

INTERNATIONAL STANDARD

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14165-116

First edition
2005-08

Information technology – Fibre channel –

Part 116: 10 Gigabit Fibre Channel (10GFC)



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**INFORMATION TECHNOLOGY –
FIBRE CHANNEL –
Part 116: 10 Gigabit Fibre Channel (10GFC)**

FOREWORD

- 1) ISO (International Organization for Standardization) and IEC (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.
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International Standard ISO/IEC 14165-116 was prepared by subcommittee 25: Inter-connection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

INTRODUCTION

The Fibre Channel signalling and physical requirements described in this document cover

- link architecture including retiming (see clause 5)
- physical layer specifications (see clause 6)
- connector performance specifications (see clause 7)
- link and cable plant management specifications (see clause 8)
- FC-1 data path interface (see clause 9)
- optional interconnect interfaces (see clauses 10, 11 and 14)
- transmission coding (see clauses 12 and 13)
- management interface and register set (see clause 15).

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INFORMATION TECHNOLOGY – FIBRE CHANNEL – Part 116: 10 Gigabit Fibre Channel (10GFC)

1 Scope

This part of ISO/IEC 14165 describes the signalling and physical requirements that may be utilized by Fibre Channel-2 (FC-2) level transport data at a rate in excess of 10 Gbit/s.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60793-1-41, *Optical fibres – Part 1-41: Measurement methods and test procedures – Bandwidth*

IEC 60793-1-49, *Optical fibres – Part 1-49: Measurement methods and test procedures – Differential mode delay*

IEC 60793-2, *Optical fibres – Part 2: Product specifications – General*

IEC 60793-2-10, *Optical fibres – Part 2-10: Product specifications – Sectional specification for category A1 multimode fibres*

IEC 60825-1:1993, *Safety of laser products – Part 1: Equipment classification, requirements and user's guide, including Amendment 1 (1997) and Amendment 2 (2001)*

IEC 60950-1, *Information technology equipment – Safety – Part 1: General requirements*

IEC 61280-4-1, *Fibre-optic communication subsystem test procedures – Part 4-1: Cable plant and links – Multimode fibre-optic cable plant attenuation measurement*

IEC 61280-4-2, *Fibre-optic communication subsystem basic test procedures – Part 4-2: Fibre optic cable plant – Single-mode fibre optic cable plant attenuation*

IEC 61300-3-3, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-3: Examinations and measurements – Active monitoring of changes in attenuation and return loss*

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

IEC 61753-1-1, *Fibre optic interconnecting devices and passive components performance standard – Part 1-1: General and guidance – Interconnecting devices (connectors)*

IEC 61753-021-2, *Fibre optic interconnecting devices and passive component performance standard – Part 021-2: Fibre optic connectors terminated on single-mode fibre for category C – Controlled environment*

IEC 61753-022-2, *Fibre optic interconnecting devices and passive components performance standard – Part 022-2: Fibre optic connectors terminated on multimode fibre for category C – Controlled environment*

IEC 61754-7, *Fibre optic connector interfaces – Part 7: Type MPO connector family*

ISO/IEC 8802-3:2000, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications (also referred to as 10GbE)¹*

¹ Including forthcoming ISO/IEC 8802-3, Amendment 1, *Media Access Control (MAC) Parameters, Physical Layers and Management Parameters for 10 Gbit/s Operation*.

ITU-T Recommendation G.707, *Network node interface for the synchronous digital hierarchy (SDH)*.

ITU-T Recommendation G.709, *Interfaces to the Optical Transport Network (OTN)*.

3 Definitions and conventions

3.1 Definitions

For the purpose of this International Standard the following definition applies:

3.1.1 compliance point

external connector for transmitters and receivers

3.2 Editorial conventions

3.2.1 General

In FC-PI, a number of conditions, mechanisms, sequences, parameters, events, states, or similar terms are printed with the first letter of each word in uppercase and the rest lowercase (e.g., Exchange, Class). Any lowercase uses of these words have the normal technical English meanings.

Numbered items do not represent any priority. Any priority is explicitly indicated.

The ISO convention of numbering is used (i.e., the thousands and higher multiples are separated by a space and a comma is used as the decimal point). A comparison of the American and ISO conventions is shown in table 1.

Table 1 – ISO and American conventions

ISO	American
0,6	0.6
1 000	1,000
1 323 462,9	1,323,462.9

In case of any conflict between figure, table and text, the text, then tables, and finally figures take precedence. Exceptions to this convention are indicated in the appropriate subclauses.

In all of the figures, tables, and text of this document, the most significant bit of a binary quantity is shown on the left side. Exceptions to this convention are indicated in the appropriate subclauses.

The term “shall” is used to indicate a mandatory rule. If such a rule is not followed, the results are unpredictable unless indicated otherwise.

If a field or a control bit in a frame is specified as not meaningful, the entity which receives the frame shall not check that field or control bit.

