Physical Media Dependent Layers
for 100Mbps – 400Mbps IEEE1394 Long Distance Links

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P1394B
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Source

P1394B S100 TG
POF/HPCF PMD Sub TG

1 Alternative long distance physical media dependent layers

The alternative long distance physical layers specified by this supplement enable distance extention over 50m keeping interoperability with existing IEEE1394-1995 interface as well as in-progress interface of P1394.a at the data rate of 100Mbps, 200Mbps and 400Mbps. Each data rate is covered by following alternatives.

Physical Media Dependent Layer	Data Rate	Baud Rate
POF and HPCF links with 650nm LED	upto 200Mbps	upto 250MBaud
TBD	upto 400Mbps	upto 500MBaud
UTP Category 5	100Mbps	125MBaud

The remarks below apply to external cabling and interface, where extra care must be exercised for safety and EMC compliance.

1.1 Plastic Optical Fiber and Hard Polymer Clad Fiber Links with 650nm Light Emitting Diode

1.1.1 Scope

This clause specifies the physical media dependent (PMD) sublayer of Plastic Optical Fiber (POF) and Hard Polymer Clad Fiber (HPCF) links with 650nm light emitting diode (LED) for the data rate of 100Mbps and 200Mbps. This PMD provides the low cost digital baseband point-to-point interconnection among IEEE1394 equipments for the distance extention over 50m, which was specified as a requirement criteria of IEEE1394 long distance link. HPCF link provides longer distance transmission capability up to 100m, POF link supports 50m minimum transmission distance though. The PMD shall provide all of the services required to transport a suitably coded digital bit stream across the link segment.

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

- Provides a means of converting the IEEE1394-1995 physical layer or in-progress physical layer of P1394.a 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 optical interface for POF and HPCF at each baud rate.
- Provides 100Mbps / 200Mbps dual mode capability for interconnecting 200Mbps interface to 100Mbps interface over common optical cable and connectors during a startup mode.

1.1.2 Cables

The POF shall be 1000 µm step index multimode plastic optical fiber. The HPCF shall be 225 µm graded index multi-mode hard polymer clad fiber.

POF 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. HPCF shall have a minimum modal bandwidth of 25MHz*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.

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 2.7 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 2.7 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.

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 2.9 dB.

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

Parameters		Unit	Min.	Max.	Loss Increment
Source center wavelength		Nm	640	660	POF: 3.4 dB HPCF: 0.1 dB
Source spectral width (FWHM)		Nm		40	
Cable Bend	Radius	Mm	25.4		POF: 0.5 dB HPCF: 0.1 dB

1.1.3 Connectors

The optical connector alternatives are summarized in table 2. The status of performance verification and the standardization in other representative standard body for each connector are shown. The mecanical specifications and figures are listed in Annex 1.

Table 2 Summary of connector alternatives and their status

Connector type	Connection performance verification for POF link	Connection performance verification for HPCF link	Reference standard
PN connector	transceiver to fiber Yes fiber to fiber Yes	transceiver to fiber Yes fiber to fiber Yes	1) IEC 1754-6, 1753-AA 2) ATM Forum Specification AF-PHY-POF155-0079.00
SMI connector	transceiver to fiber No fiber to fiber No	transceiver to fiber No fiber to fiber No	
FJ connector	transceiver to fiber No fiber to fiber Yes	transceiver to fiber No fiber to fiber No	1) TIA/EIA FOCS-6 (ANSI#PN3871, #PN3872) 2) ATM Forum Draft addendum to AF-PHY-POF155-0079.00
OMJ connector	transceiver to fiber No fiber tofiber No	transceiver to fiber No fiber to fiber No	1) IEC603-11 Miniature concentric plugs and jacks (Electrical connector)

1.1.4 Connector and cable assembly performance criteria

The worst case connector insertion loss, including the effect of environmental conditions, shall be less than 2.0 dB for POF and 1.1dB for HPCF.

1.1.5 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 nominal baudrate of 125MBaud and 250MBaud. 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.

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

An interface receiver shall operate with a bit error ratio (BER) not to exceed 10^{-12} (1 bit error in 10^{12} bits) when presented with a transmitter signal as specified in section 1.1.5.2 transmitted through a link subject to the system budget constraints specified in 1.1.5.1.

1.1.5.1 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 1.1.2 and 1.1.4 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 link is 13dB, of which 13 dB is allocated for 50m fiber. The attenuation range for HPCF link is 4.0dB, of which 2.9 dB is allocated for 100m fiber. Both of attenuation ranges are independent of baudrate. The number of connector and transmission length have a trade-off as summarized in table A2-1 of Annex 2.

1.1.5.2 Transceiver Characteristics

The values prescribed in table 3 and table 4 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 and receiver. 250MBaud interface is specified to have a capability of interconnection with 125MBaud interface during the startup mode.

Table 3 Optical Parameters for POF and HPCF Interfaces at 125MBaud

	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	1.6	1.6	ns
Maximum Random Interface Jitter	0.6	0.6	ns
Receiver Interface Characteristics			
Minimum Receiver Input Power (Note 2)	-21	-24	dBm
Minimum Overload	-2	-14	dBm
Maximum Rise (Fall) Time, (10-90%)	5.0	5.0	ns
Maximum Systematic Interface Jitter	1.6	1.6	ns
Maximum Random Interface Jitter	0.6	0.6	ns
Minimum Receiver Eye Opening (Note 3)	1.5	1.5	ns

Table 4 Optical Parameters for POF and HPCF Interfaces at 250MBaud

	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%)	3.0	3.0	ns
Maximum Overshoot	25	25	%
Maximum Systematic Interface Jitter	0.8	0.8	ns
Maximum Random Interface Jitter	0.3	0.3	ns
Receiver Interface Characteristics			
Minimum Receiver Input Power (Note 2)	-21	-24	dBm
Minimum Overload	-2	-14	dBm
Maximum Rise (Fall) Time, (10-90%)	3.5	3.5	ns
Maximum Systematic Interface Jitter	0.8	0.8	ns
Maximum Random Interface Jitter	0.3	0.3	ns
Minimum Receiver Eye Opening (Note 3)	0.8	0.8	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 level between HPCF and POF link specifications are due to the fiber core diameter and NA. 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. 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.

Annex 1 Optical connector alternatives

- PN Connector

The PN receptacle and the PN plug should meet the interface standard, IEC 1754-16 and the performance standard, IEC 1753-AA. It is recommended that the network polarity (transmit and receive) be managed in accordance with ANSI/TIA/EIA-568-A.

