INTERNATIONAL STANDARD

ISO/IEC 9314-4

First edition
1999-10

Information technology – Fibre distributed data interface (FDDI) –

Part 4: Single-mode fibre physical layer medium dependent (SMF-PMD)

Reference number
ISO/IEC 9314-4:1999(E)

INTERNATIONAL STANDARD

ISO/IEC 9314-4

First edition
1999-10

Information technology – Fibre distributed data interface (FDDI) –

Part 4: Single-mode fibre physical layer medium dependent (SMF-PMD)

PRICE CODE U

For price, see current catalogue

CONTENTS

FOREWORD

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75% of the national bodies casting a vote.

International Standard ISO/IEC 9314-4 was prepared by Joint technical Committee ISO/IEC JTC 1 *Information technology*, Subcommittee SC 25*, Interconnection of information technology equipment.*

ISO/IEC 9314 consists of the following parts, under the general title *Information technology – Fibre Distributed Data Interface (FDDI):*

– *Part 1: Token Ring Physical Layer Protocol (PHY)*

– *Part 2: Token Ring Media Access Control (MAC)*

– *Part 3: Token Ring Physical Medium Dependent Layer (PMD)*

– *Part 4: Single Mode Fibre Physical Layer Medium Dependent (SMF-PMD)*

– *Part 5: Hybrid Ring Control (HRC)*

– *Part 6: Token Ring Station Management (SMT)*

– *Part 7: Physical Layer Protocol (PHY-2)*

– *Part 8: Token Ring Media Access Control-2 (MAC-2)*

– *Part 9: FDDI Low-Cost Fibre – Physical Medium Dependent (LCF-PMD)*

– *Part 10: Token Ring Twisted Pair Physical layer Medium Dependent (TP-PMD)*

– *Part 13: Conformance Test Protocol Implementation Conformance Statement proforma (CT-PICS)*

– *Part 20: Physical Medium Dependent Conformance Testing (PMD-ATS)*

– *Part 21: Physical Layer Protocol Conformance Testing (PHY-ATS)*

– *Part 25: Abstract Test Suite for FDDI – Station Management Conformance Testing (SMT-ATS)*

– *Part 26: Media Access Control Conformance Testing (MAC-ATS)*

INTRODUCTION

The Fibre Distributed Data Interface (FDDI) is intended for use in a high-performance general purpose multistation network and is designed for efficient operation with a peak data rate of 100 megabits per second. It uses a token ring architecture. This part of ISO/IEC 9314 extends the basic FDDI by allowing both multimode and single-mode fibre, (MMF and SMF respectively), as transmission media. The basic FDDI provides for hundreds of stations operating over an extent of many kilometers. The individual link lengths supported by the basic FDDI are limited to two (2) kilometers by the characteristics of the multimode fibre it specifies. This extension to the basic FDDI standard allows links to about 60 kilometers depending on cable plant characteristics, by making it possible to include single-mode fibre links in a standard FDDI network.

The Single-mode Physical Layer Medium Dependent (SMF-PMD) specifies the lower sublayer of the Physical Layer for the FDDI. As such, it presents the specifications for conforming FDDI attachment devices at the interface to the single-mode optical network. This includes power levels and characteristics of the optical transmitter and receiver, interface optical signal requirements including jitter, the connector receptacle footprint, the requirements of conforming FDDI single-mode fibre cable plants, and the permissible BER.

SMF-PMD provides for extension of the set of basic standards for FDDI that includes the following standards:

a) A Media Access Control (MAC) standard, which specifies the lower sublayer of the Data Link Layer for FDDI, including access to the medium, data framing, addressing, and data checking;

b) A Physical Medium Dependent (PMD) standard which is the alternative standard to this document, when using MMF rather than SMF;

c) A Physical Layer Protocol (PHY) standard, which specifies the upper sublayer of the Physical Layer for FDDI, including encode/decode, clocking, and data framing;

d) A Station Management (SMT) standard, which specifies the local portion of the system management application process for FDDI, including the control required for proper operation of a station in an FDDI ring;

The idea of developing a new high speed data interface for computers based on the use of optical fibre was first raised in an October 1982 meeting. An ad hoc task group was formed to examine the issues and three project proposals, for the FDDI Physical, Data Link, and Network layers were developed and subsequently approved.