3.2.2 Hexadecimal notation

Hexadecimal notation is used to represent fields. For example, a four-byte Process_Associator field containing a binary value of 00000000 11111111 10011000 11111010 is shown in hexadecimal format as hex '00 FF 98 FA'.

3.2.3 Transmission rate abbreviations

The exact transmission rates are used in the tables and the abbreviated forms are used in text. Note that 3,187 5 gigabaud (GBd) is the preferred ISO method and is used instead of 3 187,5 megabaud (MBd) where it makes sense to do so.

Table 2 – Data rate abbreviations

Notation	Notation (FC-FS style)	True signalling rate
3,187 5 GBd	3 187,5 MBd	3 187,5 MBd

Table 2

Notation	Notation (FC-FS style)	True signalling rate
10,2 Gb/s	10 200 Mb/s	10 200 Mb/s
10,518 75 GBd	10 518,75 MBd	10 518,75 MBd
12,75 GBd	12 750 MBd	12 750 MBd

3.2.4 Acronyms and other abbreviations

Table 3 – Acronyms and other abbreviations

ASIC	application specific integrated circuit
BB-2	Fibre Channel Backbone standard (FC-BB-2)
Bd	Baud
BER	bit error ratio
CDR	clock and data recovery
CJPAT	continuous jitter test pattern
CMOS	complementary metal oxide semiconductor
CRC	cyclic redundancy check
CWDM	coarse wavelength division multiplexing
dB	decibel
dBm	decibel (relative to 1 mW)
DJ	deterministic jitter
DUT	device under test
EIA	Electronic Industries Association
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EOF	End-of-Frame
FC	Fibre Channel
FOTP	fiber optic test procedure
FWHM	full width half maximum
GbE	Gigabit Ethernet
Gb/s	gigabits per second, where gigabit = 10^9 bits
GB/s	gigabytes per second, where gigabyte = 10^9 bytes
GBd	gigabaud
GFC	Gigabit Fibre Channel
hex	hexadecimal notation
HIPPI	High-Performance Parallel Interface standard
IEEE	Institute of Electrical and Electronics Engineers
ISI	inter-symbol interference
ITU-T	The International Union Telecommunication standard (formerly CCITT)
JTPAT	jitter test pattern
LOS	loss of signal
LPSM	loop port state machine
LW	long wavelength
Mb/s	megabits per second, where megabit = 10^6 bits
MB	megabyte = 10^6 bytes
MB/s	megabytes per second, where megabyte = 10^6 bytes
MBd	megabaud
MDI	Medium Dependent Interface
MPN	mode partition noise
MPO	multiway plug optical connector
MM	multimode
MMF	multimode fiber
MT	multi vendor specific MPO connector designation
NA	not applicable
nm	nanometer
NEXT	near-end crosstalk
N_Port	Node_Port
OFSTP	optical fiber system test procedure
OFL	overfilled launch
OMA	optical modulation amplitude
ORL	optical return loss
OSI	Open Systems Interconnection
PCS	Physical Coding Sublayer
PLL	phase-locked loop
PMA	Physical Medium Attachment sublayer
PMD	Physical Medium Dependent sublayer
ppm	parts per million

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Table 3 – Acronyms and other abbreviations (continued)

ps	picosecond
PSM	FC Port State Machine
RF	remote fault
RFC-1	FC-1 Receiver
RFI	radio frequency interference
RIN	relative intensity noise
RJ	random jitter
RMS	root mean square
RS	Reconciliation Sublayer (10GbE: ISO/IEC 8802-3)
Rx	receiver
RXI	XGMII Receiver
SCSI	Small Computer System Interface standard
SD	signal detect
SDH	Synchronous Digital Hierarchy standard (ITU-T Rec G.707)
SerDes	serializer/deserializer
SM	single-mode
SMF	single-mode fiber
S/N or SNR	signal-to-noise ratio
SOF	Start-of-Frame
SW	short wavelength
TDR	time domain reflectometry
TFC-1	FC-1 Transmitter
TIA	Telecommunication Industries Association
Tx	transmitter
TXI	XGMII Transmitter
TxRx	a combination of transmitter and receiver
UI	unit interval = 1 bit period
ULP	upper level protocol
VI	Fibre Channel Virtual Interface standard
XAUI	10 Gigabit Attachment Unit Interface (see clause 11)
XGMII	10 Gigabit Media Independent Interface (see clause 10)
YGXS	XGMII Extender Sublayer (see clause 11)
XSBI	10 Gigabit Sixteen Bit Interface (see clause 14)

3.2.5 Special symbols

Unless indicated otherwise, the following symbols have the listed meanings.

Table 4 – Symbols

Symbol	Description
γ	gamma
Ω	ohm
μ	micro (e.g., μm = micrometer)
λ	wavelength
<n>	Bits and groups of bits are represented with angle brackets and a separating colon, such as <3> or <7:0>
/x/	The encoded character x is represented by preceding and following slash symbols.
y	Four encoded characters, one each in lanes 0 through 3 inclusive, synchronous to each other and arranged in a column identified by the value y, are represented by preceding and following double bar symbols.

