



Connector Identifier

In the development of fiber optic technology, many companies and individuals have invented the "better mousetrap" - a fiber optic connector that was lower loss, lower cost, easier to terminate or solved some other perceived problem. More than 100 fiber optic connectors have been introduced to the marketplace, but only a few represent the majority of the market. Here is a rundown of the connectors that have been the leaders of the industry, some that are already obsolete and some specialty connectors.

Design

Most fiber optic connectors are plugs or so-called male connectors with a protruding ferrule that holds the fibers and aligns fibers for mating. They use a mating adapter to mate the two connector ferrules that fits the securing mechanism of the connectors (bayonet, screw-on or snap-in.) The ferrule design is also useful as it can be used to connect directly to active devices like LEDs, VCSELs and detectors.

History

The big silver connector at the bottom of the photo at the right is the Deutsch 1000, what was probably the first commercially successful fiber optic connector. It was really a "pin vise" holding a stripped fiber. The nose piece is spring loaded and was pushed back when the connector was inserted into a mating adapter. The fiber stuck out into a drop of index matching fluid on a plastic lens. This solution was state of the art in the late 70s, yielding about 3 dB loss. Many users remember it as the connector on the front panel of the original Tektronix OTDR.

Above it is the Biconic, the yellow body indicating a SM version. Developed by a team led by Jack Cook at Bell Labs in Murray Hill, NJ, the Biconic was molded from a glass-filled plastic that was almost as hard as ceramic. It started with the fiber being molded into the ferrule. This lasted until the company could get a 125 micron/5mil pin insert into the plastic mold, at which point the fiber was



From the top: LC, SC, Biconic,
Deutsch 1000

glued into the ferrule with epoxy. When singlemode versions first appeared, the ferrules were ground to center the fiber core in the ferrule to reduce loss. Since it was not keyed and could rotate in the mating adapters, it had an airgap between the ferrules when mated, meaning loss was never less than 0.3 dB due to fresnel reflection. Usually MM Biconics had losses of 0.5-1 dB and SM 0.7 dB or higher.

The advent of the ceramic ferrule in the mid-80s in Japan changed the connector designs forever. The ceramic ferrule was hard and precise. Fibers were accurately located for alignment and ferrules could be allowed to touch. Adding in convex ferrules for PC (physical contact) between connectors reduced losses to levels below 0.3 dB for both MM and SM varieties.

In the late 90s, small form factor (SFF) connectors became popular, but only the LC (top) has been a runaway success, both in telcos and high bit rate LANs, SANs, etc.

Below are some more of the popular connectors over the years.

Connector Standards

The most popular connectors are covered in the TIA connector intermateability standards [FOCIS-x](#) (TIA-604-x).

Color Codes:

Since the earliest days of fiber optics, orange, black or gray was multimode and yellow singlemode. However, the advent of metallic connectors like the FC and ST made color coding difficult, so colored boots were often used. The TIA 568 color code for connector bodies and/or boots is **Beige** for multimode fiber, **Blue** for singlemode fiber, and **Green** for singlemode APC (angled) connectors.

[More on fiber optic connector and cable color codes.](#)

NOTE: THIS MAKES A GOOD STUDY GUIDE FOR THE FOA CFOT AND CFOS/C EXAMS!

Guide to Fiber Optic Connectors

Check out the "spotters guide" below and you will see the most common fiber optic connectors. (All the photos are to the same scale, so you can get an idea of the relative size of these connectors.)

If you wonder what the connector names mean, see [Fiber Optic Connector Terminology](#) in [The FOA Online Reference Guide to Fiber Optics](#).



Connector color codes: L>R, Multimode, Singlemode, SM APC

ST

ST (an AT&T Trademark) was probably still most popular connector for multimode networks until ~2005. It has a bayonet mount and a long cylindrical 2.5 mm ceramic (usually) ferrule to hold the fiber. Most ferrules are ceramic, but some are metal or plastic. A mating adapter is used to mate two connectors (shown below.) And because STs are spring-loaded, you have to make sure they are seated properly. If you have high loss, reconnect them to see if it makes a difference.

The ST/SC/FC/FDDI/ESON connectors have the same ferrule size - 2.5 mm or about 0.1 inch - so they can be mixed and matched to each other using hybrid mating adapters. This makes it convenient to test, since you can have a set of multimode reference test cables with ST or SC connectors and adapt to all these connectors. See below.

ST is covered in the TIA connector intermateability standard [FOCIS-2](#) (TIA-604-2).

SC

SC is a snap-in connector also with a 2.5 mm ferrule that is widely used for its excellent performance. It was the connector standardized in TIA-568-A, but was not widely used at first because it was twice as expensive as a ST. Now it's only a bit more expensive and much more common. It's a snap-in connector that latches with a simple push-pull motion. It is also available in a duplex configuration.