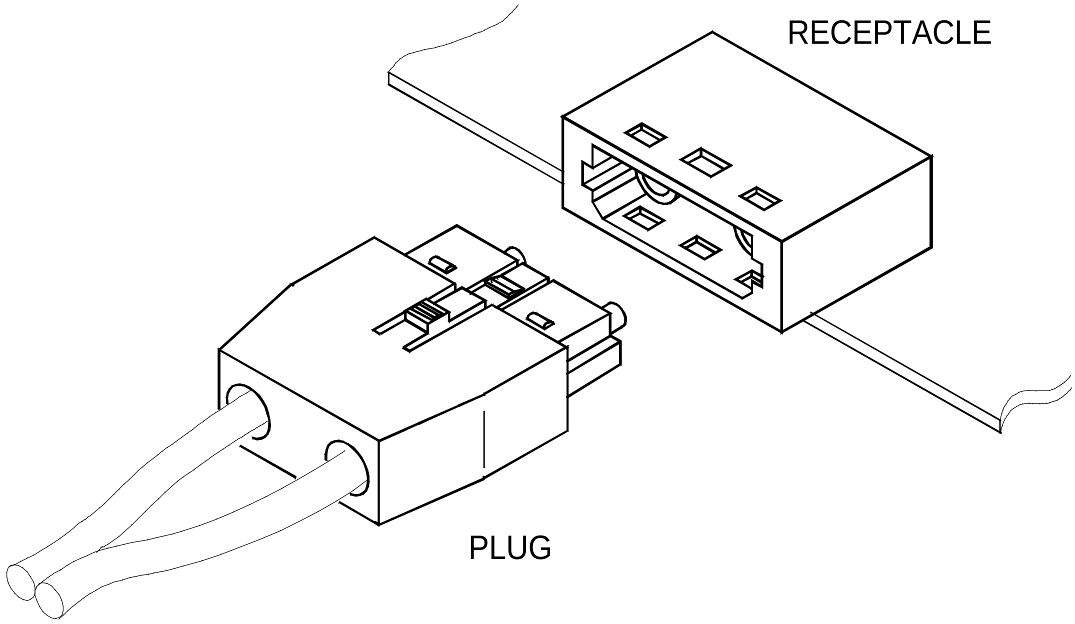


Figure A1-1 PN Plug and Receptacle

The parent connector for type PN connector family is a duplex plug connector which is characterized by a 10.16 mm pitch, and a 2.5 mm nominal ferrule diameter. It includes two type plugs. One (PN-I) is high precision type which has floating ferrules with springs. The other (PN-II) is low-cost type which has fixed ferrule, made by one piece body. Two plugs have mechanical compatibility to adapter or socket.
The subsequent pages define the standard interfaces for the type PN connector family.

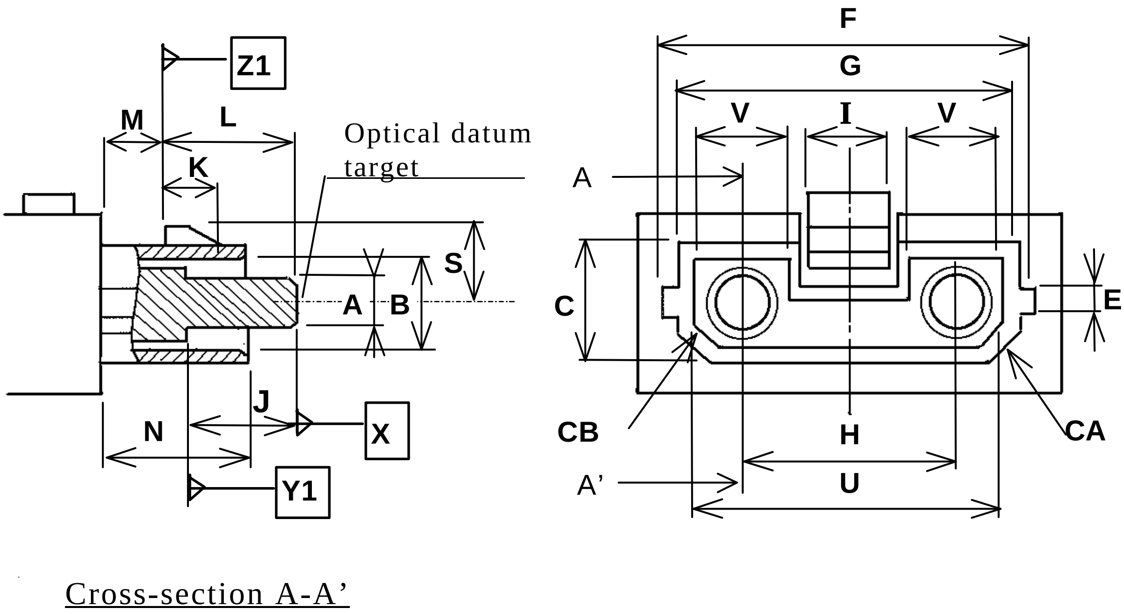


Figure A1-2 - Plug PN-I connector interface

Table A1-1 - Dimensions of the plug PN-I connector interface

Reference	Dimension Mm		Notes
	Minimum	Maximum	
A	2,49	2,50	
B	4,3	4,5	
C	5,8	6,0	
E	1,49	1,595	
F	17,45	17,65	
G	15,95	16,09	
H	10,12	10,20	
I	3,8	4,299	
J	5,30	5,40	
K	-	2,5	4
L	6,8	-	3

M	2,9	3,15	
N	6,55	6,9	
S	3,6	4,5	2
U	14,4	14,8	
V	4,4	4,6	
CA	1,35	1,7	Chamfer
CB	0,8	1,15	Chamfer

NOTES

1. Plug PN-I is high precision, floating ferrule type. It is designed for plastic optical fiber and polymer clad silica fiber, specified at IEC 793-2. type A4a,A4d,A3c,A3d fiber. (A4d,A3d are NWIP)
2. Dimension S is movable to 3.0mm when insert to adapter or socket, and lock to dimension K(figures A1-4,5).
3. Dimension L is given for plug endface when not mated. It is movable by a certain axial compression force. When mate with adapter or socket, dimension L is 6.1 to 6.45mm. And then ferrule compression force shall be 4.3N to 8.1N.
4. Dimension K is given for mating with adapter’s dimension K (figure A1-4) or socket’s dimension K (figure A1-5).
5. Plane Y1 is mechanical reference plane, and mate with adapter’s plane Y(figure A1-4) or socket’s plane Y (figure A1-5). Plane Z1 correspond to adapter’s plane Z1 (figure A1-4) or socket’s plane Z1(figure A1-5).