3.3 Keywords

- 3.3.1 expected:** Used to describe the behavior of the hardware or software in the design models assumed by this standard. Other hardware and software design models may also be implemented.
- 3.3.2 invalid:** Used to describe an illegal or unsupported bit, byte, word, field or code value. Receipt of an invalid bit, byte, word, field or code value shall be reported as error.

- 3.3.3 ignored:** Used to describe a bit, byte, word, field or code value that shall not be examined by the receiving port. The bit, byte, word, field or code value has no meaning in the specified context.
- 3.3.4 mandatory:** A keyword indicating an item that is required to be implemented as defined in this standard.
- 3.3.5 may:** A keyword that indicates flexibility of choice with no implied preference (equivalent to “may or may not”).
- 3.3.6 may not:** A keyword that indicates flexibility of choice with no implied preference (equivalent to “may or may not”).
- 3.3.7 meaningful:** A control field or bit shall be applicable and shall be interpreted by the receiver, wherever it is specified as meaningful. Wherever it is specified as “not meaningful”, it shall be ignored.
- 3.3.8 obsolete:** A keyword indicating that an item was defined in a prior Fibre Channel standard but has been removed from this standard.
- 3.3.9 optional:** A keyword that describes features that are not required to be implemented by this standard. However, if an optional feature defined by this standard is implemented, then it shall be implemented as defined in this standard.
- 3.3.10 reserved:** A keyword referring to bits, bytes, words, fields and code values that are set aside for future standardization. A reserved bit, byte, word or field shall be set to zero, or in accordance with a future extension to this standard. Recipients are not required to check reserved bits, bytes, words or fields for zero values. Reserved code values shall always be passed to higher level protocols.
- 3.3.11 shall:** A keyword indicating a mandatory requirement. Designers are required to implement all such mandatory requirements to ensure interoperability with other products that conform to this standard. This standard prescribes no specific response by a component if it receives information that violates a mandatory behavior.
- 3.3.12 should:** A keyword indicating flexibility of choice with a strongly preferred alternative; equivalent to the phrase “it is strongly recommended”.
- 3.3.13 vendor specific:** Functions, code values, and bits not defined by this standard and set aside for private usage between parties using this standard.

3.4 Notation

3.4.1 State diagram conventions

3.4.1.1 General

The operation of a protocol can be described by subdividing the protocol into a number of interrelated functions. The operation of the functions can be described by state diagrams. Each diagram represents the domain of a function and consists of a group of connected, mutually exclusive states. Only one state of a function is active at any given time (see figure 1).

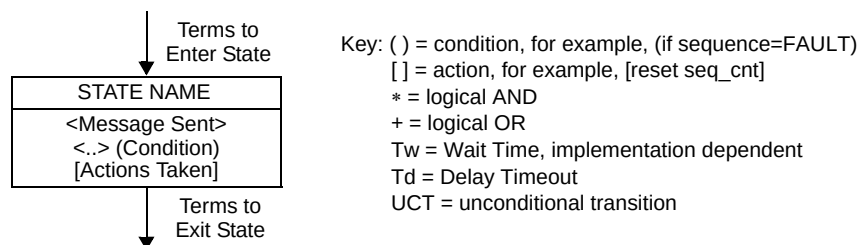


Figure 1 – State diagram notation example

Each state that the function can assume is represented by a rectangle. These are divided into two parts by a horizontal line. In the upper part the state is identified by a name in capital letters. The lower part contains the name of any ON signal that is generated by the function. Actions are described by short phrases and enclosed in brackets.

All permissible transitions between the states of a function are represented graphically by arrows between them. A transition that is global in nature (for example, an exit condition from all states to the IDLE or RESET state) is indicated by an open arrow. Labels on transitions are qualifiers that must be fulfilled before the transition will be taken. The label UCT designates an unconditional transition. Qualifiers described by short phrases are enclosed in parentheses.

State transitions and sending and receiving of messages occur instantaneously. The actions inside a state block execute instantaneously. Actions inside state blocks are atomic (i.e., uninterruptible). When a state is entered and after performing all the actions listed in a state block one time, the state block then continuously evaluates its exit conditions until one is satisfied, at which point control passes through a transition arrow to the next block. While the state awaits fulfillment of one of its exit conditions, the actions inside do not implicitly repeat.

Valid state actions may include .indicate and .request messages. No actions are taken outside of any state block.

Some devices described in this standard are allowed to have two or more ports. State diagrams that are capable of describing the operation of devices with an unspecified number of ports require qualifier notation that allows testing for conditions at multiple ports. The notation used is a term that includes a description in parentheses of which ports must meet the term for the qualifier to be satisfied (e.g., ANY and ALL). It is also necessary to provide for term-assignment statements that assign a name to a port that satisfies a qualifier. The following convention is used to describe a term-assignment statement that is associated with a transition:

- the character “:” (colon) is a delimiter used to denote that a term assignment statement follows;
- the character “←” (left arrow) denotes assignment of the value following the arrow to the term preceding the arrow.

