filter. The 3 dB cutoff frequency of the filter shall be 4 MHz for 4 Mbit/s stations and 16 MHz for 16 Mbit/s stations.

7.3.2 Accumulated correlated phase jitter

The accumulated correlated phase jitter is the total correlated jitter (measured as the time displacement of the edges of the transmitted waveform driving a high-bandwidth optical waveform analyzer) that is accumulated by the token ring stations in relation to the active monitor's embedded clock. This accumulated correlated phase jitter is accumulated by token ring stations downstream from the active monitor as a specific data pattern reaches each successive station and the receiver at each station does not fully compensate for the signal distortion introduced by the transmitter, channel, receiver and other station effects. This accumulated correlated phase jitter has both a total magnitude (accumulated correlated jitter) and a magnitude of rate-of-phase change (accumulated phase slope).

The accumulated correlated jitter determines the amount of accumulated jitter that token ring stations shall track. The elastic buffer (see part 5 of ISO/IEC 8802-5:1992) in the active monitor station shall accommodate the total magnitude of the filtered accumulated correlated jitter (FACJ), after budgeting for the accumulation of uncorrelated (random) jitter. FACJ is the sum of the mean filtered correlated jitter (mFCJ) produced at each station. The mFCJ specifications on a per station basis depend on system configuration and are determined by dividing FACJ by the number of stations and retiming elements in the measurement (a total of 250 is assumed).

Accumulated phase slope is defined as the maximum rate of phase change that is generated by token ring stations in relation to the active monitor's embedded clock. This phase slope is caused by the correlated jitter produced at each station. The magnitude of the filtered accumulated phase slope (FAPS) shall be kept below a maximum value in order for subsequent stations to correctly track received data containing worst-case data patterns.

The FACJ and FAPS values are measured after the maximum number of stations or may be extrapolated to the maximum number of stations based on at least 15 stations downstream from the active monitor station. These measurements shall be repeated at least 15 times. Between each of the 15 measurements all the stations will be de-inserted and re-inserted from the FOTCU. The test channel is a short length (approximately 10 m) of the referenced 62.5/125 multimode graded-index glass fibre. The measured filtered accumulated correlated jitter and the filtered accumulated phase slope are derived from the average of the 15 measurements and then filtered by a low-pass filter with a single pole at F6. The FACJ and FAPS average parameter values are:

Data rate	=	4	16	Mbit/s
$\lvert FACJ \rvert$	<	500	600	ns
$\lvert FAPS \rvert$	<	0.0058	0.00768	ns/ns
F6	=	125	500	kHz

7.4 Station delay and interoperability

Interoperability between token ring stations with different implementations on the same ring is ensured by meeting one of the following two alternative requirements:

a) The maximum mean data delay time (mDDT) of data through a station shall have an average given by the following parameters:

Data rate	=	4	16	Mbit/s
mDDT	<	1000	250	ns

b) Stations that include additional jitter slope attenuators shall keep the product, K*mDDT < 1, where K is the effective clock recovery bandwidth of the jitter attenuator.

7.5 Station count limit

The station count limit on a single token ring is determined by a combination of medium access control (MAC) timers and accumulated jitter. A token ring configuration may contain a combination of stations and retimers (that contain a PHY but no MAC). Examples of retimers are repeaters, the retimed active TCU port in a retimed concentrator, and external fibre retimed converters. The station count will in general include a mixture of MAC/PHY stations (NODES) and retiming elements (RETS) in the ring. Both stations and retimers in the same ring shall meet the same specifications for mFCJ.

Non-retimed FOTCU specification:

Data rate	=	4	16	Mbit/s
mDDT	<	250	250	number
Data rate	<	14	14	number
mDDT	<	1.9	2.8	ns

Retimed FOTCU specification:

Data rate	=	4	16	Mbit/s
mDDT	<	132	132	number
Data rate	<	132	132	number
mDDT	<	1.9	2.8	ns

8. Reliability

The MAC, PHY, and connecting FOIs up to and including the FMIC of each station shall be designed to minimize the probability of causing communication failure among other stations attached to the local network. The mean time to the occurrence of such a failure shall be at least 1 000 000 h of operation without requiring manual intervention to restore the network to operational status.

