The ATM Forum
Technical Committee

155 Mbps Plastic Optical Fiber and Hard Polymer Clad Fiber PMD Specification

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1 INTRODUCTION

This specification describes the Physical Medium Dependent (PMD) sublayer for a 155.52 Mbps private User Network Interface (UNI) over Plastic Optical Fiber (POF) and Hard Polymer Clad Fiber (HPCF) cabling. The remaining Physical Layer functions as required by a Transmission Convergence (TC) sublayer are referenced in this specification to existing or in-progress documents from ANSI, ITU-T, or the ATM Forum.

1.1 Scope

This PMD provides the digital baseband point-to-point communication between ATM user devices and ATM premises network equipment. The PMD shall provide all of the services required to transport a suitably coded digital bit stream across the link segment. This PMD sublayer specification assumes an accompanying 155.52 Mbps SONET/SDH based ATM TC sublayer. Operation of other TCs with this PMD is beyond the scope of this specification.

Note: A 50 m POF link is currently under discussion within ANSI TIA/EIA TR41.8.

The PMD sublayer specified in this document has the following general characteristics:

- Provides a means of coupling the SONET/SDH TC physical sublayer to the POF and HPCF link segment by way of the Active Interface.
- Provides a means of transmitting and receiving the optical signal between two active optical interfaces.
- Provides a common 155 Mbps optical interface for POF and HPCF to be used in the private network.

1.2 Glossary of Terms

BER - Bit Error Ratio

FWHM - Full Width Half Maximum

HPCF - Hard Polymer Clad Fiber

LED - Light Emitting Diode

NA - Numerical Aperture

POF - Plastic Optical Fiber

1.3 Transmission Convergence Sublayer Specification

The Transmission Convergence (TC) sublayer deals with Physical Layer aspects which are independent of the transmission medium characteristics. Most of the functions comprising the TC sublayer are involved with the generating and processing of overhead bytes contained in the SONET/SDH frame. Unless otherwise described in this specification, the requirements for the TC functions are as described for the private UNI in the ATM Forum Technical Committee ATM UNI Specification, Version 3.1 Section 2.1.

2 PHYSICAL MEDIUM DEPENDENT (PMD) SUBLAYER

2.1 Optical Fiber Interface

This section specifies a Physical Media Dependent (PMD) sublayer over plastic optical fiber (POF) and hard polymer clad fiber (HPCF) using light emitting diodes (LEDs) operating at 155 Mbps. The POF interface is intended for link lengths of up to 50 m. The HPCF interface is intended for link lengths of up to 100 m.

2.1.1 Optical Fiber

(R) The POF shall be 1000 µm multimode, step index plastic optical fiber as specified in IEC 793-2 section 4 category A4d (NWIP), including test conditions[1].

(R) The HPCF shall be 225 µm multi-mode step index hard polymer clad fiber as specified in IEC 793-2 section 3-category A3d (NWIP), including test conditions.

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[1] (NWIP) New Work Item Proposal indicates that standards are currently under development in the IEC SC86A WG1.

(R) POF and HPCF shall have a minimum modal bandwidth of 10 MHz*km at 650 nm when measured in accordance with IEC 793-1-C2A or IEC 793-1-C2B. The specifications for fiber modal bandwidth include a variation in source numerical aperture and account for the effect of bandwidth degradation to ensure correct system operation.

(R) The maximum attenuation of 50 m POF under the condition of -20 to +70 degrees C and 95% relative humidity shall be 9.1 dB. The maximum attenuation of 100 m HPCF under the condition of -20 to +70 degrees C and 95% relative humidity shall be 1.8 dB. The attenuation shall be measured in accordance with IEC 793-1-C1A or C1B using a nominal 650 nm narrow (< 5 nm FWHM) spectral width light source.

In addition, the fiber loss due to environmental conditions and launch NA is included in the attenuation of 9.1 dB for POF and 1.8 dB for HPCF. The loss increments of 3.4 dB for POF and 0.1 dB for HPCF, shown in Table 1, account for both a source center wavelength shift to 660 nm or 640 nm and the difference between the < 5 nm spectral width of the test source and 40 nm worst case source spectral width. Loss increments of 0.5 dB for POF and 0.1 dB for HPCF due to cable bends are also accounted for as shown in Table 1.

(R) For the condition shown in Table 1, the worst case fiber attenuation for 50 m POF shall be 13 dB and the worst case fiber attenuation for 100 m HPCF shall be 2.0 dB.

Table 1 Worst case loss increments for 50 m POF cable and 100 m HPCF cable

Parameters		Unit	Min.	Max.	Loss Increment	Test Method Reference
Source center wavelength		nm	640	660	POF: 3.4 dB	IEC 793-1-C1A
Source spectral width (FWHM)		nm		40	HPCF: 0.1 dB	
Cable Bends	Radius		25.4		POF: 0.5 dB	(FFS)[2]
	Number of 90 degree bends	mm		10	HPCF: 0.1 dB	(FFS)

[2] (FFS) For Future Study indicates that no standards exist but may be proposed for development.