SC is covered in the TIA connector intermateability standard [FOCIS-3](#) (TIA-604-3).

FC

FC was one of the most popular singlemode connectors for many years. It also uses a 2.5 mm ferrule, but some of the early ones use ceramic inside stainless steel ferrules. It screws on firmly, but you must make sure you have the key aligned in the slot properly before tightening. It's been mostly replaced by SCs and LCs.

FC is covered in the TIA connector intermateability standard [FOCIS-4](#) (TIA-604-4).



Mating Dissimilar Connectors

The ST, SC and FC connectors share a 2.5 mm ferrule design so they can be mated to each other. To do so requires a hybrid mating adapter as shown here.

From the top:

ST>FC

SC>FC

SC>ST

In the past, you could also get hybrid adapters for these connectors to FDDI and ESCON connectors (see below) which used the same ferrule.



LC

LC is a small form factor connector that uses a 1.25 mm ferrule, half the size of the SC. Otherwise, it's a standard ceramic ferrule connector, easily terminated with any adhesive. Good performance, highly favored for singlemode.

The LC, MU and LX-5 use the same ferrule but cross-mating adapters are not easy to find.



LC is covered in the TIA connector intermateability standard [FOCIS-10](#) (TIA-604-10).

LX-5

LX-5 is like a LC but with a shutter over the end of the fiber.

LX-5 is covered in the TIA connector intermateability standard [FOCIS-13](#) (TIA-604-13).



MU

MU looks a miniature SC with a 1.25 mm ferrule. It's more popular in Japan and the far east.

MU is covered in the TIA connector intermateability standard [FOCIS-17](#) (TIA-604-17).



MPO

MPO is a 12 fiber connector for ribbon cable, often called an array connector. The connector ferrule is plastic and contains 12 or 16 fibers in a row. The versions with 12 fiber rows can theoretically have 6 rows but more than two are rare. The 16 fiber rows are limited to 2 rows. Fiber ferrule alignment is by pins in one ferrule and holes in the other.

The MPO main use is for preterminated cable assemblies and cabling systems. Here is a 12 fiber MT broken out into 12 STs. It is also used for higher speed multimode links (40 or 100Gb/s) that use parallel optics.

MPO means multi-position optical. This connector is sometimes called a MTP which is a commercial name. It is covered in the TIA connector intermateability standard [FOCIS-5](#) (TIA-604-5) for the 12 fiber version and [FOCIS-18](#) for the 16 fiber version..

For more information on the MPO connector, including its issues with polarity and testing, [go here](#).



Military or Ruggedized Connectors

There are many styles of ruggedized connectors, mostly developed for tactical military use but are now widely used in field applications that call for rugged cables and connectors, applications such as oil and gas exploration or use at sporting events by TV networks. These connectors are generally multifiber connectors and some use expanded beam connector technology for its resistance to dirt and harsh environments. Examples of these connectors are the MIL-C-38999, TFOCA and Hughes.



New Generation Connectors

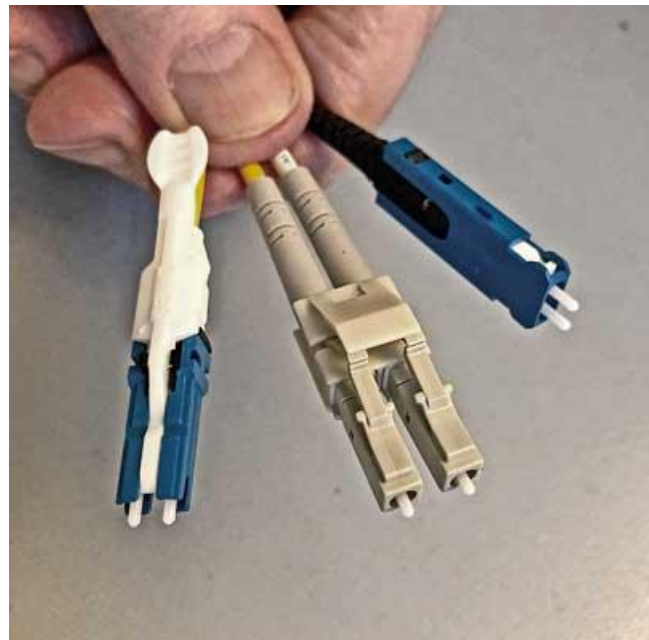
Introduced Circa 2017-2019

There were few new connectors introduced between 2000 and 2017. But there have been several new connectors that are designed for small size, making the duplex LC in the middle look quite large. The Senko CS on the left is a duplex connector using the LC 1.25mm ferrule. The SN on the right also is a duplex connector using 1.25mm ferrules but it uses a vertical format. The salient feature of these connectors is panel or transceiver density. The CS is horizontal and has about twice the density of a LC. The vertical format SN doubles even the CD density in horizontal panel space and the mating adapter is hardly any higher.