The state diagrams contain the authoritative statement of the functions they depict. When apparent conflicts between descriptive text and state diagrams arise, the state diagrams are to take precedence. However, such precedence does not override any explicit description in the text that has no parallel in the state diagrams.

The models presented by state diagrams are intended as the primary specifications of the functions to be provided. However, it is important to distinguish between a model and a real implementation. The models are optimized for simplicity and clarity of presentation, while any realistic implementation may place heavier emphasis on efficiency and suitability to a particular implementation technology. It is the functional behavior of any unit that must match the standard, not its internal structure. The internal details of the model are useful only to the extent that they specify the external behavior clearly and precisely.

3.4.1.2 State diagram variables

Once set, variables retain their values as long as succeeding blocks contain no references to them.

Setting the parameter of a formal interface message assures that, on the next transmission of that message, the last parameter value set will be transmitted.

Testing the parameter of a formal interface messages tests the value of that message parameter that was received on the last transmission of said message. Message parameters may be assigned default values that persist until the first reception of the relevant message.

3.4.1.3 State transitions

The following terms are valid transition qualifiers:

- a) Boolean expressions;

- b) An event such as the expiration of a timer: timer_done;
- c) An event such as the reception of a message: PMA_UNITDATA.indicate;
- d) An unconditional transition: UCT;
- e) A branch taken when other exit conditions are not satisfied: ELSE.

Any open arrow (an arrow with no source block) represents a global transition. Global transitions are evaluated continuously whenever any state is evaluating its exit conditions. When a global transition becomes true, it supersedes all other transitions, including UCT, returning control to the block pointed to by the open arrow.

3.4.1.4 Operators

The state machine operators are shown in table 5.

Table 5 – State diagram operators

Character	Meaning
*	Boolean AND
+	Boolean OR
^	Boolean XOR
!	Boolean NOT
<	Less than
≤	Less than or equal to
=	Equals (a test of equality)
≠	Not equals
≥	Greater than or equal to
>	Greater than
()	Indicates precedence
←	Assignment operator
∈	Indicates membership
∉	Indicates nonmembership
	Catenate
ELSE	No other state condition is satisfied

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4 Structure and concepts

4.1 Overview

This clause provides an overview of the structure, concepts and mechanisms used in 10GFC.

The Fibre Channel (FC) is logically a bi-directional point-to-point serial data channel, structured for high performance information transport. Physically, Fibre Channel is an interconnection of one or more point-to-point links. Each link end terminates in a Port. Ports are fully specified in FC-FS, FC-PI and FC-AL-2. Fiber is a general term used to cover all physical media supported by Fibre Channel including optical fiber, twisted pair, and coaxial cable.

Fibre Channel is structured as a set of hierarchical functions as illustrated in figure 2. Fibre Channel consists of related functions, FC-0 through FC-4. Each of these functions is described as a level. Fibre Channel does not restrict implementations to specific interfaces between these levels.