The POF bend test method reference is proposed to be appended to IEC 794-1-XXX.

2.1.2 Line Code

(R) The optical line coding is binary NRZ. Binary 1 shall be represented as a high light level condition.

2.1.3 Bit Error Ratio

(R) An interface receiver shall operate with a bit error ratio (BER) not to exceed 10^{-10} (1 bit error in 10^{10} bits) when presented with a transmitter signal as specified in section 2.1.4.2 transmitted through a link subject to the system budget constraints specified in 2.1.4.1.

2.1.4 Transceiver Interface

2.1.4.1 System Budget

Proper system performance is ensured by considering the attenuation and modal bandwidth of the optical path and including them as part of the link budget. In addition to these cable plant characteristics, a system power penalty is normally included in the link budget. The power penalty includes the effects of eye closure due to transmitter characteristics (finite rise and fall times, random and systematic jitter). This system power penalty is accounted for in the receiver sensitivity specification; therefore, the system budget is composed entirely of losses due to the cable plant and connectors.

The attenuation range specification for the links were defined based on the use of components meeting the requirements specified in 2.1.1 and 2.1.5 and operating up to 50 meters for POF and up to 100 meters for HPCF. The static attenuation in the optical path includes worst case loss values for the fiber media and connectors. The attenuation range for POF is 0 to 17 dB, of which 4.0 dB is allocated for connectors. The attenuation range for HPCF is 0 to 6.5 dB, of which 4.5 dB is allocated for connectors.

(R) POF links shall have an end-to-end attenuation of 17 dB or less under the worst case conditions shown in Table 1.

(R) HPCF links shall have an end-to-end attenuation of 6.5 dB or less under the worst case conditions shown in Table 1.

2.1.4.2 Transmitter Characteristics

The values prescribed are for worst case operating conditions and end of life; they are to be met over the full range of standard operating conditions, (i.e., voltage, temperature and humidity) and include aging effects. The following parameters are specified for the transmitter.

(R) The center wavelength range shall be from 640 to 660 nm.

(R) The maximum full width half-maximum (FWHM) spectral width shall be 40 nm.

(R) The mean launched power into POF shall be from -8 to -2 dBm.

(R) The mean launched power into HPCF shall be from -20 to -14 dBm.

(R) The source NA shall be from 0.2 to 0.3

(R) The minimum extinction ratio shall be 10 dB.

(R) The transmitter exit rise (fall) time shall be less than 4.5 ns.

(R) The maximum transmitter overshoot shall be 25%.

(R) The systematic interface jitter at the transmitter output shall be less than 1.6 ns.

(R) The random interface jitter at the transmitter output shall be less than 0.6 ns.

2.1.4.3 Receiver Characteristics

The values prescribed are for worst case end of life; they are to be met over the full range of standard operating conditions, (i.e., voltage, temperature and humidity) and include aging effects. The following characteristics are specified for the receiver.

(R) The minimum receiver sensitivity for POF shall be -25 dBm.

(R) The minimum receiver sensitivity for HPCF shall be -26.5 dBm.

(R) The minimum receiver overload for POF shall be -2 dBm.

(R) The minimum receiver overload for HPCF shall be -14 dBm.

(R) The receiver optical input rise (fall) time for POF shall be less than 5.0 ns.

(R) The receiver optical input rise (fall) time for HPCF shall be less than 6.0 ns.

(R) The systematic interface jitter at the receiver input shall be less than 2.0 ns.

(R) The random interface jitter at the receiver input shall be less than 0.6 ns.

(R) The minimum receiver eye opening at a 10E-10 BER shall be 1.23 ns.

The POF and HPCF interface parameters are summarized in Table 2.

Table 2 Optical Parameters for POF and HPCF Interfaces

	POF	HPCF	Unit
Transmitter Interface Characteristics			
Center Wavelength	640 to 660	640 to 660	nm
Maximum Spectral Width (FWHM)	40	40	nm
Mean Launched Power (Note 1)	-8 to -2	-20 to -14	dBm
Source NA	0.2 to 0.3	0.2 to 0.3	
Minimum Extinction Ratio	10	10	dB
Maximum Rise (Fall) Time, (10-90%)	4.5	4.5	ns
Maximum Overshoot	25	25	%
Maximum Systematic Interface Jitter	1.60	1.60	ns
Maximum Random Interface Jitter	0.60	0.60	ns
Receiver Interface Characteristics			
Minimum Receiver Input Power (Note 2)	-25	-26.5	dBm
Minimum Overload	-2	-14	dBm
Maximum Rise (Fall) Time, (10-90%)	5.0	6.0	ns
Maximum Systematic Interface Jitter	2.0	2.0	ns
Maximum Random Interface Jitter	0.60	0.60	ns
Minimum Receiver Eye Opening (Note 3)	1.23	1.23	ns