Initial proposals for the Media Access Control (MAC), corresponding to the lower half of the Data Link Layer, and for the Physical (PHY), corresponding to the Physical Layer, were both submitted in June 1983. FDDI adopted the structures of the ISO/IEC 8802 Series, and early work indicated that the FDDI MAC could be developed to operate under the Logical Link Control (LLC) described in the ISO/IEC 8802 series. This decision, in effect, obviated the development of LLC or Network Layer standards unique to FDDI. MAC has been published as ISO/IEC 9314-2.

In early 1984 a need was recognized for a separate Station Management (SMT) document. This development work remains under way on ISO/IEC 9314-6.

Recognizing that fibre technology was not yet then sufficiently settled and that critical FDDI development work was dependent upon the protocol portions of the PHY document, the Physical Layer was divided into two sublayers (PHY and PMD), with the PHY document retaining only the upper sublayer of the Physical Layer. PHY was subsequently published as ISO/IEC 9314-1.

Meanwhile, issues concerning the lower sublayer of the Physical Layer for multimode FDDI were being addressed. That work led to the publication of ISO/IEC 9314-3 FDDI PMD.

In June 1987 the need was recognized for FDDI to support station-to-station distances longer than the 2 kilometers limit of the MMF design. The project objective was to stay as close as possible to the PMD standard and in particular to have the same interfaces with PHY and SMT.

With the FDDI MAC, the FDDI PHY and the multimode FDDI PMD, the FDDI SMF-PMD standard represents an alternative PMD in the set of standards that constitute FDDI.

INFORMATION TECHNOLOGY – FIBRE DISTRIBUTED DATA INTERFACE (FDDI) –

Part 4: Single-mode fibre physical layer medium dependent (SMF-PMD)

1 Scope

This part of ISO/IEC 9314 specifies the Single-mode fibre Physical Layer–Medium Dependent (SMF-PMD) requirements for the Fibre Distributed Data Interface (FDDI).

FDDI provides a high bandwidth (100 megabits per second) general purpose interconnection among computers and peripheral equipment using a fibre optic waveguide as the transmission medium. The FDDI may be configured to support a sustained transfer rate of approximately 80 megabits (10 megabytes) per second. The FDDI may not meet the response time requirements of all unbuffered high speed devices. The FDDI establishes the connection among many stations distributed over distances of several kilometers in extent. Default values for FDDI were calculated on the basis of 1000 physical connections and a total fibre path length of 200 kilometers (see the MAC Standard – ISO/IEC 9314-2 or ISO/IEC 9314-8).

The FDDI consists of:

1) The Physical Layer Medium Dependent (PMD) is specified in four alternative standards:
   a) ISO/IEC 9314-3 (FDDI PMD) corresponding to multimode fibre (MMF) which actually means "FDDI MMF-PMD".
   b) This standard ISO/IEC 9314-4 (SMF-PMD) which contains the requirements for single-mode fibre (SMF) physical connections between stations.
   c) ISO/IEC 9314-9 (FDDI LCF-PMD), an alternative lower cost multimode fibre (LCF) for shorter distances.
   d) ISO/IEC 9314-10 (FDDI TP-PMD), a copper twisted pair (TP) alternative.

   An FDDI ring can be made up of all these alternatives. (For some restrictions see 6.4). The PMD provides all services necessary to transport a suitably coded digital bit stream from station to station. The SMF-PMD specifies the point of interconnection requirements for FDDI stations and cable plants at both sides of the Media Interface Connector (MIC) for conforming stations utilizing single-mode fibre.

   SMF-PMD includes the following:

   i) The optical power budgets for two (2) categories of Active Output and Active Input Interfaces using single-mode fibre optic cables and optical bypass switches
   ii) The MIC Receptacle mechanical mating requirements including the keying features
   iii) The single-mode fibre optic cable requirements
   iv) The services provided by PMD to PHY and SMT

2) A Physical Layer Protocol (PHY), which provides connection between multimode or single-mode PMD and the Data Link Layer (DLL). PHY establishes clock synchronization with the upstream code-bit data stream and decodes this incoming code-bit stream into an equivalent symbol stream for use by the higher layers. PHY provides encoding and decoding between data and control indicator symbols and code-bits, medium conditioning and initializing, the synchronization of incoming and outgoing code-bit clocks, and the delineation of octet boundaries as required for the transmission of information to or from higher layers. Information to be transmitted on the interface medium is encoded by the PHY into a grouped transmission code.