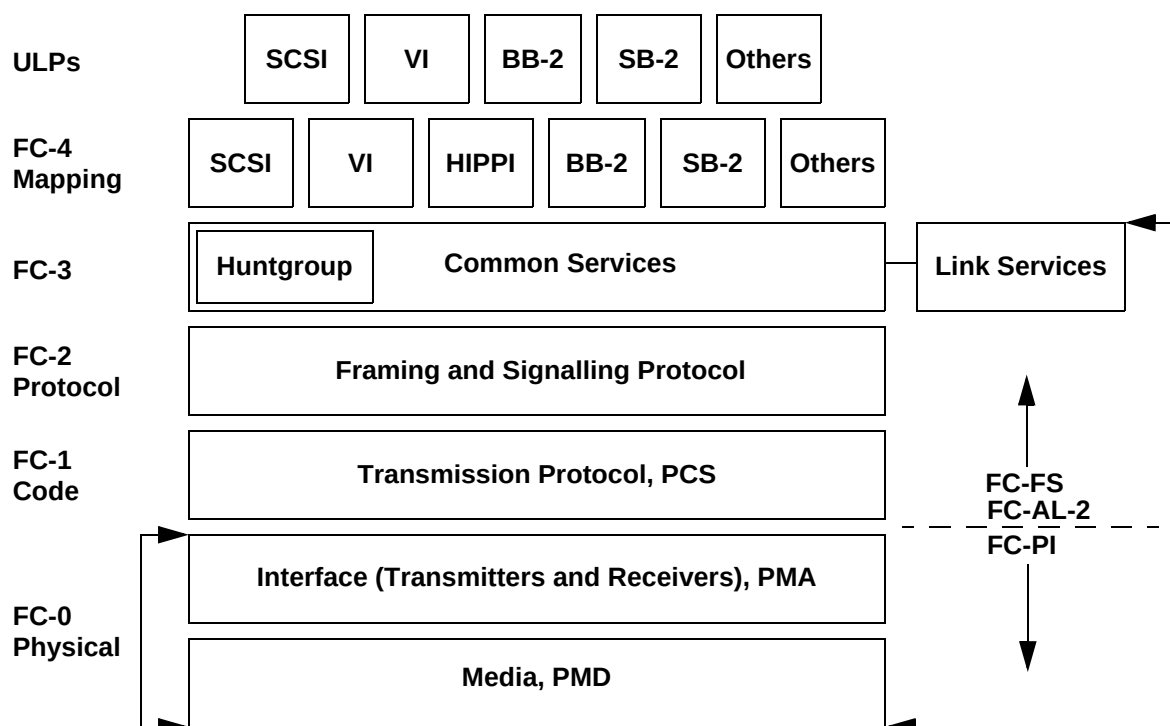


Figure 2 – Fibre channel structure

The Physical interface (FC-0), specified in FC-PI, consists of transmission media, transmitters, receivers and their interfaces. The Physical interface specifies a variety of media, and associated drivers and receivers capable of operating at various speeds.

The Transmission protocol (FC-1), Signalling protocol (FC-2) and Common Services (FC-3) are fully specified in FC-FS and FC-AL-2. Fibre Channel levels FC-1 through FC-3 specify the rules and provide mechanisms needed to transfer blocks of information end-to-end, traversing one or more links.

An Upper Level Protocol mapping to FC-FS constitutes an FC-4 which is the highest level in the Fibre Channel structure. FC-2 defines a suite of functions and facilities available for use by an FC-4.

10GFC describes the signalling and physical interface services that may be utilized by an extended version of the FC-2 level to transport data at a rate in excess of 10 gigabits per second over a family of FC-0 physical variants. 10GFC additionally introduces port management functions at the FC-3 level.

A Fibre Channel Node is functionally configured as illustrated in figure 3. A Node may support one or more N_Ports and one or more FC-4s. Each N_Port contains FC-0, FC-1 and FC-2 functions. FC-3 optionally provides the common services to multiple N_Ports and FC-4s.

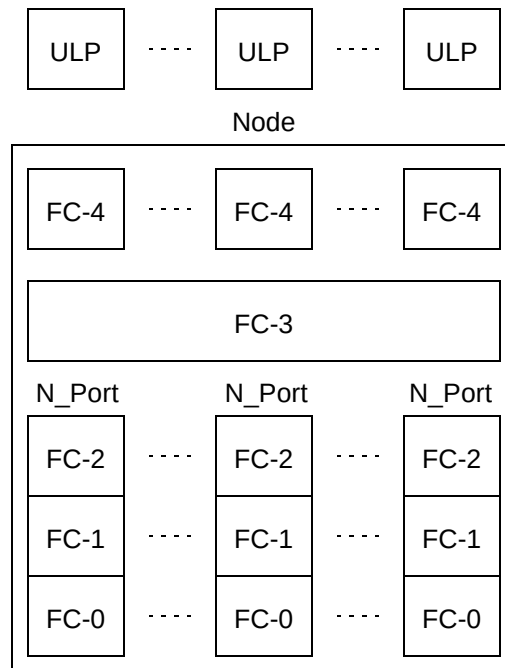


Figure 3 – Node functional configuration

4.2 10GFC structure

4.2.1 FC-3 general description

4.2.1.1 General

The FC-3 level of 10GFC extends the FC-3 levels of FC-FS and FC-AL-2 by adding a Port management interface and register set and low level signalling protocol.

4.2.1.2 Management interface and register set

The Port management interface and register set provides an interconnection between manageable devices within a Port and Port management entities. Port management is specified in clause 15.

4.2.2 FC-2 general description

The FC-2 level of 10GFC extends the FC-2 levels of FC-FS and FC-AL-2 to transport data at a rate of 10,2 gigabits per second over a family of 10GFC FC-0 physical variants.

Arbitrated loop functions defined in FC-AL-2 are not supported and outside the scope of this specification. Potential FC-AL-2 ordered set mapping, translations and related topics are provided in annex C for future reference.

4.2.3 FC-1 general description

4.2.3.1 General

The FC-1 level of 10GFC provides the ability to transport data at a rate of 10,2 Gb/s over a family of FC-0 physical variants. The FC-1 level adapts the Fibre Channel FC-2 level functions to the XGMII interface as defined in 10GbE: ISO/IEC 8802-3, and expanded in clause 10. The FC-1 level generates continuous data or control characters on the transmit path and expects continuous data or control characters on the receive path. The FC-1 level participates in link fault detection and reporting by monitoring the receive path for status reports that indicate an unreliable link, and generating status reports on the transmit path to report detected link faults to the FC-1 level on the remote end of the link.

10GFC provides the specification of optional physical interfaces applicable to the implementation of 10GFC Ports. In addition, the 10GFC FC-1 level specifies optional electrical interfaces which may be used to interconnect the physical embodiment of various sublayers. These interfaces include the 10 Gigabit Media Independent Interface (XGMII) and the 10 Gigabit Attachment Unit Interface (XAUI). One or both of these interfaces may typically be present within a 10GFC port. 10GFC provides the following FC-1 functions and interfaces.