NOTE 1: The interface specifications for both POF and HPCF fibers are based on the use of a common optical transmitter and receiver. Differences in the optical power budget between HPCF and POF link specifications are due to the fiber core diameter and NA. A 17 dB system budget is specified for POF links and a 6.5 dB budget is specified for HPCF links. The entire system budget is allocated for cable plant losses and connector losses as described in section 2.1.4.1. The interface point for the mean launched power specification is a short length of fiber (e.g. 50 cm) located immediately after the plug of the connector attached to the transmitter receptacle. The connector at this interface point is therefore considered to be part of the equipment and not part of the cable plant.

NOTE 2: The improved minimum receiver input power for the HPCF receiver interface is due to the more efficient optical coupling from the smaller diameter HPCF into the same optical detector to achieve a minimum detected current which yields a BER of 10E-10. The interface point for the minimum receiver input power specification is located between the plug of the connector and the receptacle.

NOTE 3: The receiver eye opening represents the time interval allocated for the clock recovery function after the optical to electrical conversion at the receiver.

2.1.4.4 Jitter

The following jitter specifications apply for the POF and HPCF interface.

(R) The transmit interface jitter shall be as specified in section 2.1.4.2.

(R) The receiver interface jitter shall be as specified in section 2.1.4.3.

The receiver jitter tolerance and the jitter transfer through the interface are for further study. Note that the jitter transfer specification is only applicable when the interface is synchronized to the recovered clock.

2.1.5 Physical media interface

(R) The optical fiber interface should be the PN receptacle and the duplex F07 plug or PN plug and should meet the interface standard, IEC 1754-AA (NWIP) and the performance standard, IEC 1753-BB(FFS). It is presumed that the PN receptacle accepts the PN plug and the duplex F07 plug. An example is shown in figure 1. The performance of the connector shall be tested by a standard test method (FFS)[3]. It is recommended that the network polarity (transmit and receive) be managed in accordance with ANSI/TIA/EIA-568-A. Alternative connector styles are for future study to be defined by the IEC.

(R) The worst case connector insertion loss, including the effect of environmental conditions, shall be less than 1.3 dB for POF and 2.0 dB for HPCF.

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[3] The standard test method for the connector is proposed for development in the IEC.

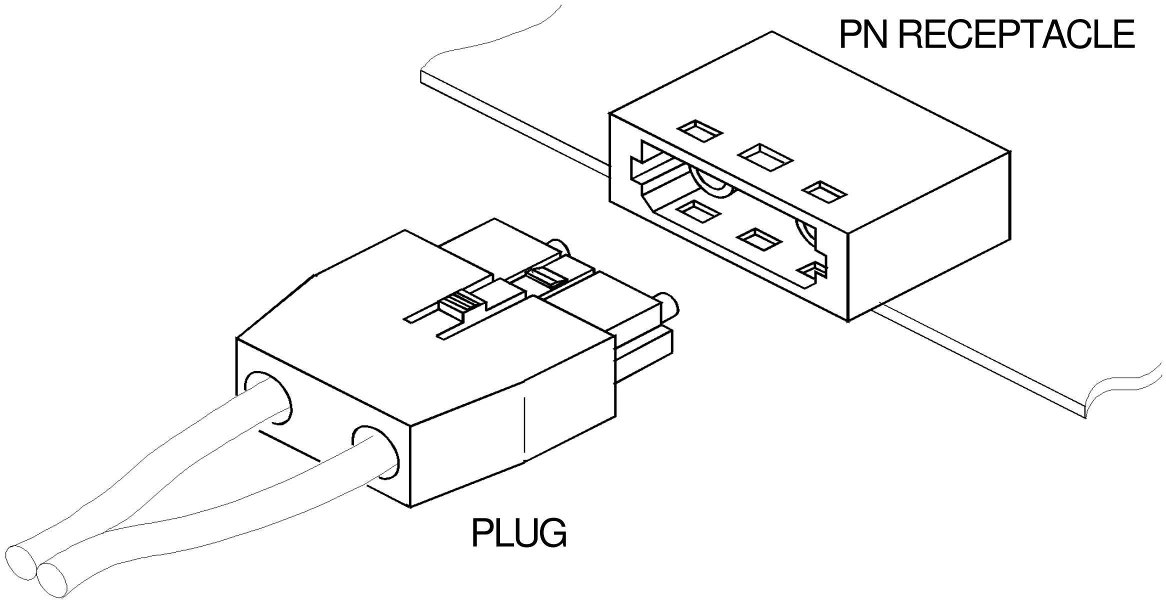

Figure 1 Physical Media Plug and Receptacle Example (F07 Plug shown)