Application Note

CONNECTOR OVERVIEW

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Abstract

The connector and its adapter protect and align the mating fibers both axially and transversally to provide a low loss connection. The ends of the fiber shall mate in such a manner to keep the reflections from the fiber joint low. Both single-mode and multimode interconnect cables are available. Optical connectors are used to make connections that may be altered at some point during their service lifetime. They are capable of being connected and disconnected many times while still maintaining low loss and low reflectance. They are used exclusively in communication central offices on fiber distribution frames (FDFs), fiber transmission equipment, optical test equipment, and fiber-to-the customer passive fiber distribution hubs and customer premises equipment.

Keywords

ITU-T, OH-Lite, BOW-Lite, PC, APC, Ferrule, SC, ST, FC, LC, MTP/MTO, Single/Multi -fiber, Reflectance, Insertion Loss

General

This document provides a summary of optical connectors to physically and optically mate two or more fibers. The connector and its adapter protect and align the mating fibers both axially and transversally to provide a low loss connection. The ends of the fiber shall mate in such a manner to keep the reflections from the fiber joint low.
Most often optical connectors are factory installed on the ends of fire rated interconnect cables. Both single-mode and multimode interconnect cables are available. Optical connectors are used to make connections that may be altered at some point during their service lifetime. They are capable of being connected and disconnected many times while still maintaining low loss and low reflectance. They are used exclusively in communication central offices on fiber distribution frames (FDFs), fiber transmission equipment, optical test equipment, and fiber-to-the customer passive fiber distribution hubs and customer premises equipment.
This paper will provide a listing of the different types of optical connectors including a brief description of them, where they are used, and any information that may be of interest to a prospective user.

Connector Components

An SC type connector can be examined to understand how the individual parts of a typical optical connector fit together. The SC connector is one of the most popular connectors in use. Figure 1 presents an expanded view of an SC connector. The SC connector is intended for use with a single bare fiber in a cable. The cable is stripped back about 60 mm from its end exposing the bare fiber(s). Two centimeters of coating and buffer tube are stripped from the end of the fiber to down to its cladding (125mm). An optical quality epoxy is dripped into the connector ferrule's central hole and onto the stripped bare fiber end. Then the fiber is thread into the connector ferrule. The cable's usually aramid yarn strength members are folded back under the crimp eyelet and crimped over it to secure cable to the end of the connector sub-assembly. The epoxy must be given time to cure, sometimes heat or UV light are used to accelerate the epoxy cure. The ferrule assembly is screwed in to a polishing puck and either hand polished in the field or machine polished in a factory using successively finer and finer abrasive paper and water. Once the connector is polished it is checked to determine its performance. It can be further polished if it is more reflective or higher in loss than required. Once polishing is complete the bend buffer boot is slipped on the end of the connector sub-assembly over the crimped eyelet