3) A Data Link Layer (DLL), which controls the accessing of the medium and the generation and verification of frame check sequences to assure the proper delivery of valid data to the

higher layers. DLL also concerns itself with the generation and recognition of device addresses and the peer-to-peer associations within the FDDI network. For purpose of the PHY, references to DLL are made in terms of the Media Access Control (MAC) entity, which is the lowest sublayer of DLL.

4) A Station Management (SMT), which provides the control necessary at the station level to manage the processes underway in the various FDDI layers such that a station may work cooperatively on a ring. SMT provides services such as control of configuration management, fault isolation and recovery, and scheduling procedures.

This part of ISO/IEC 9314 is a supporting document to ISO/IEC 9314-1 which should be read in conjunction with it.

The SMT document ISO/IEC 9314-6 should be consulted for information pertaining to supported FDDI station and network configurations.

The set of FDDI standards specifies the interfaces, functions and operations necessary to insure interoperability between conforming FDDI implementations. This part of ISO/IEC 9314 is a functional description. Conforming implementations may employ any design technique which does not violate interoperability.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO/IEC 9314. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO/IEC 9314 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO/IEC 9314-1:1989, Information technology – Fibre Distributed Data Interface (FDDI) – Part 1: Token Ring Physical Layer Protocol (PHY)

ISO/IEC 9314-2:1989, Information technology – Fibre Distributed Data Interface (FDDI) – Part 2: Token Ring Media Access Control (MAC)

ISO/IEC 9314-3:1990, Information technology – Fibre Distributed Data Interface (FDDI) – Part 3: Token Ring Physical Medium Dependent Layer (PMD)

ISO/IEC 9314-6:1998, Information technology – Fibre Distributed Data Interface (FDDI) – Part 6: Token Ring Station Management (SMT)

ISO/IEC 9314-7:1998, Information technology – Fibre Distributed Data Interface (FDDI) – Part 7: Physical Layer Protocol (PHY-2)

ISO/IEC 9314-8:1998, Information technology – Fibre Distributed Data Interface (FDDI) – Part 8: Token Ring Media Access Control-2 (MAC-2)

ISO/IEC 11801:1995, Information technology – Generic cabling for customer premises

IEC 60793-1-1:1999, Optical fibres – Part 1-1: Generic specification – General

IEC 60793-1-2:1995, Optical fibres – Part 1: Generic specification – Section 2: Measuring methods for dimensions

IEC 60793-1-3:1995, Optical fibres – Part 1: Generic specification – Section 3: Measuring methods for mechanical characteristics

IEC 60793-1-4:1995, Optical fibres – Part 1: Generic specification – Section 4: Measuring methods for transmission and optical characteristics

IEC 61300-3-4:1998, Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-4: Examination and measurements – Attenuation

IEC 61300-3-6:1997, Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-6: Examinations and measurements – Return loss

IEC 61300-3-9:1997, Fibre optic interconnecting devices and passive composants – Basic test and measurement procedures – Part 3-9: Examinations and measurements – Far-end crosstalk

IEC 61754-12: under development: Fibre Optic Connector Interfaces, Part-12: Type FS connector family

3 Concepts

3.1 General Description

A ring network consists of a set of stations logically connected as a serial string of stations and transmission media to form a closed loop. Information is transmitted sequentially, as a stream of suitably encoded symbols, from one active station to the next. Each station generally regenerates and repeats each symbol and serves as the means for attaching one or more devices to the network for the purpose of communicating with other devices on the network. The method of actual physical attachment to the FDDI network may vary and is dependent on specific application requirements as described in subsequent paragraphs.

The basic building block of an FDDI network is a Physical Connection as shown in Figure 1. A Physical Connection in the FDDI network consists of the Physical Layers of two stations which are, connected over the transmission medium by a Primary Link and a Secondary Link. The two Physical Links of a Physical Connection must use the same fibre technology at the MIC: both multimode or both single-mode. A Primary Link consists of an output, called Primary Out, of a Physical Layer, communicating over a Primary medium to the input, called Primary In, of a second Physical Layer. The Secondary Link consists of the output, called Secondary Out, of the second Physical Layer communicating over a secondary medium to the input, called Secondary In, of the first Physical Layer. Physical Connections may be subsequently logically connected within stations, via attached MACs or other means, to the network. As such, the function of each station is implementer defined and is determined by the specific application or site requirements.

Two classes of stations are defined; dual (attachment) and single (attachment). Physical FDDI rings may be composed only of dual stations which have two PHY entities to accommodate the dual (counter-rotating) rings. Concentrators provide additional PHY entities for the attachment of single stations which have only one PHY and thus cannot directly attach to the physical FDDI dual ring. A dual station, or one-half of a dual station, may be substituted for a single station in attaching to a concentrator. The logical FDDI ring consists of all attached stations.