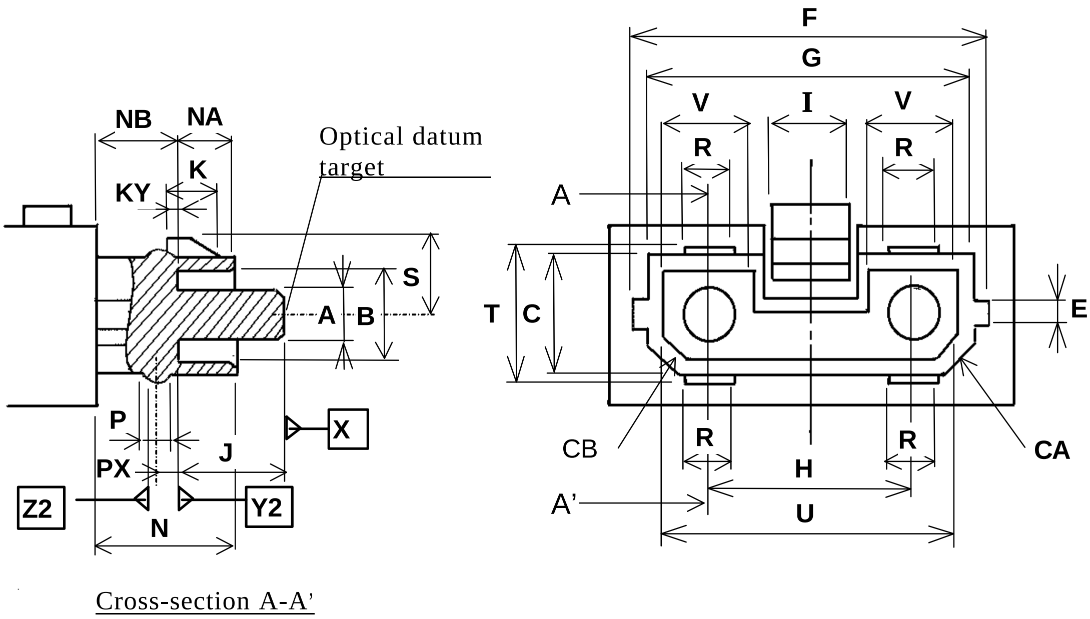


Figure A1-3 - Plug PN-II connector interface

Table A1-3 - Dimensions of the plug PN-II connector interface

Reference	Dimension Mm		Notes
	Minimum	Maximum	
A	2,42	2,50	
B	4,3	4,5	
C	5,8	6,0	
E	1,49	1,595	
F	17,45	17,65	
G	15,95	16,09	
H	10,12	10,20	
I	3,8	4,299	
J	5,30	5,40	
K	-	2,5	3
KY	0,7	0,8	

N	6,55	6,9	6
NA	2,7	2,9	
NB	3,85	4,0	
P	1,75	1,91	4
PX	0,9	1,0	
R	2,7	2,9	4
S	3,6	4,5	2
T	6,35	6,45	4
U	14,4	14,8	
V	4,4	4,6	
CA	1,35	1,7	Chamfer
CB	0,8	1,15	Chamfer

NOTES

1. PN-II is one piece body type. It is designed for plastic optical fiber, specified at IEC 793-2. type A4a,A4d fiber. (A4d is NWIP)
2. Dimension S is movable to 3.0mm when insert to adapter or socket, and lock to dimension K(figures A1-4,5).
3. Dimension K is given for mating with adapter or socket’s (figures A1-4,5) dimension K.
4. Detents of dimension P-R-T deflects dimension C when insert to adapter or socket (figure A1-4,5) rectangle holes of dimension P-R.
5. Plane Y2 is mate with socket (figure A1-5) plane Y.
   Plane Z2 is correspond to adapter or socket (figures A1-4,5) plane Z1.
6. Dimension N = dimension NA + dimension NB.