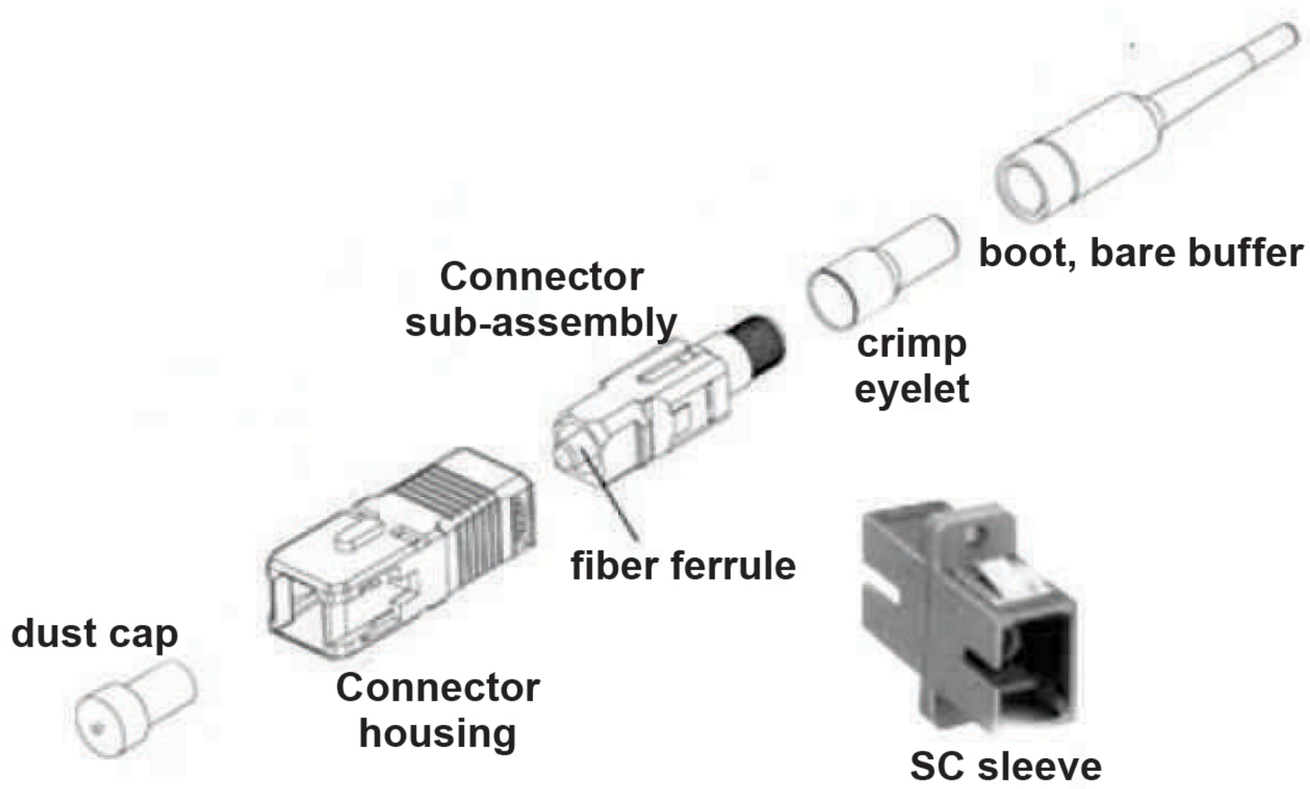


Fig.1 Exploded view of SC Optical connector

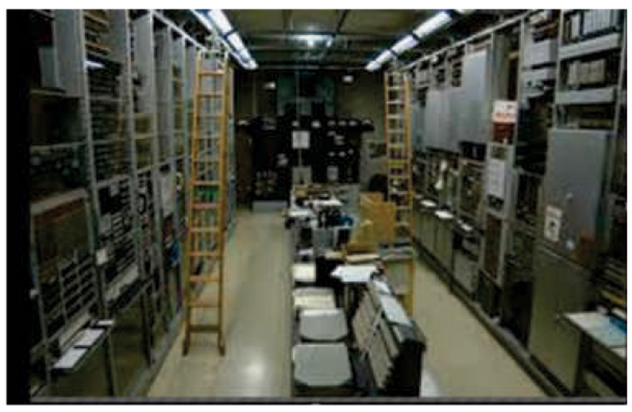
Applications and Environmental Conditions

Most optical connectors will be used indoors with dielectric cables in a controlled environment although many new applications are taking these connectors into partially controlled environments within the outside plant. Typical controlled building environments are shown in Table 1.

Table 1 – Typical Temperatures Indoor Cable May be Exposed to During Operation

Category	Vertical Backbone cable	Horizontal Backbone cable and Interconnect Cable	Weatherized indoor Optical Cable
Operation	-20°C to +70°C	0°C to +70°C	-40°C to +70°C
Installation (Riser fire rating):	-10°C to +60°C		
Installation (Riser and General purpose fire rating):		-10°C to +60°C	-10°C to +60°C
Installation (Plenum fire rating):	0°C to +60°C	0°C to +60°C	0°C to +60°C
Storage / Shipping:	-40°C to +70°C	-40°C to +70°C	-40°C to +70°C

Many of the optical connectors will be installed on the ends of interconnect cables as jumpers or "pig tail" cordage. These cables are used to interconnect FDFs in communications central offices, FTTx fiber distribution hubs, and as the final link to the desk in office applications. Some of the cables will be installed on tight buffered backbone cables for indoor use or for use as cable stubs within a fiber distribution hub in the field. Some of the connectors will be used to connect directly to passive and active optical equipment or test sets. Figure 2 shows a graphical representation of some of the applications of optical connectors.



