Working Draft

T11.1 / Project 1249-D / Rev 0.3

January 12, 1998

Information Technology - High-Performance Parallel Interface – 6400 Mbit/s Optical Specification (HIPPI-6400-OPT)

Secretariat : National Committee for Information Technology Standardization (NCITS)

This is an internal working draft of T11.1, a Task Group of Technical Committee T11 of Accredited Standards Committee NCITS. As such, this is not a completed standard. The contents are actively being modified by T11.1.

ABSTRACT

This document describes a media-level, point-to-point, 12-channel, full-duplex, electrical / optical interface, with each channel operating at 1 Gbit/s. Multimode (MM) ribbon fiber and single mode (SM) ribbon fiber are used for distances up to 300 m and 10 km respectively. Differential signals are used on the electrical side.

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Comments on Rev 0.3

This is a preliminary document undergoing lots of changes. Many of the additions are just place holders, or are put there to stimulate discussion. Hence, do not assume that the items herein are correct, or final – everything is subject to change. This page tries to outline where we are; what has been discussed and semi-approved, and what has been added or changed recently and deserves your special attention. This summary relates to changes since the previous revision. Also, previous open issues are outlined with a single box, new open issues ones are marked with a double bar on the left edge of the box.

Changes are marked with margin bars so that changed paragraphs are easily found, and then highlights mark the specific changes. The list below just describes the major changes, for detail changes please compare this revision to the previous revision. **The major technical changes are printed in bold.**

Please help us in this development process by sending comments, corrections, and suggestions to the Technical Editor, Don Tolmie, of the Los Alamos National Laboratory, at det@lanl.gov. If you would like to address the whole group working on this document, send the comment(s) to hippi@network.com.

1. In 3.1.12 and 3.1.13, changed the rise and fall time measurement points from 10%-90% to 20%-80%.
2. In 3.1.19, deleted the sentences reading: "Jitter is not tracked by the clock recovery and directly affects the timing allocations in a bit cell. For HIPPI-6400-OPT the lower cutoff frequency for jitter is defined as the bit rate divided by 2,500.".
3. In 3.1.29, added a new definition for "optical passive loss". It was copied from the fourth paragraph of 7.2.
4. In 3.1.36, changed "The condition of receiving the…" to "The".
5. In 3.3, changed "megabit/s" to "megabit per second".
6. In Figure 1, added a note that the Transmitter_enable signal may be removed.
7. **In 7.1, added the second and third paragraphs, which had been inadvertently deleted in Rev 0.2.**
8. **In Table 4, changed the title from "Optical parameters" to "850 nm optical parameters". Deleted the column for "1300 nm MM/SM".**
9. **In Table 5, added this as a whole new table for the 1300 nm variant. Most of the table is a direct copy from the original 1300 nm column of Table 4, except where highlighted. Split the values into separate columns for MM and SM. Changed the optical passive loss from "TBD" to "2.5/7 dB". Changed the SM total link power budget from "6" to "8" dB. Changed "Avg. launched power (max. per channel)" to "Launched power (max. per channel)". Changed "Optical modulation amplitude (min. per channel)" to "Extinction ratio". Changed "Received optical modulation amplitude (min.)" to "Dynamic range (min.)". Changed "Avg. received power (max.)" to "Sensitivity (max.)". In note 1, changed "2.6 dB" to "2 dB", and deleted "For systems with fewer in-line connections, see Annex A.1 to determine operating distance.". In note 2, deleted "and shall not exceed -4 dBm for any fiber" from the end. In note 6, changed "…shown is under study and may change" to "…shown may change".** (Thanks to Quentin Tan of Optobahn for supplying the information to generate table 5.)
10. In 8, changed "Note that there is a half-twist when viewing the cable from the optical transmitter, through any intermediate connectors or patch panels to the optical receiver…" to "Note that…".
11. In 8.1, changed "…table 4…" to "…tables 4 and 5…".
12. In 8.2, changed "…table 4…" to "…tables 4 and 5…".
13. In 9, added "as shown in figure 4" in the middle of the paragraph.

14. Added the connector drawing as supplied by John Keesee of US Connect.
15. Added Annex B, "Optical modulation amplitude measurement technique", as supplied by Dan Brown of AMP.

Contents

Tables

Figures

Annexes

Foreword (This foreword is not part of American National Standard X3.xxx-199x.)

This American National Standard specifies a media-level, point-to-point, 12-channel, full-duplex, electrical / optical interface, with each channel operating at 1 Gbit/s. Multimode (MM) ribbon fiber and single mode (SM) ribbon fiber are used for distances up to 300 m and 10 km respectively. Differential signals are used on the electrical side.

This standard specifies an optical interface for HIPPI-6400 systems, that may also be used with other systems.

Requests for interpretation, suggestions for improvement or addenda, or defect reports are welcome. They should be sent to the National Committee for Information Technology Standards, 1250 Eye Street, NW, Suite 200, Washington, DC 20005.

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

(List of NCITS members to be included in the published standard by the ANSI Editor.)

Subcommittee T11 on Device Level Interfaces, which reviewed this standard, had the following participants:

(List of T11 Committee members, and other active participants, at the time the document is forwarded for public review, will be included by the Technical Editor.)

Task Groups T11.1 on the High-Performance Parallel Interface, and T11.2 on Physical Variants, which jointly developed this standard, had the following participants:

(List of T11.1 Task Group members, and active participants, at the time the document is forwarded for public review will be included by the Technical Editor.)

(List of T11.2 Task Group members, and active participants, at the time the document is forwarded for public review will be included by the Technical Editor.)

American National Standard for Information Technology –

High-Performance Parallel Interface – 6400 Mbit/s Optical Specification (HIPPI-6400-PH)

1 Scope

This American National Standard specifies a media-level, point-to-point, 12-channel, full-duplex, electrical / optical interface, with each channel operating at 1 Gbit/s. Multimode (MM) ribbon fiber and single mode (SM) ribbon fiber are used for distances up to 300 m and 10 km respectively. Differential signals are used on the electrical side.