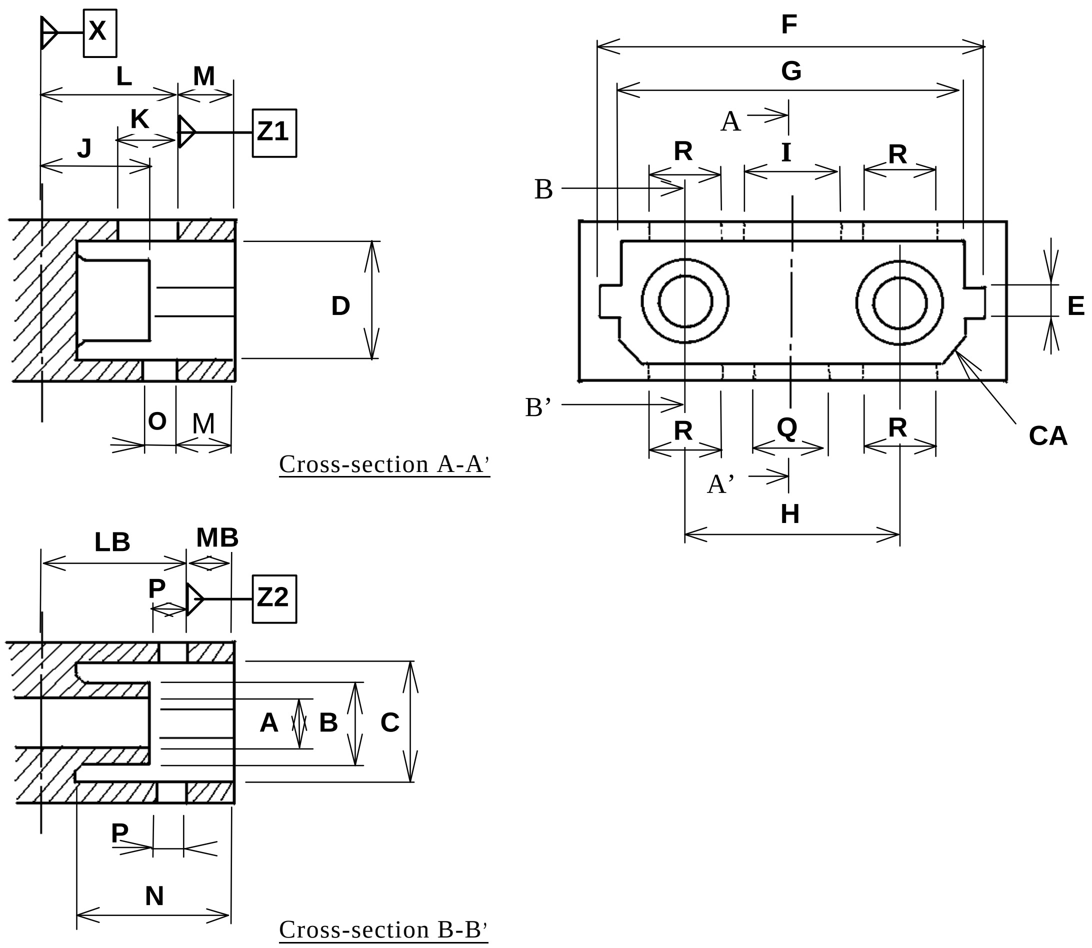


Figure A1-4 – Adapter PN connector interface

Table A1-4 - Dimensions of adapter PN connector interface

Reference	Dimensions Mm		Notes
	Minimum	Maximum	
A	2,501	2,521	
B	3,9	4,1	
C	6,1	6,25	
D	6,05	6,25	

E	1,6	1,7	
F	18,2	18,5	
G	16,1	16,2	
H	10,12	10,20	
I	4,5	4,7	
J	5,05	5,15	
K	2,6	2,8	
L	6,25	6,45	
LB	6,65	6,75	
M	2,55	2,8	
MB	2,25	2,5	
N	6,95	-	
O	1,3	1,5	
P	1,3	1,5	1
Q	3,5	3,7	
R	3,5	3,7	1
CA	1,0	1,3	Chamfer

NOTE

1. This hole is given for mating with PN-II plug, not used for mating with PN-I plug. When PN-II plug is inserted, dimension C is deflected, and mate with PN-II’s detents (figure A1-3. dimension P-R.)
2. Dimension L’s left plane, X shows plug’s ferrule end face at mated, so correspond to plug’s plane X (figures A1-2,3). When mate with PN-I plug, plane Z1 correspond to plug’s plane Z (figure A1-2) . When mate with PN-II plug, plane Z2 correspond to plug’s plane Z (figure A1-3).

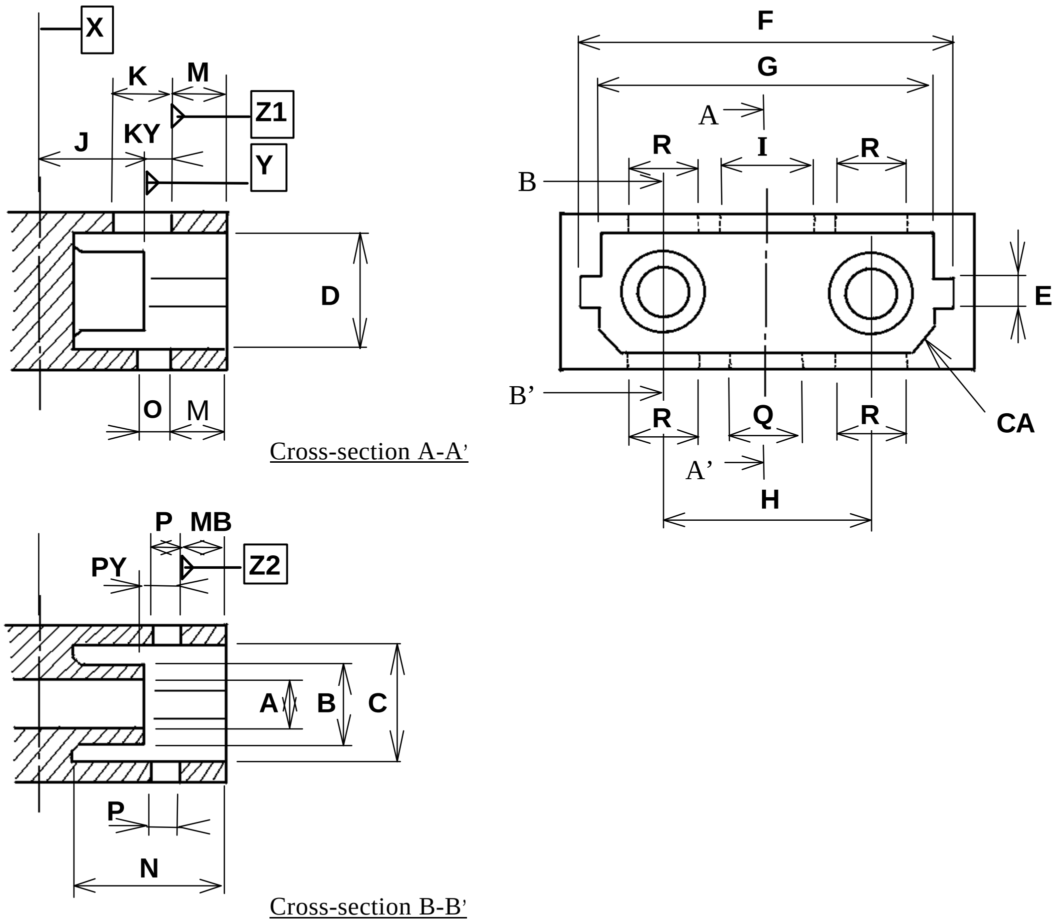


Figure A1-5 – Socket (Receptacle) PN connector interface

Table A1-5 - Dimensions of socket (receptacle) PN connector interface

Reference	Dimensions Mm		Notes
	Minimum	Maximum	
A	2,501	2,551	
B	3,9	4,1	
C	6,1	6,25	
D	6,05	6,25	
E	1,6	1,7	

F	18,2	18,5	
G	16,1	16,2	
H	10,12	10,20	
I	4,5	4,7	
J	5,3	5,4	3
K	2,6	2,8	
KY	0,8	0,9	4
M	2,75	2,85	
MB	2,4	2,5	
N	6,95	7,25	
O	1,3	1,5	
P	1,3	1,5	1
PY	1,15	1,25	3
Q	3,5	3,7	
R	3,5	3,7	1
CA	1,0	1,2	Chamfer

NOTE .