This part of ISO/IEC 9314 specifies two categories of Active Output and Input Interfaces and allows for the four corresponding combinations. With this approach cable plant losses from 0 dB to 32 dB can be accommodated. This allows for Repeaterless Physical Link lengths up to 40 km to 60 kilometers.

The example of Figure 2 shows the concept of using multiple Physical Connections to create logical rings of combinations of SMF and MMF media. As shown, the logical sequence of MAC connections is stations 1, 3, 5, 8, 9, 10, and 11. Stations 2, 3, 4, and 6 form a physical ring. Stations 1, 5, 7, 10 and 11 are attached to the FDDI network by lobes branching out from the stations forming the physical ring. Stations 8 and 9 are in turn attached to the FDDI network by lobes branching out from station 7. Stations 2, 4, 6, and 7 are concentrators, serving as the means for logically connecting multiple stations to the physical ring. Concentrators may or may not have MAC entities and full station functionality, although the example of Figure 2 shows them without.

Connection to the physical medium as established by SMF-PMD is controlled by the station insertion and removal algorithms of Station Management (SMT) which are beyond the scope of this part of ISO/IEC 9314.

3.2 Environment

As shown in Figure 2 and as described in 3.1, an FDDI network consists of a large number of connected stations which may be distributed over a large area when using SMF-PMD Physical Connections. Configuring an FDDI network requires proper selection of the category of the Physical Connection, taking into account constraints described in this part of ISO/IEC 9314 as well as MAC, PHY and SMT portions of the FDDI standard. SMT establishes the Physical Connections between stations, and the correct internal station configurations, to create an FDDI network of logical rings.

It is understood that restrictions of the transmission media as defined (i.e., dynamic range, bandwidth and length) may place limits on realizable physical configurations. Tradeoffs may be made within specific site applications, such as distance vs. optical bypass, and media consistent with these limitations. While not intended to be limiting, the FDDI has been defined to serve four major application environments including:

3.2.1 Data Center Environment

The data center environment is characterized by a relatively small number of stations, typically mainframe computers and peripheral equipment, where a high degree of reliability and fault tolerance is required. The FDDI network in a data center environment is comprised of a preponderance of dual stations with relatively few, if any, concentrators. In this environment, it is desirable that two stations maintain unimpaired operation even under the circumstance where up to four intervening stations are powered down thereby causing their optical bypass switches to be in the active connection path between the communicating stations. This environment assumes a total fibre length not exceeding 400 meters between two communicating stations.

3.2.2 Office/Building Environment

The office/building environment is characterized by both a relatively large number of single attachment stations (typically smaller computers, communications concentrators, workstations, and peripherals) and by a radial wiring scheme to connect these stations. Moreover, the stations are frequently powered down by their users. Concentrators, which are typically always powered on, are often used to attach these stations to the FDDI network because they facilitate radial wiring and because concentrators allow any set of the single attachment stations to be without power.

3.2.3 Campus Environment

The campus environment is characterized by stations distributed across multiple buildings where links of up to 2 kilometers may be encountered. Such a distance requirement is expected to be uncommon and would not allow the bypass techniques that are useful in the Data Center environment. This application is typically used for trunk lines between office/building and/or data center environments.

3.2.4 Multi-campus Environment

The multi-campus environment is characterized by clusters of stations, located in different campuses or buildings, often separated by distances significantly greater than the maximum 2 kilometers supported by multimode PMD FDDI technology. Multi-campus environments may also include the requirement to traverse rights-of-way owned or controlled by local utilities or government entities.

SMF-PMD Physical Connections can be used in the above four environments for different reasons. In the multi-campus environment, SMF is required to accommodate link lengths greater than the 2 kilometers maximum specified for multimode PMD. SMF support may also be required to accommodate facilities already owned by local common carriers. In the other three environments, the end-user may select SMF for other considerations.

3.3 Definitions

For the purposes of this part of ISO/IEC 9314 the following definitions apply. Furthermore, ISO 9314-1, ISO 9314-2, ISO/IEC 9314-7 and ISO/IEC 9314-8 contain additional definitions of interest.