Specifications are included for:

– 12 separate full-duplex channels, each capable of 1 Gbit/s operation;

– operating distances of up to 300 m over multimode fiber, and 10 km over single mode fiber respectively;

– the fiber media and connectors;

– the optical signals, including eye-safety considerations;

– the differential electrical signals;

– an overall channel-to-channel skew specification.

A HIPPI-6400-OPT interface may be included with other electronic components on a printed circuit board, or may be fabricated as a plug-in daughter board. HIPPI-6400-OPT does not mandate a specific connector on the electrical side.

2 Normative references

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

Copies of the following documents can be obtained from ANSI: Approved ANSI standards, approved and draft international and regional standards (ISO, IEC, CEN/CENELEC, ITUT), and approved and draft foreign standards (including BSI, JIS, and DIN). For further information, contact ANSI Customer Service Department at 212-642-4900 (phone), 212-302-1286 (fax) or via the World Wide Web at http://www.ansi.org. Additional availability contact information is provided below as needed.

2.1 Approved references

ANSI/TIA/EIA 455-34A-1995 - FOTP-34, *Fiber Optics Interconnection Device Insertion Loss Test* (revision and redesignation of ANSI/TIA/EIA 455-34A-1990 (R1995))

ANSI/EIA/TIA 455-107-1989 - FOTP-107, *Return Loss for Fiber Optic Components*

ANSI/EIA/TIA 455-127-1991 - FOTP-127, *Spectral Characterization of Multimode Lasers*

ANSI/TIA/EIA 568-A-1995 - *Commercial Building Telecommunications Cabling Standard* (revision and redesignation of ANSI/EIA/TIA 568-1991)

ANSI/EIA/TIA 492AAAA-1989 - D*etail Specification for 62.5µm Core Diameter/125-µm Cladding Diameter Class 1a Multimode Graded-Index Optical Waveguide Fibers*

ANSI/EIA 526-3-1989 - OFSTP-3, *Fiber Optic Terminal Equipment Receiver Sensitivity and Maximum Receiver Input*

ANSI/TIA/EIA 526-4-1995 - OFSTP-4, *Optical Eye Pattern Measurement Procedure*

ANSI/EIA/TIA 526-11-1991 - OFSTP-11, *Measurement of Single-Reflection Power Penalty for Fiber Optic Terminal Equipment*

ANSI/EIA/TIA 526-14-1990 - OFSTP-14, *Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant*

Food and Drug Administration (FDA) / Department of Health and Human Services (DHHS) Regulations 21 CFR Chapter I, Subchapter J, Part 1040.10, Performance standards for light-emitting products

ISO/IEC 825-1:1993, Safety of laser products – Part 1: Equipment classification, requirements and user's guide.

ISO/IEC 825-2:1993, Safety of laser products – Part 2: Safety of optical fibre communications systems.

ISO/IEC 1754-7, Fibre Optic Connector Interfaces - Type MPO Connector Family

JIS C 5973 - FO4 Type Connectors for Optical Fiber Cards

2.2 References under development

At the time of publication, the following referenced standards were still under development. For information on the current status of the document, or regarding availability, contact the relevant standards body or other organization as indicated. For information about obtaining copies of this document or for more information on the current status of the document, contact National Committee for Information Technology Standards, 1250 Eye Street, NW, Suite 200, Washington, DC 20005, 202-626-5746.

ANSI X3.xxx-199x, High-Performance Parallel Interface – 6400 Mbit/s Physical Layer (HIPPI-6400-PH)

IEEE Draft P802.3z/D3.1Supplement to Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method & Physical Layer Specifications

3 Definitions and conventions

3.1 Definitions

For the purposes of this standard, the following definitions apply.

3.1.1 attenuation: The transmission medium power loss expressed in units of dB.

3.1.2 average power: The optical power measured using an average reading power meter when transmitting a specified code sequence as defined in the test procedure.

3.1.3 bandwidth: Maximum effective transfer rate for all of the channels.

3.1.4 Baud: The signaling speed in transitions per second.

3.1.5 bit error rate (BER): The statistical probability of a transmitted bit being erroneously received in a communication system. The BER is measured by counting the number of erroneous bits received and dividing by the total number of bits transmitted.

3.1.6 cable plant: All passive communications elements (e.g., optical fiber, connectors, splices, etc.) between a transmitter and a receiver.

3.1.7 center wavelength (laser): The nominal value of the central wavelength of the operating, modulated laser. This is the wavelength (see FOTP-127) where the effective optical power resides.

3.1.8 channel: The path for a single signal of a parallel word.

3.1.9 connector: An optical connector which connects the media to the transmitter or receiver. The connector consists of a receptacle and a plug.

3.1.10 disparity: The difference between the number of ones and zeros in a channel.

3.1.11 dispersion: A term used to denote pulse broadening and distortion. The two general categories of dispersion are modal dispersion, due to the difference in the propagation velocity of the propagation modes in a multimode fiber, and chromatic dispersion, due to the difference in propagation of the various spectral components of the optical source.

3.1.12 electrical fall time: The time interval for the falling edge of an electrical pulse to transition from its 80% amplitude level to its 20% amplitude level.

3.1.13 electrical rise time: The time interval for the rising edge of an electrical pulse to transition from its 20% amplitude level to its 80% amplitude level.

3.1.14 extinction ratio: The ratio (in dB) of the average optical energy in a logic one level to the average optical energy in a logic zero level measured under modulated conditions at the specified baud rate.

3.1.15 eye opening: The time interval across the eye, measured at the 50% normalized eye amplitude which is error free to the specified BER.

3.1.16 fiber optic cable: A jacketed optical fiber or fibers.

3.1.17 fiber optic test procedure (FOTP): EIA/TIA standards developed and published by the Electronic Industries Association (EIA) and Telecommunications Industry Association (TIA) under the EIA-RS-455 series of standards.