4.2.3.2 Ordered sets

FC-1 signals convey FC-2 data as well as frame delimiters and control information to be encoded by FC-1 transmission code. The same conveyance exists in the reverse direction. 10GFC Ordered Sets are specified in clause 9.

4.2.3.3 10 Gigabit media independent interface (XGMII)

The 10 Gigabit Media Independent Interface provides a physical instantiation of a 10,2 Gb/s parallel data and control transport within FC-2. Its implementation is typically an internal chip interconnect or chip-to-chip interconnect. The XGMII supports 10,2 Gb/s data transport through its 32-bit wide data and four bit wide control transmit and receive paths.

Though the XGMII is an optional interface, it is used extensively in this standard as a basis for specification of the interface between FC-2 and FC-1. The FC-1 Physical Coding Sublayer (PCS) is specified to the XGMII interface, so if not implemented, a conforming implementation shall behave functionally as if the XGMII were implemented. The XGMII is specified in clause 10.

4.2.3.4 10 Gigabit attachment unit interface (XAUI)

The 10 Gigabit Attachment Unit Interface provides a physical instantiation of a 10,2 Gb/s four lane serial data and control transport within FC-2 or between FC-2 and lower levels including FC-1 and FC-0. The XAUI is an optional interface defined as an XGMII extender. Its implementation is typically a chip-to-chip interconnect including chips within transceiver modules. The XAUI supports 10,2 Gb/s data transport through its four 8B/10B based serial transmit and receive paths. The XAUI is specified in clause 11.

4.2.3.5 8B/10B transmission code

The 8B/10B transmission code is the same as that specified in FC-FS. It is intended for encoding data on four serial lanes at a cumulative data rate of 10,2 Gb/s. 8B/10B transmission code is utilized for both XAUI and four lane PMDs. For PMDs, the four transmitters and receivers may be either optically multiplexed to and from a single fiber optic cable or directly conveyed over four individual fibers. The 8B/10B transmission code as well as its corresponding Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayers are specified in clause 12.

4.2.3.6 64B/66B transmission code

The 64B/66B transmission code is a PCS intended for 10,2 Gb/s data transport across a single fiber optic cable. The primary reason for the adoption of this code is to provide minimal overhead above the 10,2 Gb/s serial data rate to allow the use of optoelectronic components developed for other high volume 10 Gb/s communications applications such as SONET OC-192. A secondary reason for use of 64B/66B code (with scrambler) was to spread the spectrum of EMI radiation. The 64B/66B transmission code is specified in clause 13.

4.2.3.7 10 Gigabit sixteen bit interface (XSBI)

The 10 Gigabit Sixteen Bit Interface is a PMA that provides a physical instantiation of a 16-bit wide data path that conveys 64B/66B encoded data to and from FC-0. The XSBI is intended to support serial FC-0 variants. The XSBI is specified in clause 14.

4.2.4 FC-0 general description

4.2.4.1 General

The FC-0 level of 10GFC describes the Fibre Channel link. The FC-0 level covers a variety of media and associated transmitters and receivers capable of transporting FC-1 data. The FC-0 level is designed for maximum flexibility and allows the use of a large number of technologies to meet the broadest range of Fibre Channel system cost and performance requirements.

4.2.4.2 FC-0 interface overview

The nomenclature used by 10GFC to reference various combinations of components is defined in clause 5.

The link distance capabilities specified in 10GFC are based on ensuring interoperability across multiple vendors supplying the technologies (both transceivers and cable plants) under the tolerance limits specified in 10GFC. Greater link distances may be obtained by specifically engineering a link based on knowledge of the technology characteristics and the conditions under which the link is installed and operated. However, such link distance extensions are outside the scope of 10GFC.

4.2.4.3 Optical physical variants

Multiple optical serial physical full-duplex variants are specified to support the transport of encoded FC-1 data transport over fiber-optic medium. The variants include:

- four quarter speed lanes over individual fibers;
- four quarter speed lanes optically multiplexed over a single fiber, and;
- one full speed lane over one fiber.

The optical interfaces for all physical variants are specified in clause 6. Clause 7 contains the accompanying receptacle specifications. Clause 8 contains the accompanying cable plant specifications. Nomenclature for 10GFC physical variants is specified in 5.2.

5 Functional characteristics

5.1 General characteristics

FC-PI describes the physical link, the lowest level, in the Fibre Channel system. It is designed for flexibility and allows the use of several physical interconnect technologies to meet a wide variety of system application requirements. This 10GFC standard extends FC-PI with multiple physical variants specified to operate at a data rate of 1 200 MBytes/sec.

In the physical media signals a logical “1” shall be represented as the state with the higher optical power.

The FC-FS protocol is defined to operate across connections having a bit error rate (BER) detected at the receiving node of less than 10⁻¹². It is the combined responsibility of the component suppliers and the system integrator to ensure that this level of service is provided at every node in a given Fibre Channel installation. This 10GFC standard extends FC-FS with FC-3, FC-2 and FC-1 level specifications in support of multiple physical variants.