1. This hole is given for mating with PN-II plug, not used for mating with PN-I plug. When PN-II plug is inserted, dimension C is deflected, and mate with PN-II’s detents (figure A1-3. dimension P-R.)
2. When mate with PN-I plug, plane Y correspond to plug’s plane Y1, and plane Z1 correspond to plug’s plane Z1. When mate with PN-II plug, plane Y correspond to plug’s plane Y2, and plane Z2 correspond to plug’s plane Z2.
3. Dimension J’s left plane, X shows plug’s ferrule end face at mating.
4. Dimension KY + dimension M = dimension PY + dimension MB (= Minimum: 3,55 Maximum: 3,75)

- SMI connector

The parent connector for type SMI connector family is a duplex plug connector which is characterized by a 5.0 mm pitch, and a 2.5 mm nominal ferrule diameter. The subsequent pages define the standard interfaces for the type SMI connector family.

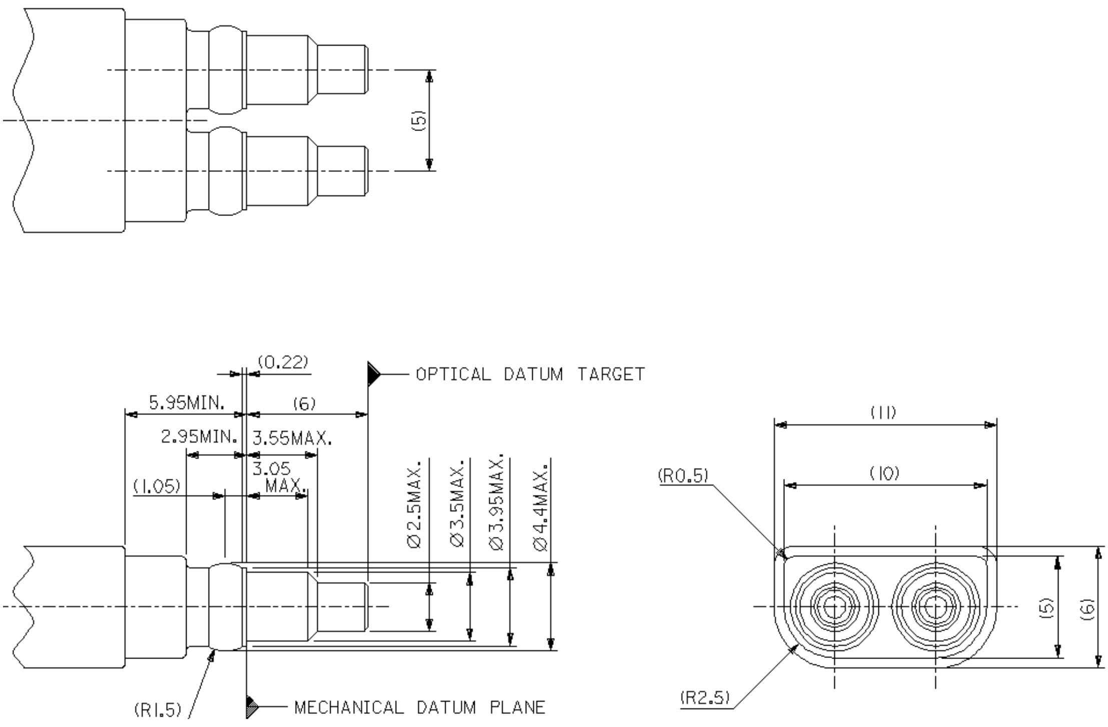


Figure A1-6 Plug SMI connector interface

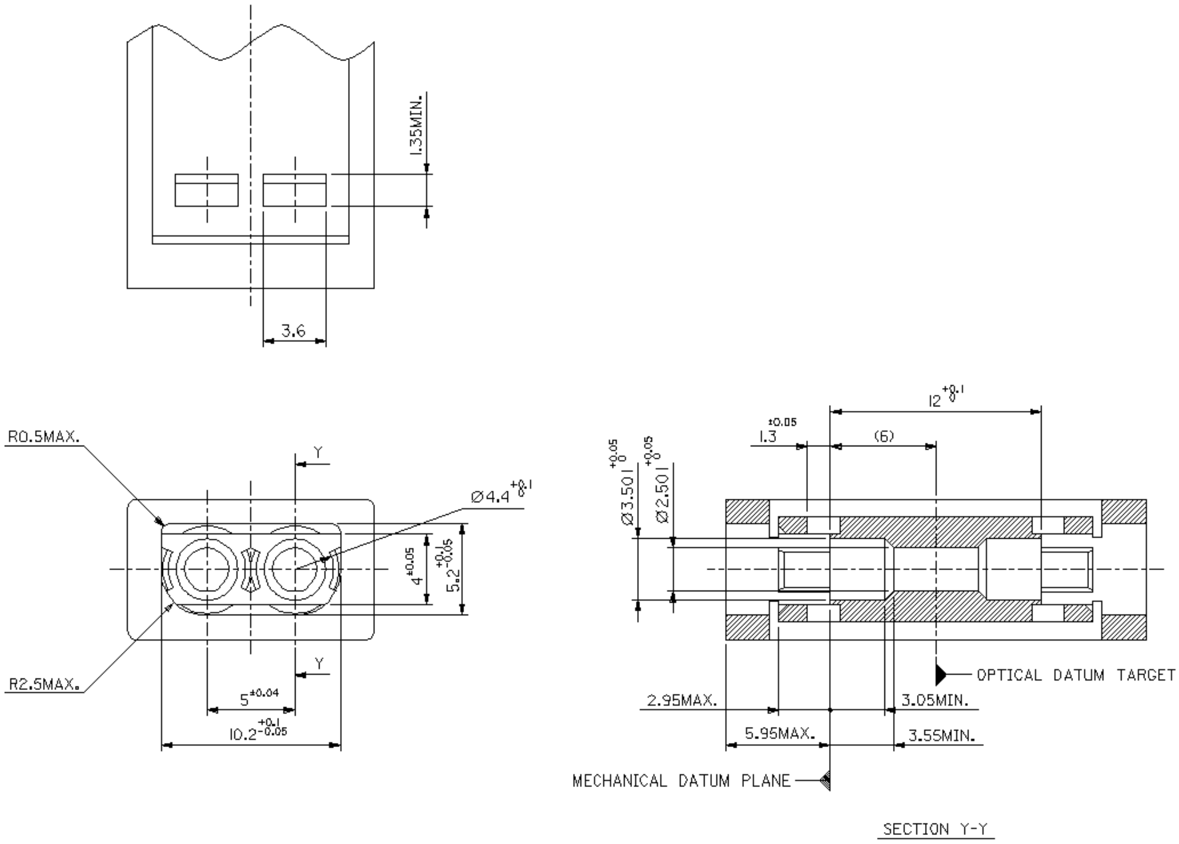


Figure A1-7 Adapter SMI connector interface

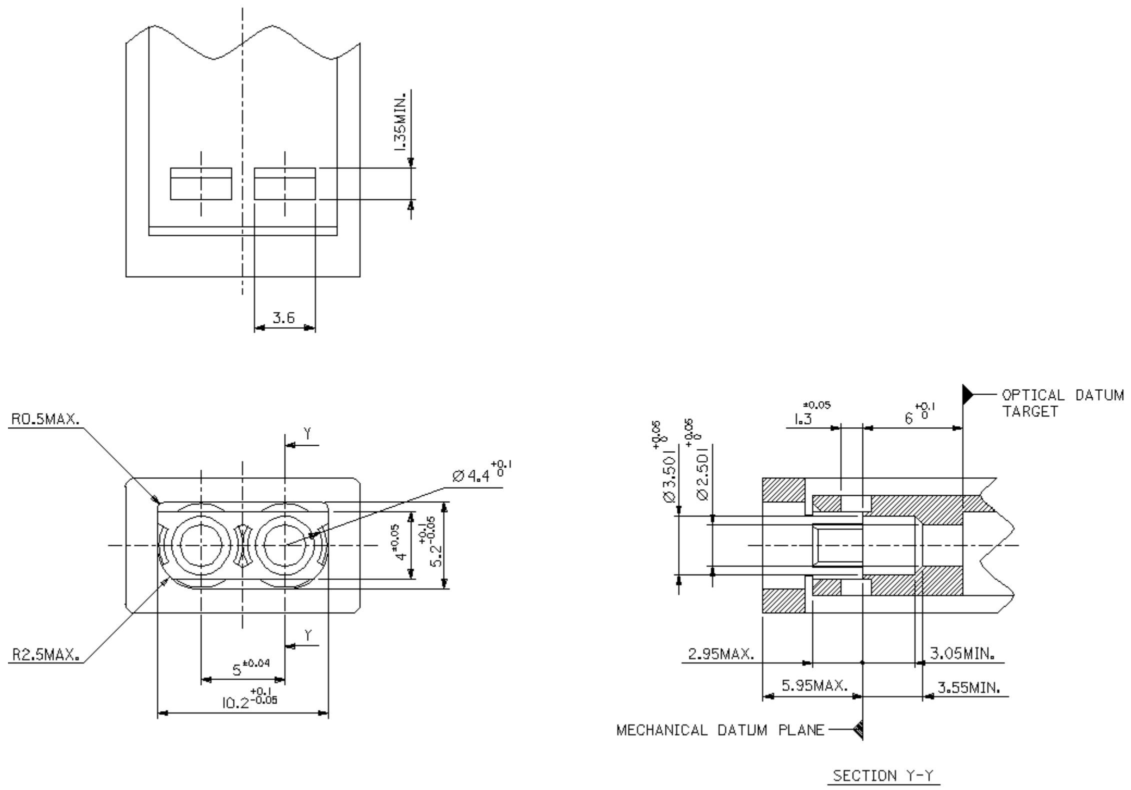


Figure A1-8 Socket (receptacle) SMI connector interface

- OMJ Connector

The parent connector for type Optical Mini Jack (OMJ) connector family is a simplex plug connector which is characterized by a 3.5 mm nominal ferrule diameter. The subsequent pages define the standard interfaces for the type OMJ connector family.