3.3.1
Active Input Interface (AII)
the active PMD element that detects modulated light from an Active Output Interface via a fibre optic waveguide and converts it to digital electrical signals

3.3.2
Active Output Interface (AOI)
the active PMD element that converts digital electrical signals into modulated light to be transmitted to an Active Input Interface via a fibre optic waveguide

3.3.3
Attenuation
level of optical power loss expressed in units of decibels (dB)

3.3.4
Average Power
the optical power measured using an average reading power meter when the FDDI station is transmitting a stream of Halt symbols

3.3.5
Bit Error Rate (BER)
the number of bits with the wrong detected value divided by the total number of bits transferred

3.3.6
Bypass
the ability of a station to be optically isolated from the network while maintaining the integrity of the ring

3.3.7
Central Wavelength
the weighted average wavelength of the Active Output Interface optical spectrum

3.3.8
Code-bit
the smallest signaling element used by the Physical Layer for transmission on the medium

3.3.9
Concentrator
an FDDI node that provides additional attachment points for stations that are not part of the dual ring

3.3.10
Cut-off Wavelength
In an optical fibre, the wavelength above which light propagates only in a single mode

NOTE The cut-off wavelength of cabled optical fibre, l_{CC}, is typically lower than the cut-off wavelength of uncabled optical fibre.

3.3.11
Dual Attachment Station
a station that offers two attachments to the FDDI network that are capable of accommodating a dual (counter-rotating) ring. It may offer additional attachments (see Concentrator)

3.3.12
Extinction Ratio
the ratio of the low, or off optical power level, (P_L) to the high, or on optical power level, (P_H) when the station is transmitting a stream of Halt symbols

3.3.13
Extinction Ratio (%)
$(P_L/P_H)*100$

3.3.14
Fibre
dielectric material that guides light; waveguide (see Multimode Fibre and Single-mode fibre)

3.3.15
Fibre Optic Cable
a jacketed fibre(s)

3.3.16
Interchannel Isolation
the ability to prevent undesired optical energy from appearing in one signal path as a result of coupling from another signal path; cross talk

3.3.17
Jitter, Data Dependent (DDJ)
jitter that is related to the transmitted symbol sequence. DDJ is caused by the limited bandwidth characteristics and imperfections in the optical channel components. DDJ results from non-ideal individual pulse responses and from variation in the average value of the encoded pulse sequence that may cause base-line wander and may change the sampling threshold level in the receiver

3.3.18
Jitter, Duty Cycle Distortion (DCD)
distortion usually caused by propagation delay differences between low-to-high and high-to-low transitions. DCD is manifested as a pulse width distortion of the nominal baud time

3.3.19
Jitter, Random (RJ)
RJ is due to thermal noise and may be modeled as a Gaussian process. The peak-peak value of RJ is of a probabilistic nature and thus any specific value requires an associated probability

3.3.20
Media Interface Connector (MIC)
an optical fibre connector that connects the fibre media to the FDDI attachment. The MIC consists of two halves. The MIC plug is the male half used to terminate an optical fibre signal transmission cable. The MIC receptacle is the female half that is associated with the FDDI attachment

3.3.21
MIC Plug
the male half of the MIC that terminates an optical signal transmission cable

3.3.22
MIC Receptacle
the fixed or stationary female half of the MIC that is part of an FDDI station

3.3.23
Mode Field Diameter
a measure of the width of the guided optical power's intensity distribution in the core and the cladding of a single-mode fibre

3.3.24
Multimode Fibre (MMF)
multimode fibre is an optical fibre waveguide usually characterized by a core diameter of 50 to 100 µm that will allow a large number of modes to propagate

3.3.25
Optical Fall Time
the time interval for the falling edge of an optical pulse to transition from 90% to 10% of the pulse amplitude

3.3.26
Optical Reference Plane
the plane that defines the optical boundary between the MIC Plug and the MIC Receptacle

3.3.27
Optical Return Loss (ORL)
the ratio (expressed in units of dB) of optical power reflected by a component or an assembly to the optical power incident on a component port when that component or assembly is introduced into a link or system

3.3.28
Optical Rise Time
the time interval for the rising edge of an optical pulse to transition from 10% to 90% of the pulse amplitude

3.3.29
Physical Connection
the full-duplex Physical Layer association between adjacent PHY entities (in concentrators or stations) in an FDDI ring, i.e., a pair of Physical Links

3.3.30
Physical Link
the simplex path (via PMD and attached medium) from the transmit function of one PHY entity to the receive function of an adjacent PHY entity (in concentrators or stations) in an FDDI ring

3.3.31
Primitive
an element of the services provided by one entity to another