5.2 10GFC physical variant nomenclature

The nomenclature for the 10GFC physical variants, also referred to as Physical Medium Dependent (PMD) options, is specified in figure 4.

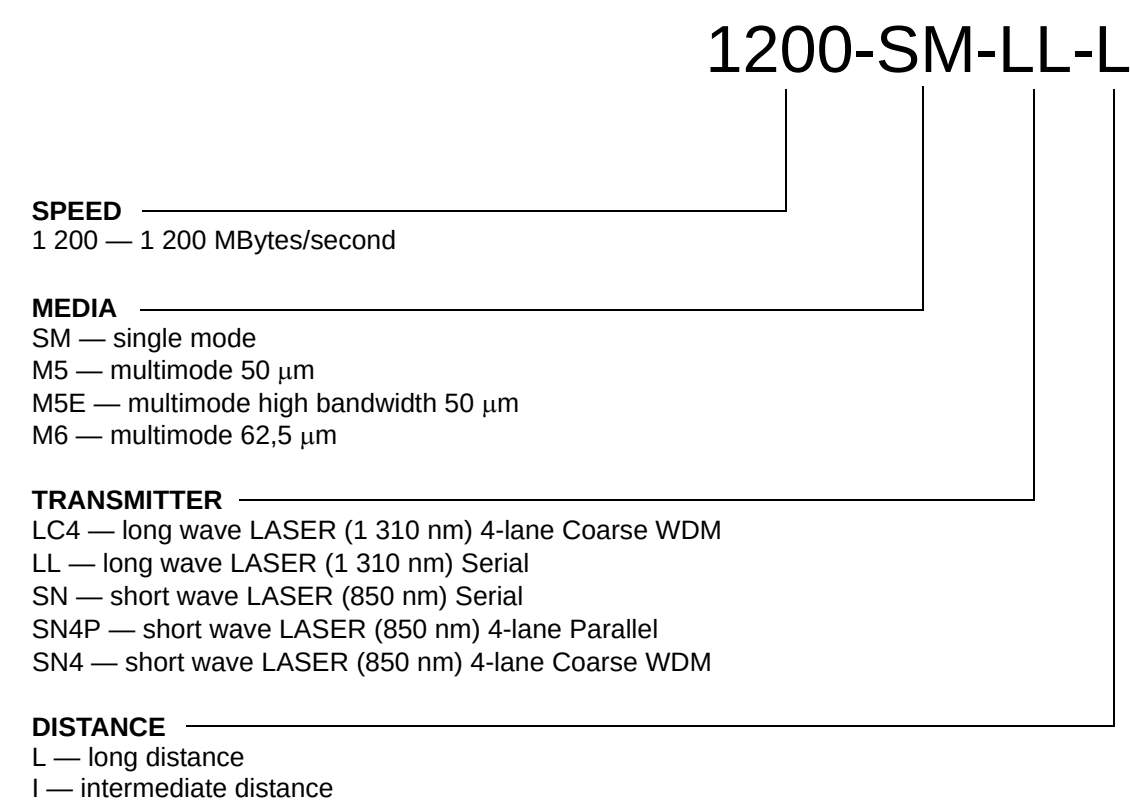


Figure 4 – 10GFC physical variant nomenclature

6 Optical interface specification

6.1 General

This clause defines the optical signal characteristics at the interface connector receptacle. Each conforming optical FC attachment shall be compatible with this optical interface to allow interoperability within an FC environment. Fibre Channel links shall not exceed the BER objective (10^{-12}) under any valid condition. The parameters specified in this clause support meeting that requirement under any valid condition including the minimum input power level. Clause 7 specifies the corresponding interface receptacle. Clause 8 specifies the corresponding cable plant.

The following physical variants (PMDs) are included in this clause:

- 850 nm Parallel (four lane) PMD, type 1200-MX-SN4P-I, specified in this clause;
- 850 nm Serial PMD, type 1200-MX-SN-I, specified in 10GbE: ISO/IEC 8802-3;
- 850 nm CWDM (four wavelength) PMD, type 1200-MX-SN4-I, specified in this clause;
- 1 310 nm Serial PMD, type 1200-SM-LL-L, specified in 10GbE: ISO/IEC 8802-3;
- 1 310 nm CWDM (four wavelength) PMD, type 1200-X-LC4-L, specified in 10GbE: ISO/IEC 8802-3.

6.2 850 nm Parallel (4 lane) PMD, type 1200-MX-SN4P-I

6.2.1 Overview

This clause specifies the four-lane parallel-optic with denomination 1200-MX-SN4P-I PMD (including MDI) and the baseband medium for multimode optical fiber with data transfer rate of 1 200 MB/s. The PMD variants support three different media described by replacing X with “5” for standard 50 μ m MMF (500 MHz•km), “5E” for high-bandwidth 50 μ m MMF (2 000 MHz•km), and “6” for 62,5 μ m MMF (200 MHz•km). Only 1200-M5-SN4P-I PMD specification is normative. The specifications for 1200-M5E-SN4P-I and 1200-M6-SN4P-I are informative. In order to form a complete physical layer, the PMD shall be integrated with the appropriate physical sublayers and management functions as specified in table 6.