3.1.18 intersymbol interference: The effect on a sequence of symbols in which the symbols are distorted by transmission through a limited bandwidth medium to the extent that adjacent symbols begin to interfere with each other.

3.1.19 jitter: Deviations from the ideal timing of an event which occur at high frequencies. Jitter is customarily subdivided into deterministic and random components.

3.1.20 jitter, deterministic (DJ): Timing distortions caused by normal circuit effects in the transmission system. Deterministic jitter is often subdivided into duty cycle distortion (DCD) caused by propagation differences between the two transitions of a signal and data dependent jitter (DDJ) caused by the interaction of the limited bandwidth of the transmission system components and the symbol sequence.

Open Issue – The jitter of the parallel signals has been proposed as the jitter in a single channel plus the jitter in the CLOCK signal. This needs to be firmed up.

3.1.21 jitter, random (RJ): Jitter due to thermal noise which may be modeled as a Gaussian process. The peak-to-peak value of RJ is of a probabilistic nature and thus any specified value yields an associated BER.

Open Issue – We need to make sure that the jitter definition matches the Jitter and PWD in the specification..

3.1.22 laser chirp: A phenomenon in lasers where the wave-length of the emitted light changes during modulation.

3.1.23 mode-partition noise: Noise in a laser based optical communication system caused by the changing distribution of laser energy partitioning itself among the laser modes (or lines) on successive pulses in the data stream. The effect is a different center wavelength for the successive pulses resulting in arrival time jitter attributable to chromatic dispersion in the fiber.

3.1.24 numerical aperture: The sine of the radiation or acceptance half angle of an optical fiber, multiplied by the refractive index of the material in contact with the exit or entrance face.

3.1.25 open fiber control (OFC): A safety interlock system that controls the optical power level on an open optical fiber cable.

3.1.26 optical fall time: The time interval required for the falling edge of an optical pulse to transition between the 80% and 20% levels of the signal amplitude.

3.1.27 optical fiber: Any filament or fiber, made of dielectric material, that guides light.

3.1.28 optical fiber system test practice (OFSTP): Standards developed and published by the EIA/TIA under the EIA/TIA-526 series of standards.

3.1.29 optical passive loss: The insertion loss resulting from connections (connectors or splices), and attenuation attributable to the fiber cable plant.

3.1.30 optical rise time: The time interval required for the rising edge of an optical pulse to transition between the 20% and 80% levels of the signal amplitude.

3.1.31 optical return loss (ORL): The ratio (expressed in units of dB) of optical power incident upon a component port or an assembly to the optical power reflected by that component when that component or assembly is introduced into a link or system.

3.1.32 optical system penalty: A link penalty to account for those effects other than optical passive loss.

3.1.33 optional: Characteristics that are not required by HIPPI-6400-OPT. However, if any optional characteristic is implemented, it shall be implemented as defined in HIPPI-6400-OPT.

3.1.34 plug: The cable half of the interface connector.

3.1.35 receiver: An electronic circuit (Rx) that converts an optical signal to an electrical logic signal.

3.1.36 receiver overload: The maximum acceptable value of the received average optical power at the receiver input to achieve a BER < 10^{-12}.

3.1.37 receiver sensitivity: The minimum acceptable value of the optical modulation amplitude at the receiver input to achieve a BER < 10^{-12}.

3.1.38 receptacle: The fixed or stationary half of the interface connector which is part of the transmitter or receiver.

3.1.39 relative intensity noise (RIN): Laser noise in dB/Hz measured relative to the average optical power.

3.1.40 return loss: See optical return loss.

3.1.41 run length: Maximum number of consecutive identical bits in the transmitted signal e.g., the pattern 0011111010 has a run length of five (5).

3.1.42 running disparity: A binary parameter indicating the cumulative Disparity (positive or negative) of all previously issued bits.

3.1.43 spectral width (RMS): The weighted root mean square width of the optical spectrum (see FOTP-127).

3.1.44 transmitter: An electronic circuit (Tx) that converts an electrical logic signal to an optical signal.

3.2 Editorial conventions

In this standard, certain terms that are proper names of signals or similar terms are printed in uppercase to avoid possible confusion with other uses of the same words (e.g., CLOCK). Any lowercase uses of these words have the normal technical English meaning.

A number of conditions, sequence parameters, events, states, or similar terms are printed with the first letter of each word in uppercase and the rest lowercase (e.g., Block, Source). Any lowercase uses of these words have the normal technical English meaning.

In the case of conflict between figure, table, and text, the text takes precedence. Exceptions to this convention are indicated in the appropriate clauses.

The word *shall* when used in this American National standard, states a mandatory rule or requirement. The word *should* when used in this standard, states a recommendation.

3.3 Acronyms and other abbreviations

Abbreviations, acronyms and symbols applicable to this American National Standard are listed. Definitions of several of these items are included in 3.1

BER	Bit Error Rate
dB	decibel
dBm	decibel (relative to 1 mw power)
DJ	deterministic jitter
EIA	Electronic Industries Association
FOTP	fiber optic test procedure
Gb/s	gigabit per second
Hz	Hertz = 1 cycle per second
km	kilometer
LOL	loss of light
m	meter
Mb/s	megabit per second
MBd	mega Baud
ms	millisecond
µs	microsecond
MM	multimode
n/a	not applicable
ns	nanosecond
OFC	open fiber control
OFSTP	optical fiber system test practice
ORL	optical return loss
ppm	parts per million
ps	picosecond
RIN	relative intensity noise
RJ	random jitter
RMS	root mean square
Rx	receiver
s	second
SM	single mode
SW	short wavelength
Tx	transmitter
UI	unit interval = 1 bit period

3.4 Symbols

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

@	at
Ω	Ohm
µ	micro (e.g., µm = micrometer)

4 System overview

This clause provides an overview of the structure, concepts, and mechanisms in HIPPI-6400-OPT.