Central Office FDF

FTTH FDH

Fiber Distribution Terminal

Testing at Customer Premises

Figure 2 – Some of the Applications of Optical Connectors

Optical connectors are commonly used in varying environments other than in controlled indoor conditions, see Table 2. In FTTx systems optical connectors are used in above ground, rain resistant cabinets, closures and drop boxes, but exposing the connectors used within the cabinet etc. to the uncontrolled ambient temperatures of the surrounding air. Many of these connectors will experience high temperatures when used in closures or pedestals in direct sunlight. As a result, it is important that the connectors used have passed international specifications that are designed to produce connectors that can perform properly when exposed to harsh environmental conditions.

Table 2 – Four Environmental Designations That Describe the Conditions Optical Communications Connectors May Experience When Used in the OSP

Environmental Designation	Typical Application	Example Of Lactaion	Operating Temperature
Controlled and Protected	controlled and protected from stresses from outside weather and environment by a building	Telecommunications hut and CEV	-5?°C to +60°?C*
Protected	Protected from weather and environment stresses by a closure	Location with active enviro -nmental control devices and devices within the enclosure to dissipate heat from active equipment	-40°?C to +65°?C
Protected Equipment in OSP	Equipment spaces protected from direct sunlight and rain. Closures need not be sealed	Pedestals, distribution cross-connect boxes, interior spaces in outdoor cabinets in desert	-40°C to +70°C
Unprotected Environment	integrated equipment directly exposed to the weather, sunlight, rain, and wind.	Unprotected enclosure with equipment housed indside	-40°C to +70°C or -40°C to +45 °C plus solar radiation

Often connectors are used in the field inside a pedestal or fiber distribution hub (FDH) to connect feeder cable from the central office to distribution cable to the customer. Feeder cables often contain fewer fibers than distribution cables. Fibers in feeder cables are often connected to “fan outs” that provide transitions from either fiber ribbons or individual fibers in a buffer tube to individual connectorized simplex cables. These connectorized simplex cables are often terminated on the backplane of a fiber distribution shelf, fiber interface box, or pedestal. A customer is connected to service by plugging the connector on the end of the feeder cable into the port connected to the appropriate feeder cable on the fiber distribution panel that serves the customer.

Most communication optical connectors are compatible with both multimode and single-mode fibers with core and cladding outside diameter of 0.125 µm. Connectors that have a ferrule use a cylindrical sleeve to align the outside diameter of the two mating ferrules to complete the connection. Other connection types use a pin and hole alignment technique to achieve alignment for the mating connectors.

Some connectors are designed to enable single fibers to be mated; others are designed to enable multiple fiber connections to be made with a single connector. These multi-fiber connectors often use the pin and hole technique for fiber alignment.

Most interconnect cables are either simplex (1 fiber) or duplex (2 fibers). They are generally terminated on the ends of fire rated cable with an NEC plenum rating (OFNP) or equivalent.