Table 6 – 1200-MX-SN4P-I PMD type and associated sublayer and clause

Sublayer	Clause	1200-MX-SN4P-I
FC-1	9	Required
XGMII ¹	10	Optional
XGXS and XAUI	11	Optional
PCS/PMA	12	Required
Management	15	Optional
¹ The XGMII is an optional interface. However, if the XGMII is not implemented, a conforming implementation must behave functionally as though XGMII were present.		

The services provided by the 1200-MX-SN4P-I PMD are specified in 10GbE: ISO/IEC 8802-3.

6.2.2 PMD MDIO function mapping

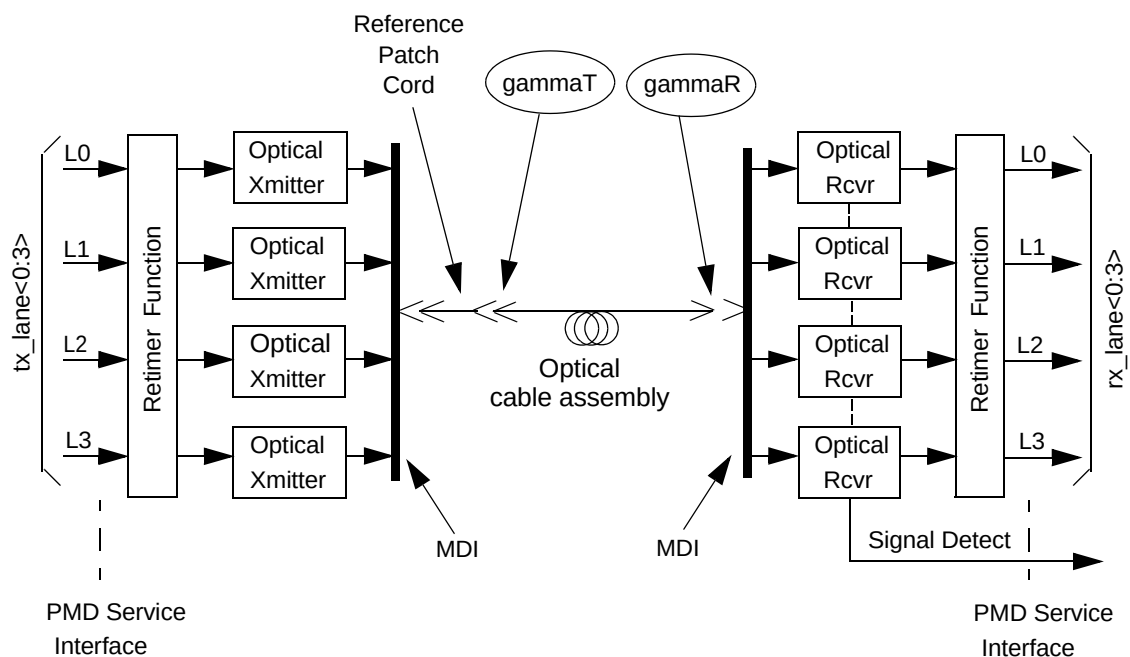
Specified in 10GbE: ISO/IEC 8802-3.

6.2.3 PMD functional specifications

The 1200-MX-SN4P-I PMDs perform the Transmit and Receive functions which convey data between the PMD service interface and the MDI plus various management functions if the optional MDIO is implemented.

6.2.3.1 PMD block diagram

The PMD block diagram is shown in figure 5. For purposes of system conformance, the PMD sublayer is standardized at the points described in this subclause. The optical transmit signal is defined at the output end of a reference patch cord ($\gamma_T = TP2$), between 0,5 m and 5 m in length, of a type consistent with the link type connected to the transmitter receptacle defined in 7.3. Unless specified otherwise, all transmitter measurements and tests defined in 6.2.6 are made at γ_T . The optical receive signal is defined at the output of the fiber optic cabling ($\gamma_R = TP3$) at the MDI (see 7.3). Unless specified otherwise, all receiver measurements and tests defined in 6.2.6 are made at γ_R .



NOTE Specification of the retimer function is beyond the scope of this standard. However, a retimer may be required to ensure compliance at test points γ_T and γ_R .

Figure 5 – Block diagram for one direction of the 1200-MX-SN4P-I PMD signal paths

6.2.3.2 PMD transmit function

The PMD Transmit function shall convert the four electronic bit streams requested by the PMD service interface message PMD_UNITDATA.request (tx_bit<0:3>) into four separate optical signal streams for transmission over tx_lane<0:3>. The four optical signal streams shall then be delivered to the MDI, all according to the transmit optical specifications in this clause. The higher optical power level in each signal stream shall correspond to a tx_bit = ONE.