Figure 1 shows an example HIPPI-6400-OPT system with 12 channels in each direction. Figure 2 shows the details of one direction of a full-duplex signal path.

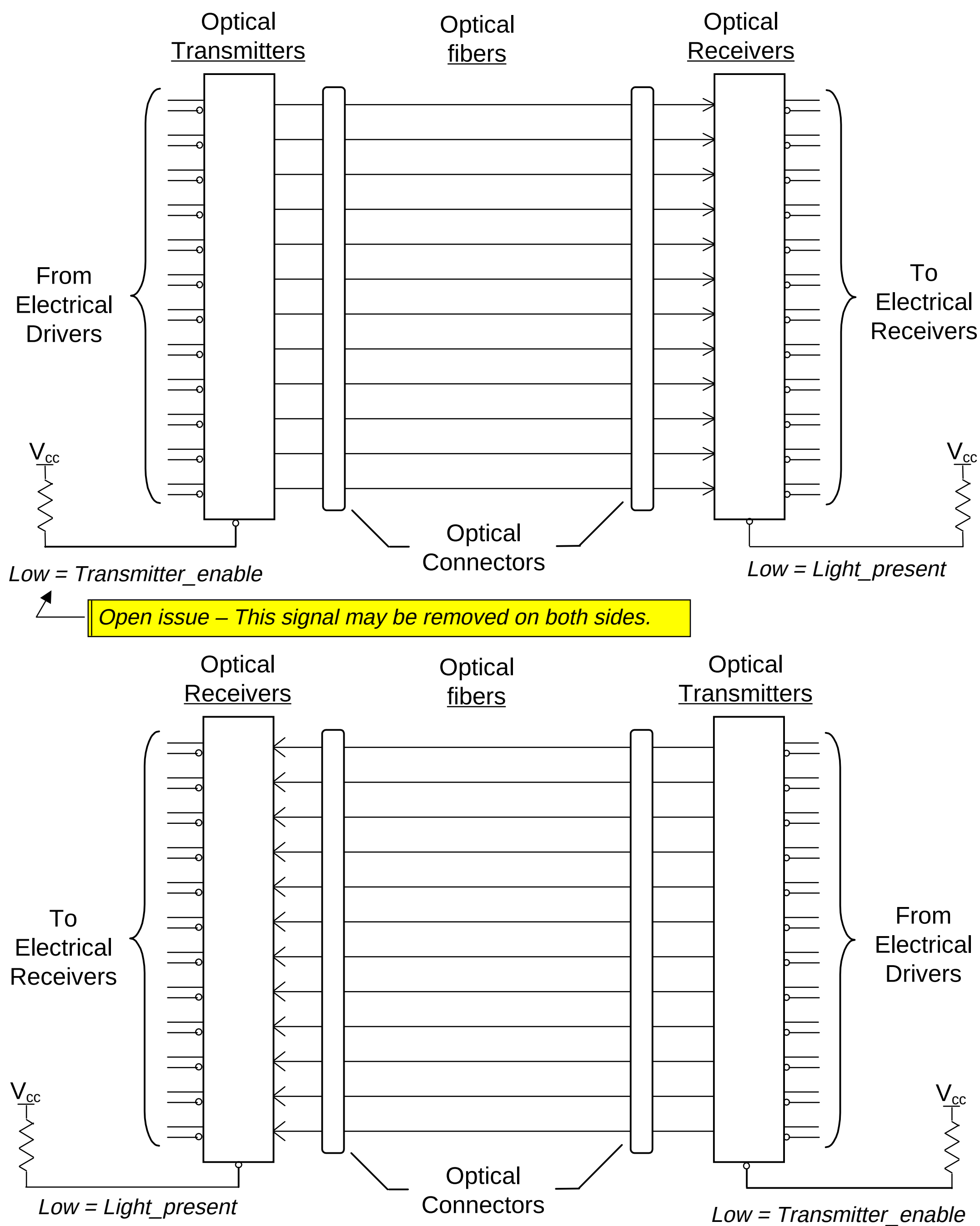

Figure 1 – System block diagram

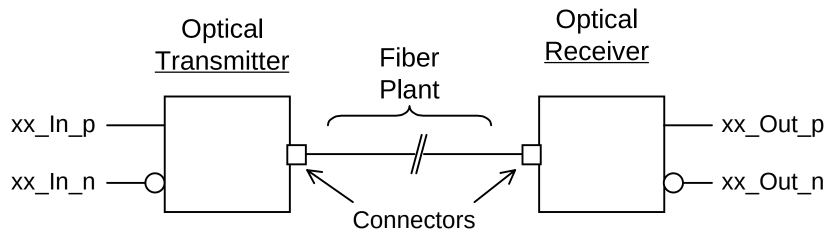

Figure 2 – Details of one direction of a full-duplex signal path

5 Electrical interface

5.1 Signal characteristics

The signals transmitted through each channel shall be dc balanced with a maximum run length of 20 bits with a maximum disparity of 20. (See HIPPI-6400-PH, clauses 10 and 11 for representative waveforms and data coding.)

5.2 Optical transmitter electrical interface

The timing for the optical transmitter's input signals shall be as specified in table 1, and shall be measured at the optical transmitter's input pins.

Differential signals shall be used on all input signal lines, except for the Transmitter_enable signal. Differential signals in the 'true' or '1' state shall have the xx_In_p pins more positive than the xx_In_n pins with a peak-to-peak value within the voltage range specified in table 2 for the transmitter input voltage. The corresponding transmitted optical signal shall be 'true' or '1' = 'light-on'. Electrical rise and fall times shall be measured at the 20% and 80% points of the peak-to-peak signal transition. All parameters shall be measured at the optical transmitter's input pins.

The Transmitter_enable signal, pulled low to a value of +TBD - +TBD V with a current of ≤ TBD mA shall enable light to be driven from all channels of the optical transmitter. When the Transmitter_enable signal is allowed to float high to a value of +TBD - +TBD V, only one channel of the optical transmitter may transmit light.