9. Safety requirements

All stations in accordance with this Technical Report shall conform to the safety requirements specified in 7.7 of ISO/IEC 8802-5:1992.

10. Electromagnetic emanation

Equipment shall comply with local and national requirements for limitation of electromagnetic interference. Where no local or national requirements exist, equipment shall comply with the Class A limits of CISPR Publication 22 (1985).

11. Conformance test interface connector (CTIC)

In order to provide a single interface for conformance testing, a conformance test interface connector (CTIC) is defined below. A cable or other device to connect the FMIC to a CTIC socket shall be provided. Implementors may, but are not required to, use the CTIC as their FMIC.

Conformance test equipment shall provide two fibres terminated with a duplex plug, as specified in ISO/IEC 9314-3:1990, as modified with the unique keying specified in figure 4. The corresponding mating connector socket shall be the conformance test interface, also known as the CTIC.

The CTIC has latch points that mate with latches on the body of the CTIC plug and ports that mate with the CTIC plug ferrules and align them and the ends of the associated fibres they contain with the mating transducers or fibres at the optical reference plane.

11.1 CTIC ferrule

The CTIC receptacle shall accommodate a ferrule as shown in figure 7 of ISO/IEC 9314-3:1990.

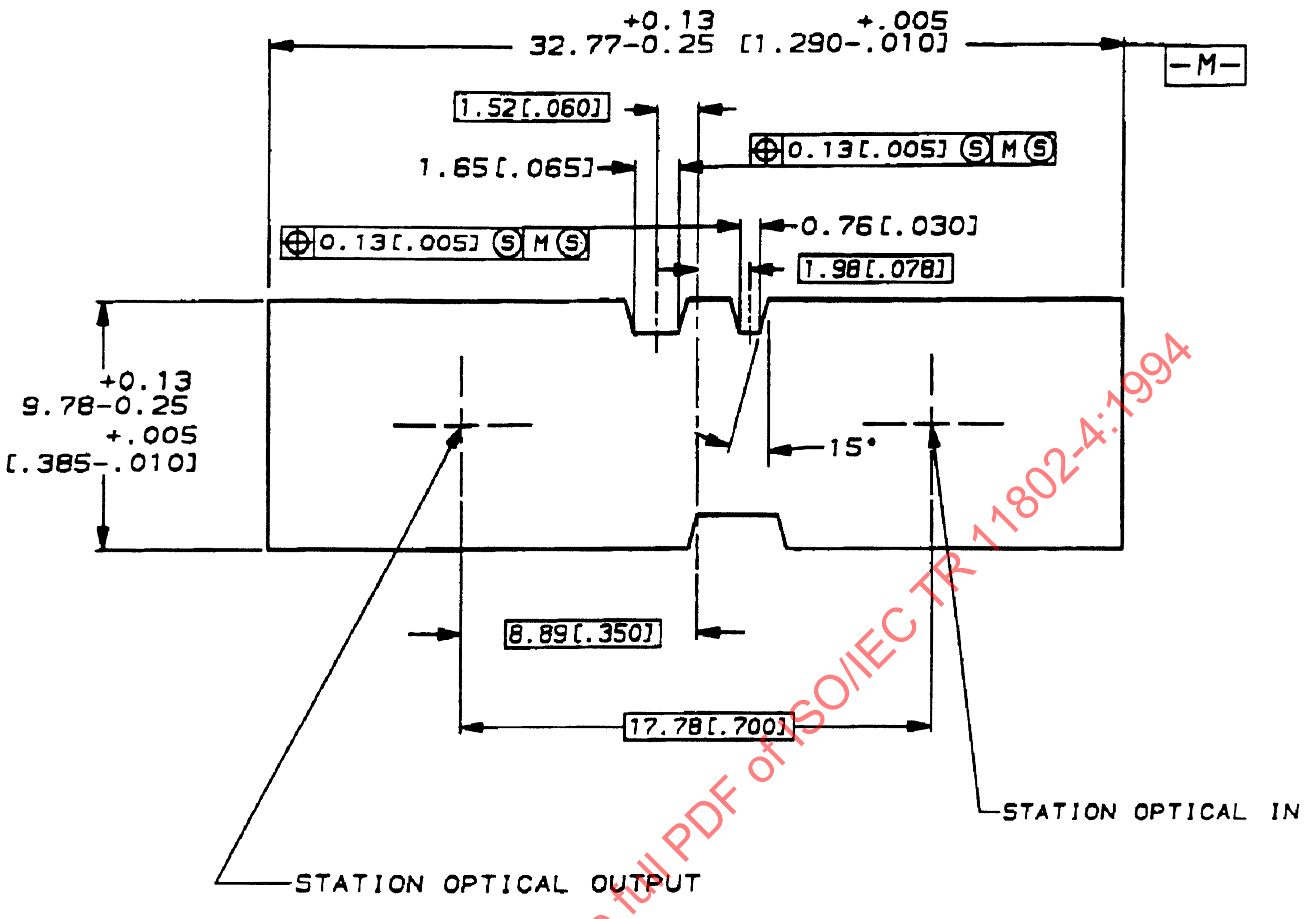
11.2 FMIC connector losses

The FMIC optical loss under operating conditions is not directly specified. Trade-offs between connector/ fibre precision and source/detector performance (as well as other factors) are implementation issues. Imperfections in the FMIC receptacle are included in the power and sensitivity requirements of the OTX and

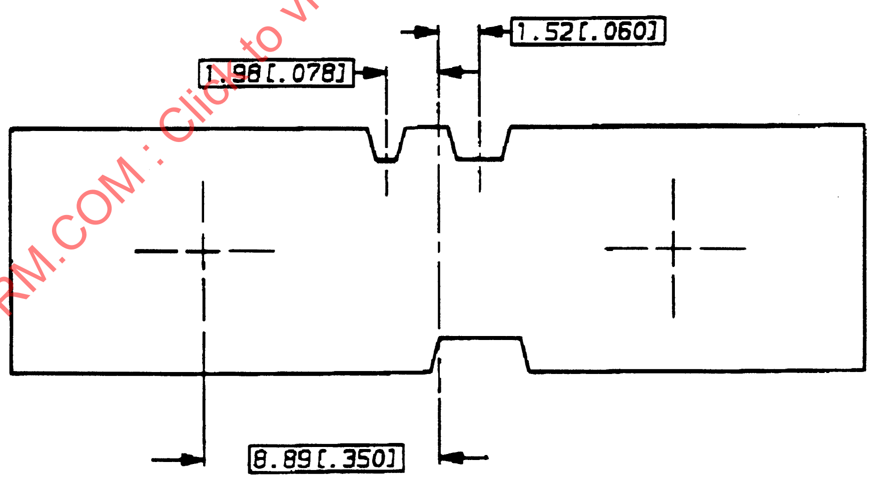
ORX active interfaces (see 7.1 and 7.3). Imperfections in the FMIC plug are included in the channel (cable plant) loss.

11.3 CTIC polarization and (optional) keying detail

Figure 4 shows the polarization and keying attributes of an CTIC receptacle. When viewing the FMIC receptacle with the keying on top, the left ferrule shall be the station optical output (TX) port. The right ferrule shall be the station optical input (RX) port. If the keying option is used, the fibre optic media access unit (FOMAU) and FOTCU FMIC receptacles are keyed as shown in figure 4.



a) Station attachment type



b) TCU attachment type

Figure 4—CTIC polarization and (optional) keying detail