The most common single-mode fiber used in interconnect cables is ITU-T G.652C and G.652D equivalent to OH-LITE fiber. ITU-T G.652 fiber is the standard fiber for use when dispersion issues are not a problem. G.657 is similar in most ways to G.652 fiber except that it is more resistant to bend loss. BOW-LITE Fiber is equivalent to ITU-T G.657 fiber

To eliminate modal inference and ensure single mode operation of dispersion un-shifted (ITU-T G652) optical fiber, the fiber's cut-off wavelength must be less than the operating wavelength. The cut-off wavelength is dependent upon fiber length and is different for fiber and cabled fiber. Fiber cut off wavelength, $_{Cf}$, is larger than cabled cut off wavelength, $_{CC}$. However, $_{CC}$ is closer to the actual cut off wavelength that occurs in actual use. The fiber cut-off wavelength, $_{Cf}$, measured under the standard length and bend conditions of FOTP-80, will generally exhibit a value larger than the $_{CC}$. For short cables, e.g. pigtails and jumper cables, $_{CC}$ may be larger than $_{Cf}$. For applications in long-haul telecommunication; optical fiber should be selected on the basis of cable cutoff wavelength rather than fiber cutoff wavelength. As a result, jumper cables that are shorter than 20 meters may experience a cut-off wavelength well below the value cable it is paired with.

Optical Connectors Available from

Table 3 provides a listing of common multimode and single-mode connectors available. The table also presents many of the key features of these connectors as well as the Standard that describes the connector in greater detail and an example of their intended use

Table 3 – Common Optical Connections Available from Technologies

Connector	Name	Coupling Mechanism	ferrule Diam (mm)	Standard	Application
E-2000(AKA LSH)		snap2	2.500	IEC 61754-15	DWDM Sys
ESCON	Enterprise System Connection	Alignment pin/Snap	2.500		IBM Mainfra -me Computers
FC	fiber connectors	Pin / Screw	2.500	IEC 61754-13	Datacom, telecom
FSMA		Keyed Screw	3.175	IEC 61774-2	Datacom, telecom
LC	Lucent connector	Keyed / Snap	1.250	IEC 61744-20	High density Conncetions
LD	Lucent conne -ctor duplex	Keyed / Snap	1.250	IEC 61744-20	High density Conncetions
FDDI / MIC	Media interfa -face connectors	Snap	2.500		Fiber distributed data interface
MPO / MTP	multiple Fiber push on/pull-off	Snap	2.5x6.4	IEC 61754-7	Indoor cabling

MT	mechanical Transfer	Pinned / Snap	2.5x6.4	IEC 61754-7	Outdoor pre-terminated cabling

1) The cut-off wavelength is the wavelength at which light being transmitted through a fiber transitions from multimode to single-mode.

2)Connector is designed to fit together in only one orientation, when connector is fully seated in adapter it locks in place.

Connector	Name	Coupling Mechanism	ferrule Diam (mm)	Standard	Application
MT-RJ	Mechanical Transfer Register Jack	Pinned / Snap	2.5x6.4		outdoor pre-terminated Cabling
MU	Miniature Unit	Keyed / Snap	2.5x6.4		Common in apan
SC	Standard conncetor	Keyed / Snap	2.500	IEC 61754-4	datacom and telecom
SMA 905	Subminiature A	Screw	3.140		Telecom MM, military
SMA 906	Subminiature A	Screw	Stepped		Telecom MM, military
ST / BFOC	Straight tip bayonet	bayonet	2.500	IEC 61754-2	mostly MM

Connectors use ceramic ferrules to assure high performance and to provide reliable connections. Indoor interconnection cables are available in duplex and simplex format with either multimode or single-mode fiber and PC, UPC, or APCpolished end faces. These are suitable for use with 900 µm or 2.0 to 2.8 mm cables (buffered tubes). The cables conform to international standards and provide consistent long-term mechanical and optical performance.

A high level of precision and accuracy is required in the manufacture of the connector and its housing to keep the insertion loss and the reflectance of the connector low and within required threshold values, controls every stage of the manufacturing process so that quality is built in to its complete range of optical connectors, rather than selected out at the end of the manufacturing process through testing. To ensure the accuracy and precision of the connector, routinely calibrates and recertifies process equipment and measurement benches against internationally traceable standards from NPL/NIST, and follows test methods compliant with EIA/TIA, IEC and ITU standards.