Open Issue – The enable signal text is still very preliminary and is subject to change.

5.3 Optical receiver electrical interface

A 'light-on' received optical signal shall indicate 'true' or '1'. The corresponding differential electrical signal shall have the xx_Out_p pin more positive than the xx_Out_n pin. Differential signals shall be used on all electrical signals from the optical receiver except for the "Light-present" signal. The optical receiver electrical output signals shall be as specified in table 3. Rise and fall times, at the optical receiver's output pins, shall be measured differentially at the 20% and 80% points of the peak-to-peak signal transition when driving a test load consisting of a 50 Ω transmission line, Thevenin terminated to Vtt/2 using a 50 Ω equivalent. All parameters shall be measured at the optical receiver's electrical output pins.

A no-light condition on the monitored signal for a period of at least TBD ms shall be indicated by no current in the Light_present signal line, allowing it to float to a value of +TBD - +TBD V. Pulling the activity monitor input to a value of +TBD - +TBD V, with a maximum current of TBD mA, shall indicate light present.

Open Issue – The Light_present signal text is still very preliminary and is subject to change.

Table 1 – Optical transmitter input signal timing

Parameter	Value	Units	Comments
CLOCK signal			
Period	2	ns	
Tolerance	± 0.4	ps	± 0.02% or 200 ppm
Duty Cycle	50	%	Nominal, except during a Training sequence
Tolerance	± 0.8	%	i.e., 49.2% to 50.8%
T_{PWD}	32	ps	peak-to-peak pulse width distortion during a Training sequence
T_{JITTER}	30	ps	peak-to-peak jitter
Other signals			
Baud Period	1	ns	
T_{PWD}	32	ps	peak-to-peak pulse width distortion
T_{JITTER}	62	ps	peak-to-peak jitter

Table 2 – Optical transmitter electrical input signals

Parameter	Max.	Typical	Min.	Units	Comments
V_{IN}	1000		200	mVp-p	Input voltage swing
T_R and T_F	250	135	90	ps	At 20% and 80% points into test load
Bit Rate			1000	MBd	Bit Rate
Imbalance	40			ps	Within pair skew
Absolute maximum input voltage					
V_{in}	3400		-700	mV	Input voltage limits
Input signal timing					
Channel skew	500			ps	Total pair-to-pair skew
NOTE – All measurements, except for T_R and T_F, are single-ended rather than differential.					

Table 3 – Optical receiver electrical output signals

Parameter	Max.	Typical	Min.	Units	Comments
Input signal parameters					
V_{OUT}	2700	-	200	mVp-p	Output voltage swing
T_R and T_F	400			ps	At 20% and 80% points into test load
NOTE – All measurements, except for T_R and T_F, are single-ended rather than differential.					

6 Open fiber control safety system

This clause is a place holder in the event that we include OFC in the specification.

7 Optical specifications

This clause defines the optical signal characteristics at the interface connector receptacle. Each conforming optical attachment shall be compatible with this optical interface to allow interoperability within an environment. The BER of each channel shall not exceed 10^{-12} under any conditions. The parameters specified in this clause support meeting that requirement under all conditions including the minimum input power level. All transmitter and receiver parameters for each channel must be met when all channels are active. The corresponding cable plant specifications are described in clause 8.

7.1 Optical output interface

The maximum and minimum of the allowed range of average transmitter power coupled into the fiber are worst-case values to account for manufacturing variances, drift due to temperature variations, aging effects, and operation within the specified minimum value of the optical modulation amplitude.

For purposes of specifying a parallel optical link, the concept of extinction ratio has been replaced with optical modulation amplitude. Optical modulation amplitude is defined as the difference in optical power between a logic-1 and logic-0. Specifying a minimum optical modulation amplitude ensures that given the specified link power budget, sufficient AC signal swing will be present at the receiver input to maintain adequate signal to noise ratio and allow reliable link operation.

The benefit of specifying optical modulation amplitude is that it removes the difficulties associated with maintaining some minimum value of extinction ratio across a laser array over all conditions (temperature, power supply voltage, etc.)

The transmitted signal must not only meet eye opening requirements, but also overshoot and undershoot limitations. These parameters specifying the (normalized) mask are shown in figure 3.

Open Issue – We need to define the eye mask test conditions, probably in an informative annex.

Open Issue – The eye mask values are preliminary and may change.

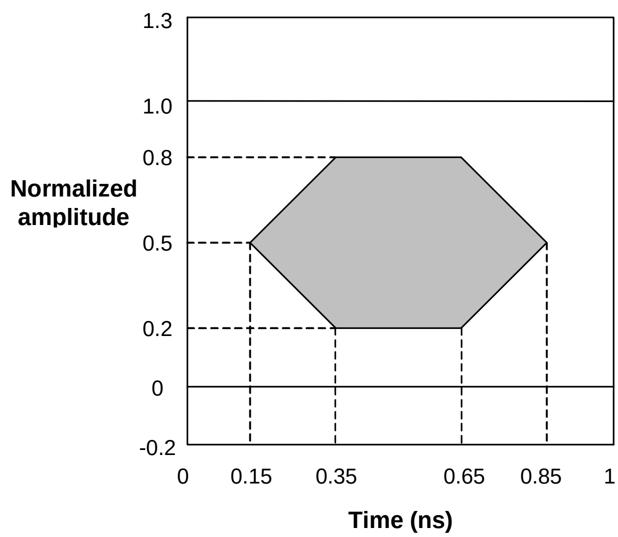

Figure 3 – Eye mask

7.2 Optical input interface

Each channel's receiver shall operate at a BER of $\leq 10^{-12}$ over the link's lifetime and temperature range when the input power falls within the range given in table 4 and when driven by a data stream output that fits the specified eye diagram mask through a cable plant as specified in clause 8.