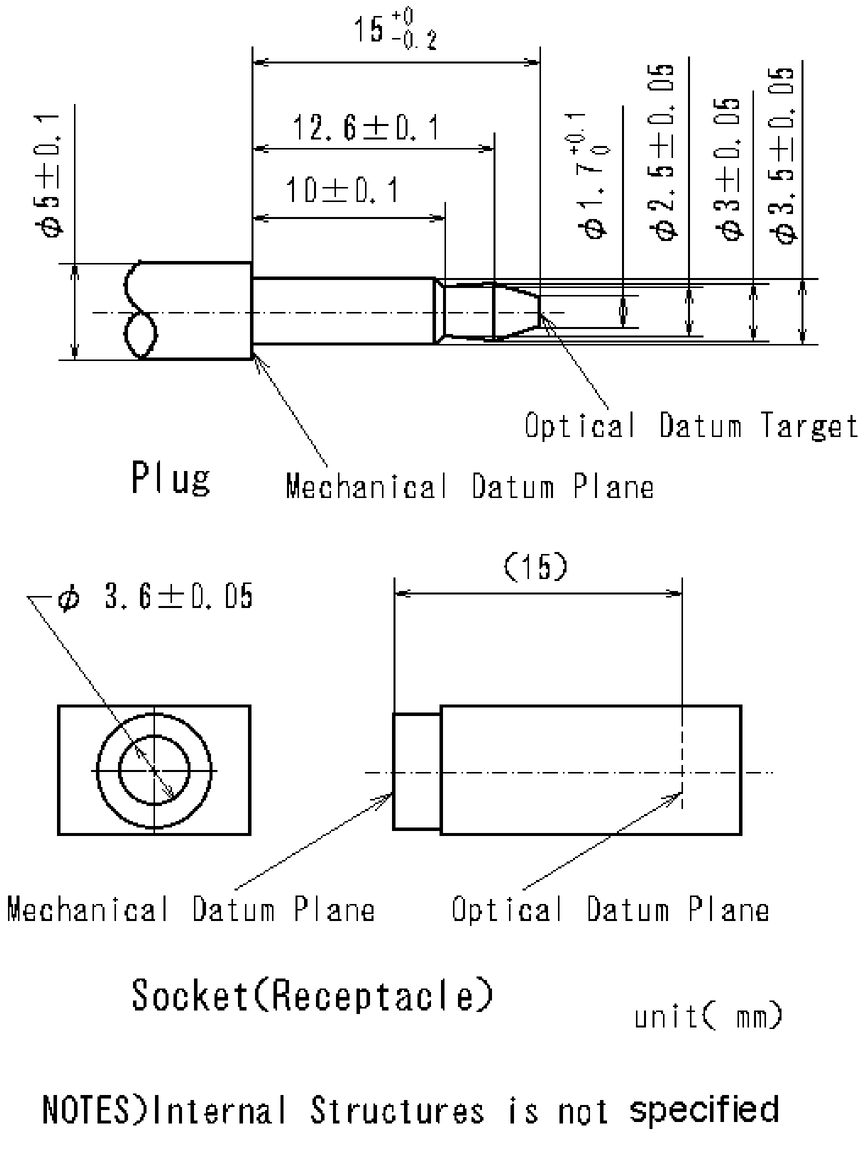


Figure A1-9 Plug and socket OMJ interface

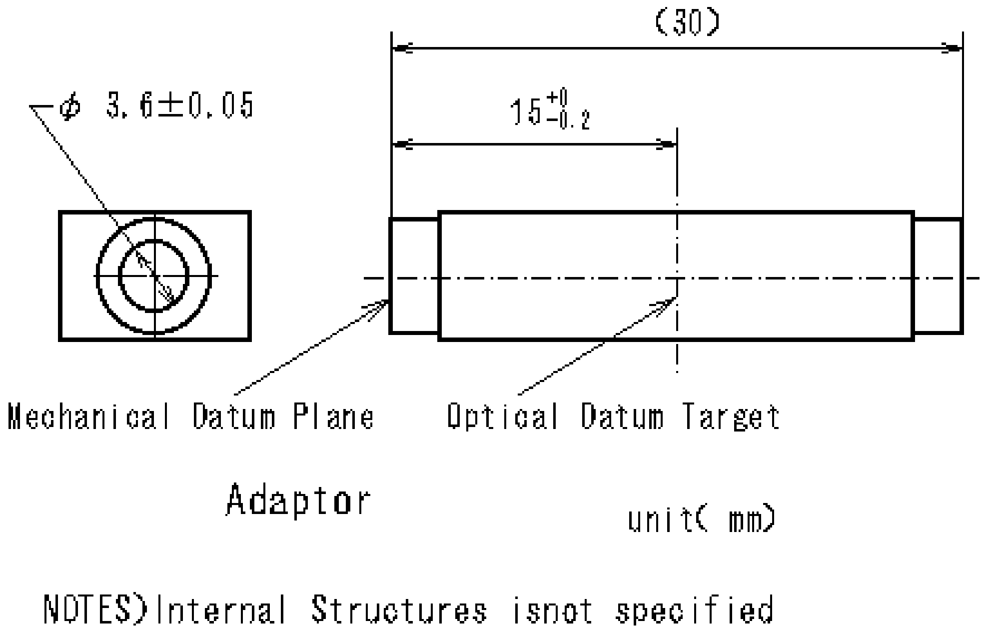


Figure A1-10 Ataptor OMJ interface

FJ connector

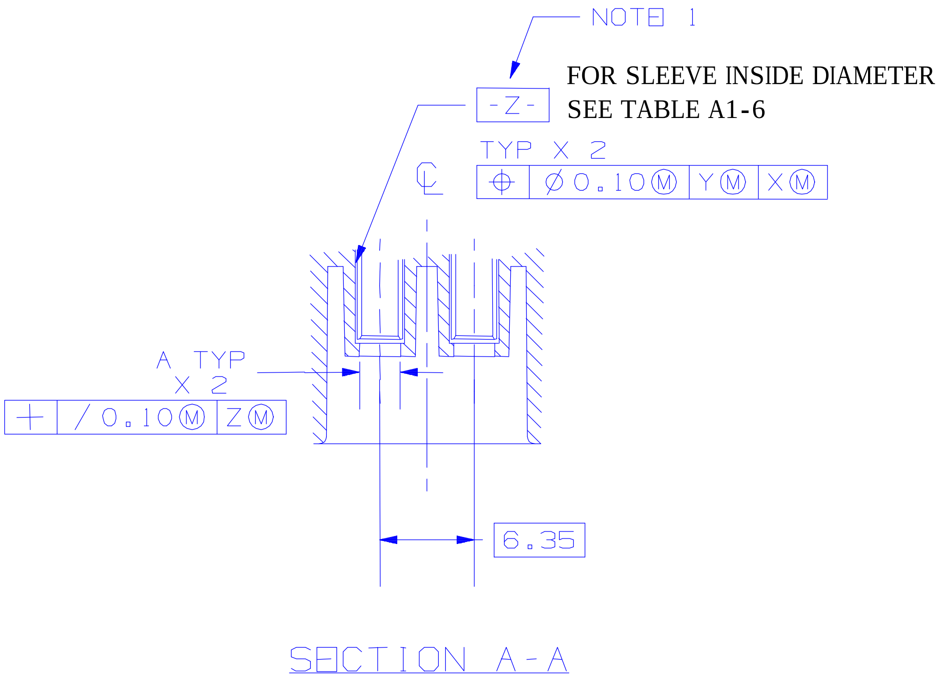
The Fiber Jack (FJ) receptacle, jack and plug shall meet the interface standard TIA FOCIS-6 (ANSI PN#3871) and Plastic Optical Fiber FJ Detail performance standard (ANSI PN#3872). Network polarity are to be managed in accordance with ANSI/TIA/EIA-568-A. The parent connector for type FJ connector family is a duplex plug and jack which is characterized by a modular plug and jack latching style and 2.5mm nominal ferrules set on a 6.25mm pitch. Thereare two plugs, the PJ-1 and PJ-2. The PJ-1 independently spring loads the ferrules into which the two fibers are mounted. The PJ-2 is a low cost type comprized of a one piece body and fiber retaining clip. The two plugs have mechanical compatibility with the Fiber Jack style jack. The FJ interface is described by TIA/EIA FOCS-6.

Table A1-6 Sleeve Inside Diameter (mm)

Ferrule Diameter	Minimum Inside Diameter	Maximum Inside Diameter
t = 5 (POF)	2.515 mm	2.565 mm

Table A1-7 Ferrule Diameter and Fiber Type (mm)

t	Min.	Max.	Fiber
1	2.4985	2.4995	SM
2	2.498	2.500	MM
3	2.497	2.500	MM
4	2.494	2.500	MM
5	2.48	2.50	POF