Table 4- Typical Features of Optical Connectors

Parameter	Description
Ferrule Capillary Diameter	(MM)126-0/3 µm,(SM)126-0/1 µm
Ferrule diameter	2.499mm ± 0.001mm
Insertion loss	<0.3dB (UPC); ≤ - 60 dB (APC)
Reflectance (SMF)	≤ -50 dB (UPC);≤ -60 dB (APC)
Mating durability	After 1000 cycles; IL < 0.2 dB
Temperature range	-40°C to +80°C

3) Physical contact, ultra-physical contact, and angled-physical contact (7° to 8°) connectors.

Figure 3- Common Optical Connectors

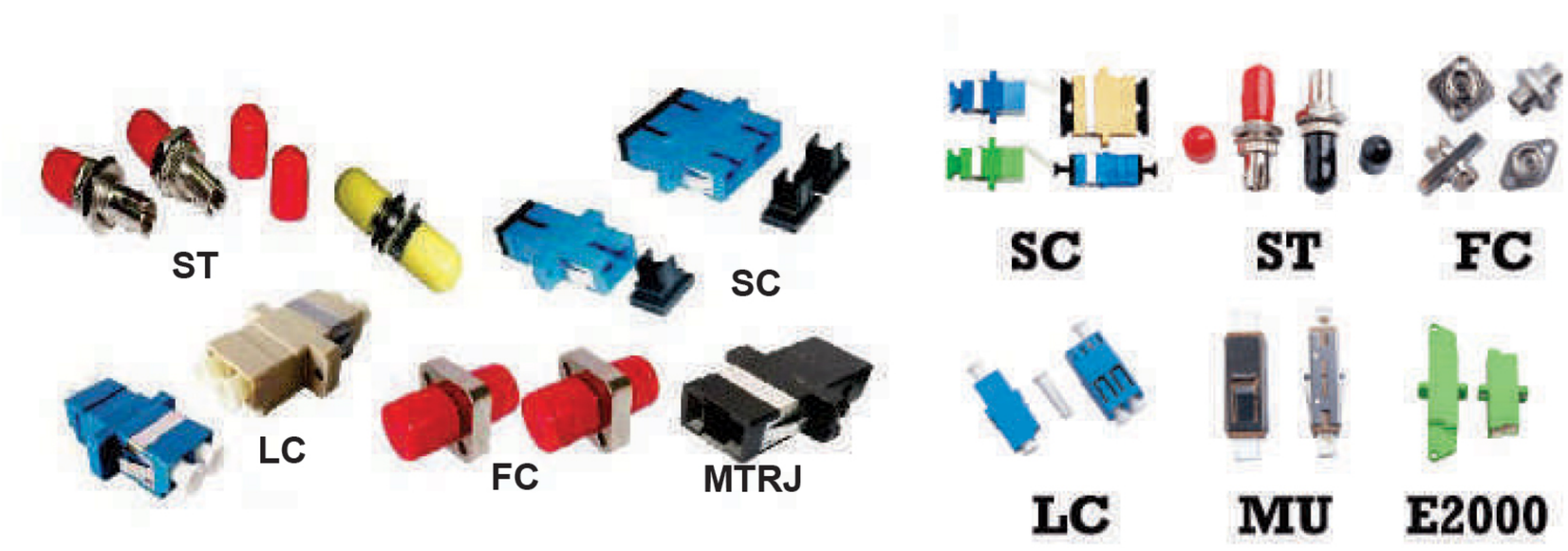


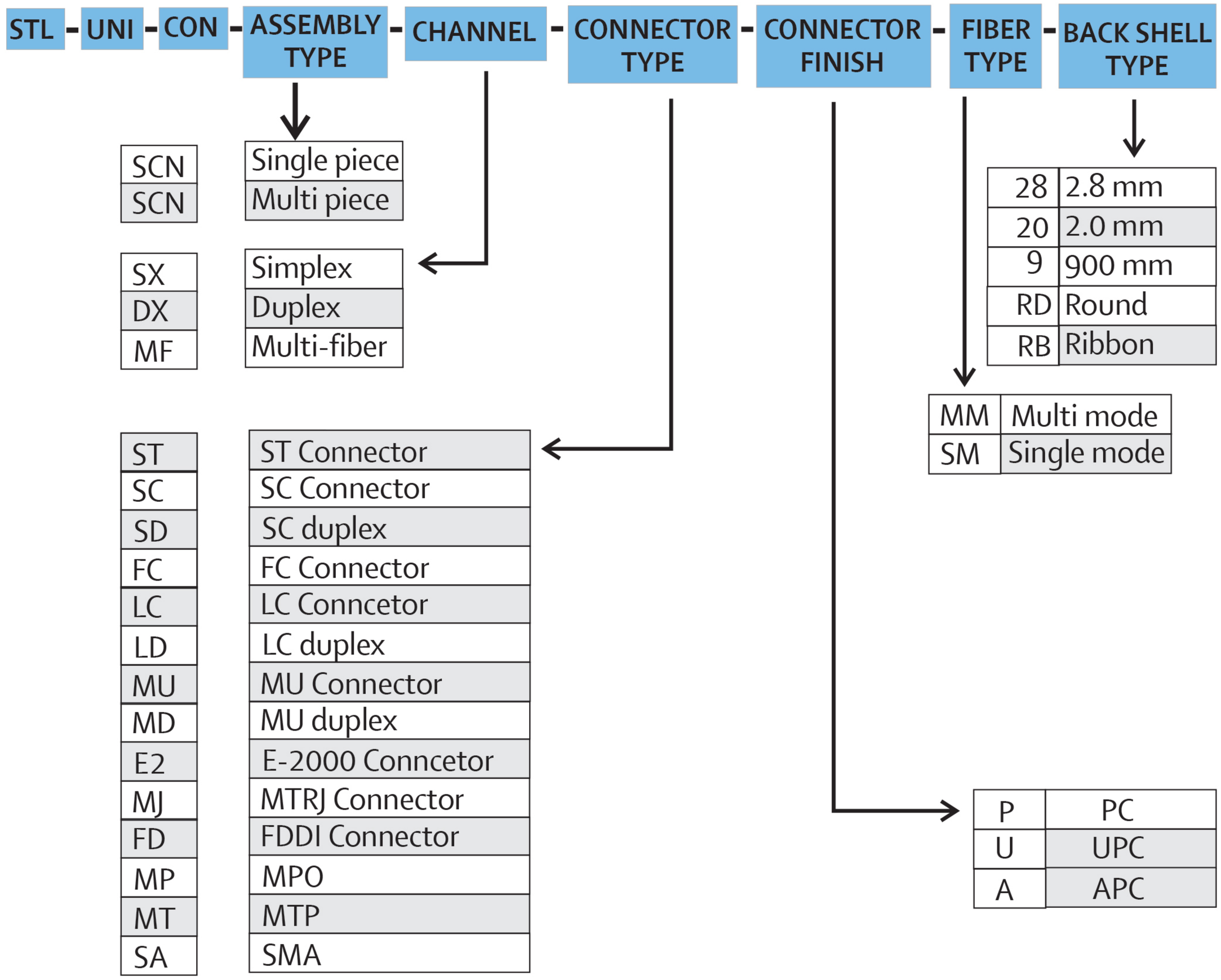
Figure 4- Common Optical Connector Adapter Sleeves

The following performance levels are typical of what can be expected from connectors.

Figure 5- Summery Of Optical Characteristics for Optical Connectors

Parameter	Maximum Loss (dB)			
	MMF 1300 nm		SMF (1310 nm and/or 1550 nm)	
Connector Type	All	SMA & MT-RJ	ALL APC	E-2000 / APC
Insertion Loss	0.30 dB	0.50 dB	0.30 dB	0.30 dB
Reflectance	NA	NA	-60.06 dB	-70.0 dB

Connector product options



Additional Information

If there are additional questions on this topic or other fiber optic issues, please contact Sterlite Technologies at:

Contact Information
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www.technologies.com