Receiver characteristics specified in this document are receiver sensitivity, overload, reflectance, and the allowable power penalty from the combined effects of dispersion, reflections, and jitter.

Table 4 – 850 nm optical parameters

Parameter	Value	Units
Data link		
Channel count	12	
Nominal Baud rate (per channel)	1000	MBaud
User data rate (per channel)	800	Mbit/s
Bit error rate (per channel)	$\leq 10^{-12}$	
Optical passive loss	***TBD*** [6]	dB
Optical system penalty	***TBD*** [6]	dB
Total link power budget (min.)	6	dB
Operating distance [1]	***TBD*** [6]	meters
Transmitter		
Wavelength (min.)	830	nm
Wavelength (max.)	860	nm
Spectral width (max.)	0.85	nm RMS
Avg. launched power (max. per channel)	note 2	dBm
Optical modulation amplitude (min. per channel)	0.125	mW
Eye opening (min.) [3]	0.57	UI
Relative intensity noise (max.)	-116	dB/Hz
Optical rise/fall time (max.) [4]	260	ps
Channel-to-channel skew [5]	500	ps
Receiver		
Received optical modulation amplitude (min.)	0.031	mW
Avg. received power (max.)	-4	dBm
Receiver return loss (min.)	12	dB
Eye opening (min.) [3]	***0.3*** [6]	UI
Electrical rise/fall time (max.) [4]	400	ps
Channel-to-channel skew [5]	500	ps
Optical path		
Fiber core diameter	62.5	µm
Worst case modal bandwidth	***TBD*** [6]	MHz*km
Interchannel skew (max.)	5	ns
Recommended connector	MPO	

NOTES –

1 – Operating distance calculated with 2.6 dB connection loss. For systems with fewer in-line connections, see Annex A.1 to determine operating distance.

2 – Max. average coupled power must conform to IEC requirements for Class 3a laser product and CDRH CFR 21 Ch. 1 (J) Part 1040.1 requirements for Class 1 laser product and shall not exceed -4 dBm for any fiber.

3 – at BER $\leq 10^{-12}$

4 – Specified at 20% and 80% points

5 – Transmitter or receiver contribution to channel-to-channel skew. Does not include contribution due to jitter and duty cycle distortion.

6 – An open issue, the value shown is under study and may change.

Table 5 – 1300 nm optical parameters

Parameter	MM value	SM value	Units
Data link			
Channel count	12	12	
Nominal Baud rate (per channel)	1000	1000	MBaud
User data rate (per channel)	800	800	Mbit/s
Bit error rate (per channel)	$\leq 10^{-12}$	$\leq 10^{-12}$	
Optical passive loss	2.5	7	dB
Total link power budget (min.)[6]	6	8	dB
Operating distance [1]	300	10,000	meters
Transmitter			
Wavelength (min.)	1260	1260	nm
Wavelength (max.)	1360	1360	nm
Spectral width (max.)	4	4	nm RMS
Launched power (max. per channel)[2,6]	-8	-8	dBm
Extinction ratio[6]	6	6	dB
Eye opening (min.) [3]	0.57	0.57	UI
Relative intensity noise (max.)	-122	-122	dB/Hz
Optical rise/fall time (max.) [4]	260	260	ps
Channel-to-channel skew [5]	500	500	ps
Receiver			
Dynamic range (min.)[6]	10	12	dB
Sensitivity (max.)[6]	-18	-20	dBm
Receiver return loss (min.)	12	12	dB
Eye opening (min.) [3]	0.3	0.3	UI
Electrical rise/fall time (max.) [4]	400	400	ps
Channel-to-channel skew [5]	500	500	ps
Optical path			
Fiber core diameter	62.5	9.5	µm
Worst case modal bandwidth	500	10,000	MHz*km
Interchannel skew (max.)[5]	5	5	ns
Recommended connector	MPO	MPO	

NOTES –
1 – Operating distance calculated with 2 dB connection loss.
2 – Max. average coupled power must conform to IEC requirements for Class 3a laser product and CDRH CFR 21 Ch. 1 (J) Part 1040.1 requirements for Class 1 laser product.
3 – at BER $\leq 10^{-12}$
4 – Specified at 20% and 80% points
5 – Transmitter or receiver contribution to channel-to-channel skew. Does not include contribution due to jitter and duty cycle distortion.
6 – An open issue, the value shown may change.

The minimum optical modulation amplitude and maximum average received power give the input power range to maintain a BER ≤ 10^{-12} per channel. These values take into account power penalties caused by the use of a transmitter with a worst-case combination of transmitter spectral characteristics, optical modulation amplitude, maximum average power, and pulse shape characteristics.

The total link power budget (in dB) is determined from the sum of the optical system penalty and the optical passive loss in the link. The optical system penalty accounts for total degradation along the optical path resulting from the combined effects of RIN, jitter, intersymbol interference, mode partition noise, and modal noise. The optical passive loss accounts for the insertion loss resulting from connections (connectors or splices), and attenuation attributable to the fiber cable plant.

A unique power penalty consideration for laser data links on multimode fiber is mode selective loss. Refer to annex E for design considerations related to mode selective loss.

Open Issue – Do we need to include an annex that is the equivalent to FC-PH 4.3 annex E?

The minimum acceptable value for receiver sensitivity shall equal the values specified in table 4. In addition, the receiver shall be designed to accommodate the maximum received power and the optical rise/fall time at the input to the receiver.

Open Issue – 7.1 & 7.2 need to include additional text describing considerations for skew and jitter for the transmitter, receiver, and entire link. Additional information on managing the link timing budget would also be appropriate.

8 Optical fiber cable plant

The optical fiber for a link shall consist of ribbons of 12 fibers in each direction. The optical fibers shall conform to EIA/TIA 492AAAA. Table 6 specifies the cable termination. Note that pin 1 at one end connects to pin 12 at the other end.