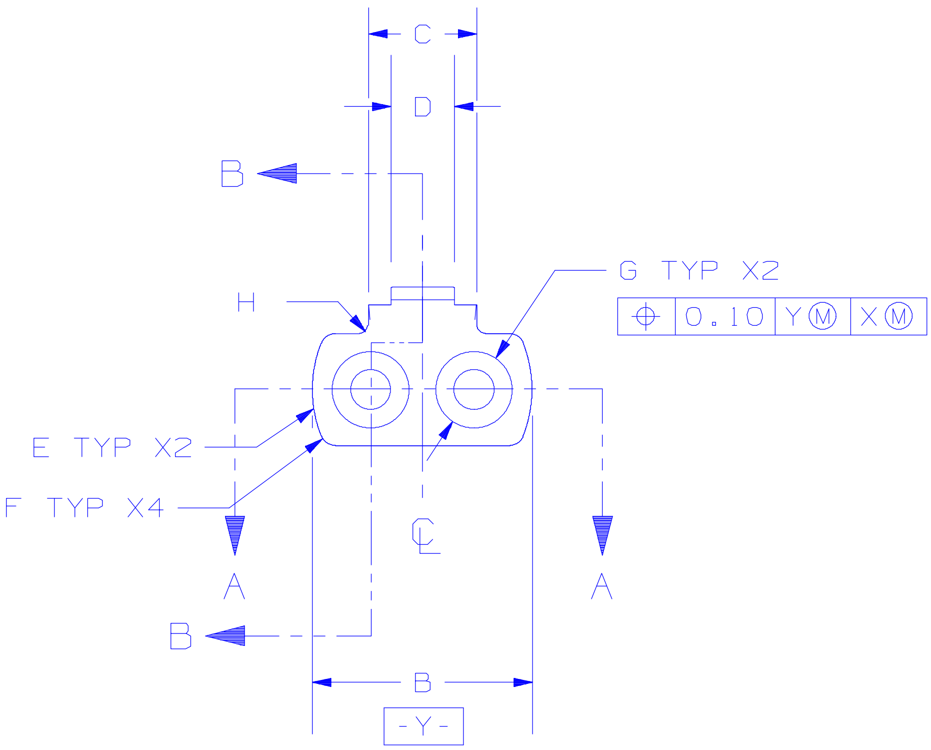


DIMENSIONS	MIN. (mm)	MAX. (mm)	NOTES
A	2.51	-	1

Notes:

1. For a sleeve that is fixed in position datum *z* defines the axis of the sleeve. For a floating sleeve a gage pin inserted in the sleeve must be capable of moving freely into a position such that it is coincident with datum *z*, the diameter of the bore (see Table 1 in section 2.2.2).

Figure A1-11 Jack Interface (top)

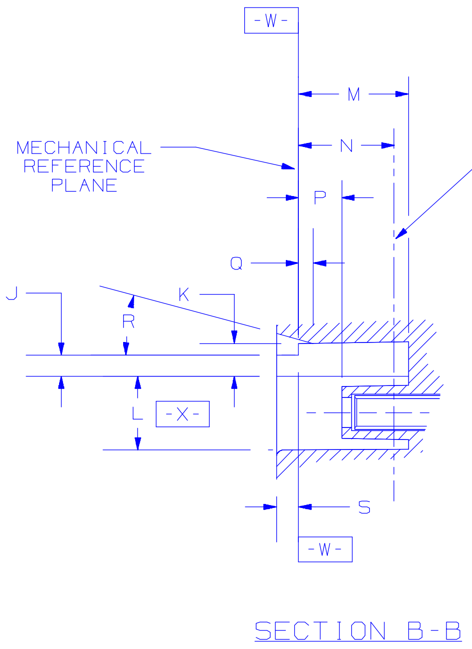


DIMENSIONS	MIN. (mm)	MAX. (mm)	NOTES
B	13.43	13.65	-
C	6.55	6.75	-
D	4.10	4.30	-
E	7.97	-	1
F	-	.635	1
G	-	5.01	2
H	-	1.27	1

Notes:

1. Radius
2. Diameter

Figure A1-12   Jack Interface (front)

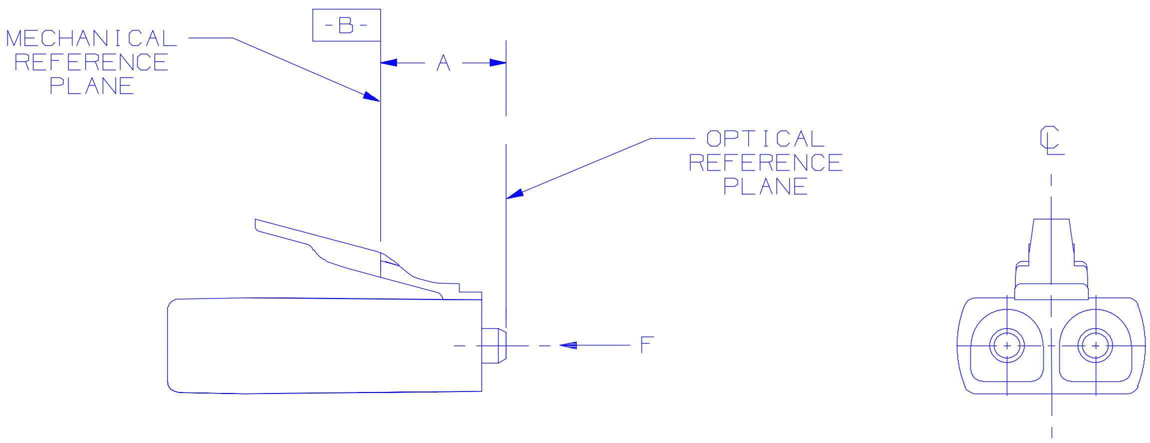


DIMENSIONS	MIN. (mm)	MAX. (mm)	NOTES
J	1.65	1.85	-
K	2.69	2.99	-
L	6.77	7.00	-
M	8.05	-	-
N	8.96	9.87	1
P	3.94	-	-
Q	1.23	-	-
R	15°	17°	-
S	-	2.15	-

Notes:

1. The Optical Reference Plane designates the location of the end of the fiber that is terminated in the jack.

Figure A1-13 Jack Interface (side)



Requirements on Ferrule Travel and Contact Force	
IF	**Then**
F=0	A $\geq$ 9.90 mm
A < 9.90 mm	F $\geq$ 7.8 N (800 gmf)
A $\geq$ 8.76 mm	F $\leq$ 16.0 N (1635 gmf)

Figure A1-14   Plug Interface Option (d=0)

Annex 2 Allowance of connection number

The maximum transmission distance depends on the number of fiber to fiber connection point on the cable plant. Table A2-1 summarizes the trade-off based on worst case component attenuation as specified in section 1.1.2, 1.1.3 and 1.1.4.

Table A2-1 Trade-off for the number of connection and transmission length

No. of connection	Length of POF link (m)	Length of HPCF link (m)
0	50	100
1	42	100
2	34	60
3	27	21