8.1 Modal bandwidth

The modal bandwidth, as specified in tables 4 and 5, shall be the worst case modal bandwidth, measured according to the methods of IEEE 802.3z. Worst case modal bandwidth is defined as the lowest bandwidth that may occur in a fiber under reasonable launch conditions.

In practice, worst case modal bandwidth is used to account for differences in multimode fiber bandwidth that may occur under restricted launch conditions relative to bandwidth observed using an overfilled launch condition.

8.2 Cable plant loss budget

The loss budget shall be no more than specified in tables 4 and 5. The loss of the fiber plant shall be verified by the methods of OFSTP-14A.

8.3 Optical return loss

The fiber plant optical return loss, with the receiver connected, shall be ≥ 12 dB. The receiver shall have a return loss ≥ one glass-air interface. Connectors and splices shall each have a return loss ≤ 20 dB as measured by the methods of FOTP-107.

Open Issue – We need to verify FOTP-107.

Table 6 – Optical media connector layout

Transmit side			Receive side	
HIPPI-6400 signal name	**Connector pin**	**Channel number**	**Connector pin**	**HIPPI-6400 signal name**
CLOCK_Out	1	1	12	CLOCK_In
D00_Out	2	2	11	D00_In
D01_Out	3	3	10	D01_In
D02_Out	4	4	9	D02_In
D03_Out	5	5	8	D03_In
D04_Out	6	6	7	D04_In
D05_Out	7	7	6	D05_In
D06_Out	8	8	5	D06_In
D07_Out	9	9	4	D07_In
C0_Out	10	10	3	C0_In
C1_Out	11	11	2	C1_In
FRAME_Out	12	12	1	FRAME_In

9 Optical interface connector

The primary function of the optical interface connector is to align the optical transmission fiber mechanically to an optical port on a component such as a transmitter or receiver, and to interconnect two fiber ribbons. The parent connector for the Type MPO connector family, as specified in IEC 1754-7, is a multiway plug connector characterized by a rectangular ferrule normally 6.4 X 2.5 mm which utilizes two pins of 0.7 mm diameter for alignment. The connector, as shown in figure 4, includes a push-pull coupling mechanism and a ferrule spring loaded in the direction of the optical axis. Connector interfaces are configured using a female plug without pins, a male plug with two fixed pins, and an adapter. The female plug mates with the male plug.

NOTE – In the U.S.A., the connector is also known as the MTP connector, and is available from several vendors.

Note that in this clause and figures only unique HIPPI-6400 dimensions are provided. All others are in the referenced IEC 1754-7 standard for type MPO connector family. HIPPI-6400-OPT uses the 12 fiber version of the MPO connector.

9.1 Optical receptacle

The optical receptacle shall consist of a female plug conforming to IEC 1754-7-1, MPO Female Plug Connector Interface - Push/Pull.

9.2 Optical plug

The optical plug shall consist of a female plug conforming to IEC 1754-7-2, MPO Male Plug Connector Interface - Push/Pull.

Open Issue – The text in 9.1 and 9.2 is preliminary. Dan Schwartz has an action item to draft new text.

9.3 Adapter

An adapter conforming to IEC 1754-7-3, MPO Adaptor Interface - Push/Pull, shall be used to connect a male plug to a female plug.

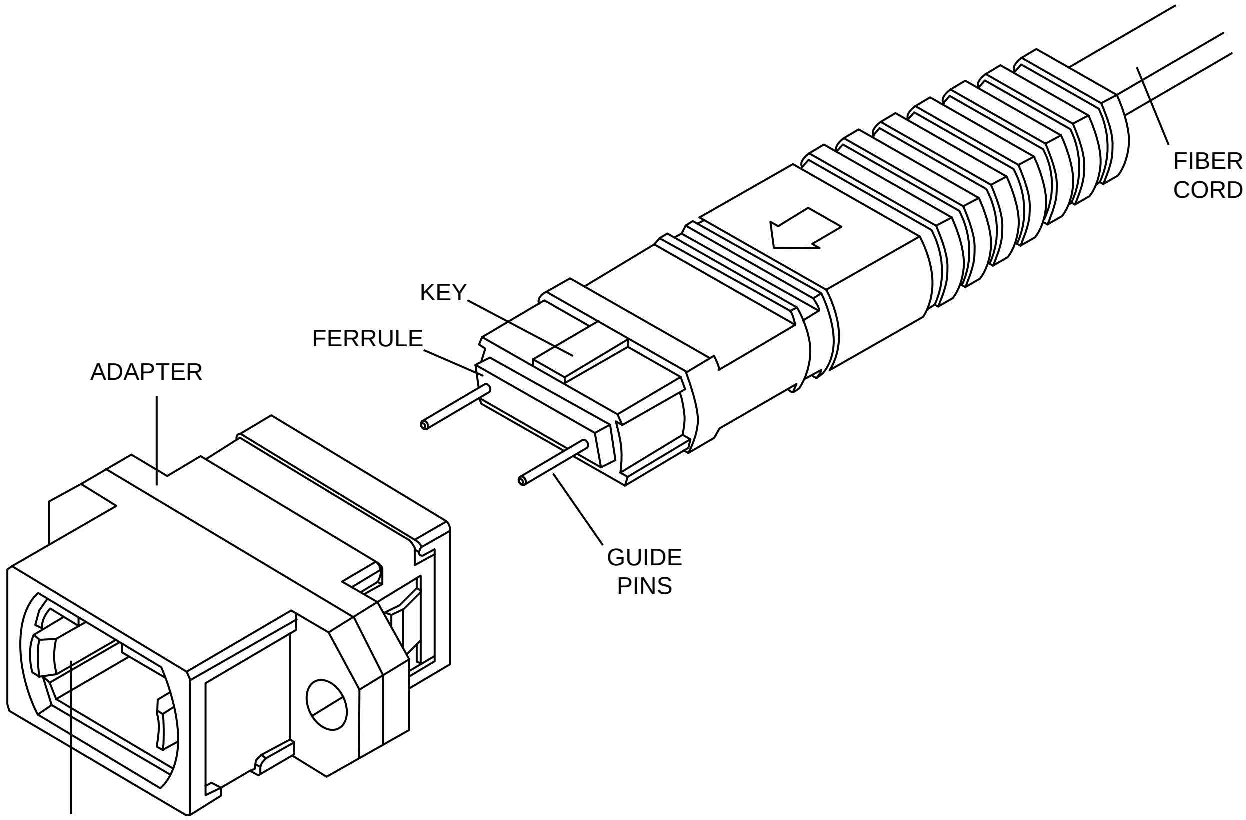

Figure 4 – MTP connector

Annex A
(informative)

Relevant information

A.1 Connection loss

The allowable link operating distance is specified as a function of total connection loss in table A.1. This table allows the link length to be determined as a function of the total loss resulting from connectors and splices in the link. As the number of connections is reduced, link length can be extended since a larger portion of the link power budget is made available to allow for fiber attenuation and the optical system penalty resulting from link bandwidth limitations.

Table A.1 – Operating distance vs. connection loss

Total connection loss (dB)	Operating distance (m)
0.00	TBD
0.50	TBD
1.00	TBD
1.50	TBD
2.00	TBD
2.50	TBD
3.00	TBD

NOTES –

1 – Connection loss is part of the optical passive loss. It is defined as the combined insertion loss in the link resulting from connectors or splices.

2 – Operating distance calculated using 'TBD' MHz*km worst case modal bandwidth.

Open Issue – This annex would also be a good place to include a description of how to calculate connection loss (using statistical analysis) and examples (similar to Serial HIPPI Annex B.5).

Open Issue – We need an annex describing test methods for channel-to-channel skew, jitter, and optical modulation amplitude.

Annex B
(informative)[DT1]

Optical modulation amplitude measurement technique

Optical modulation amplitude is defined as the difference in optical power between a logic-1 and a logic-0. The recommended technique for measuring optical modulation amplitude requires test equipment with the following minimum requirements:

– an oscilloscope with 500 MHz bandwidth (minimum)

– a signal generator capable of supplying a 100 MHz square wave with rise and fall characteristics compliant with HIPPI-6400-OPT transmitter requirements.

– optical to electrical converter with 500 MHz minimum bandwidth. The O/E converter shall be calibrated at the appropriate wavelength for the transmitter under test.

– a 4th order Bessel-Thompson filter with a 3dB bandwidth of 797 MHz (optional).

While supplying the optical transmitter with 100 MHz square wave, use the following procedure to measure optical modulation amplitude:

a Configure the test equipment as illustrated in Figure B.1 such that the O/E converter is used as a front end for the oscilloscope input electrical channel.

b With a valid waveform displayed on the oscilloscope, place the first cursor at the mean voltage level of the logic “1” as defined over the center 20% of the time interval which the laser is in the high state. (see Figure B.2)

c Place the second cursor on the mean voltage level of the logic “0” as defined over the center 20% of the time interval which the laser is in the low state.

d Measure and record the voltage difference between the two cursors.

e Calculate the optical modulation amplitude by multiplying the voltage difference by the conversion gain of the O/E converter at the wavelength of the laser source.

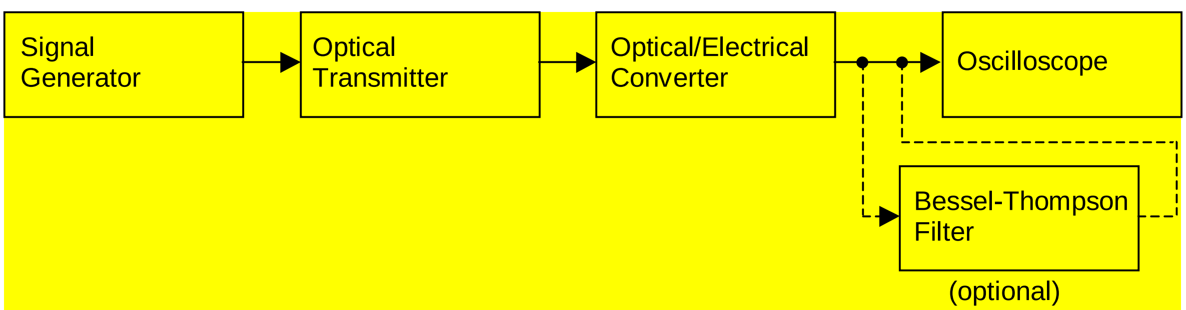

Figure B.1 – Optical modulation amplitude test equipment configuration

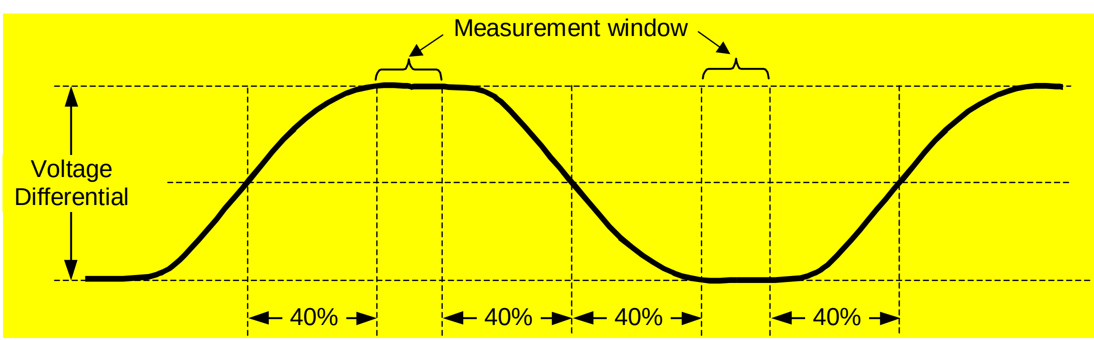

Figure B.2 – Optical modulation amplitude waveform measurement