Similar to the SENKO is the US Conec MDC which appears to have been designed to a similar requirement.

Two expanded beam connectors have been introduced to compete with the MPO array connector, from 3M Expanded beam and the R&M QXB. Expanded beam connectors have fewer problems with alignment and dirt but their higher cost has limited their acceptance.

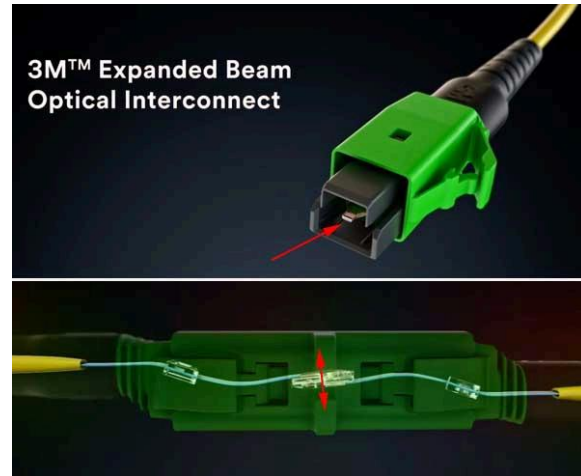
These connectors are new and future commercial success is an unknown.



CS (L) and SN (R) connectors with a duplex LC



US Conec MDC



Obsolete Connectors

Deutsch 1000

Deutsch 1000 was probably the first commercially successful fiber optic connector. It was really a "pin vise" holding a stripped fiber. The nose piece is spring loaded and was pushed back when the connector was inserted into a mating adapter. The fiber stuck out into a drop of index matching fluid on a plastic lens. This solution was state of the art in the late 70s, yielding about 3 dB loss. Many users remember it as the connector on the front panel of the original Tektronix OTDR.



SMA

Amphenol developed the SMA from the "Subminiature A" hence SMA, microwave connector. The model 905 had a machined ferrule exactly 1/8 inch in diameter that mated in a machined adapter. When the adapters were not precise enough for better fibers, a necked-down ferrule that mated with a Delrin adapter for better insertion loss performance. These connectors are still in use on some military and industrial systems.



BICONIC

This is the Biconic, the yellow body indicating a SM version - MMs were usually black. Developed by a team led by Jack Cook at Bell Labs in Murray Hill, NJ, the Biconic was molded from a glass-filled plastic that was almost as hard as ceramic. It started with the fiber being molded into the ferrule. This lasted until the company could get a 125 micron/5mil pin insert into the plastic mold, at which point the fiber was glued into the ferrule with epoxy. When singlemode versions first appeared, the ferrules were ground to center the fiber core in the ferrule to reduce loss. Since it was not keyed and could rotate in the mating adapters, it had an airgap between the ferrules when mated, meaning loss was never less than 0.3 dB due to fresnel reflection. Usually MM Biconics had losses of 0.5-1 dB and SM 0.7 dB or higher.



Jack Cook retired from Bell Labs, obtained a license from AT&T and started Dorran Photonics to make Biconic connectors which later became 3M fiber optics.

Biconic is covered in the TIA connector intermateability standard [FOCIS-1](#) (TIA-604-1).

NEC D4

The NEC D4 was probably the first connector to use ceramic or hybrid ceramic/stainless steel ferrules. It uses a smaller ferrule than SCs or FCs. It was widely used in telco networks in the 80s to early 90s and some may still be in use.



AMP OPTIMATE

The AMP Optimate was popular in the early 80s. It used a conical plastic ferrule and screw-on nut. It was available for every fiber size including plastic fiber. Some may still be in use in utility and industrial systems.



FDDI - ESCON

Besides the SC Duplex, you may occasionally see the FDDI and ESCON* duplex connectors which mate to their specific networks. They are generally used to connect to the equipment from a wall outlet, but the rest of the network will have ST or SC connectors. Since they both use 2.5 mm ferrules, they can be mated to SC or ST connectors with adapters.



FDDI - above - has a fixed shroud over the ferrules

ESCON - below - the shroud over the ferrules is spring-loaded and retracts



*ESCON is an IBM trademark

MT-RJ

MT-RJ is a duplex connector with both fibers in a single polymer ferrule. It uses pins for alignment and has male and female versions. Multimode only, field terminated only by prepolished/splice method.

MT-RJ is covered in the TIA connector intermateability standard [FOCIS-12](https://www.tiaonline.org/standards/604-12) (TIA-604-12).

MT-RJ, Volition and Opti-Jack (below) are difficult connectors to test, as most test sets do not allow direct adaptation to the connector. If you have to use hybrid (ST or SC to MT-RJ) reference cables, you cannot do a Method B (one jumper reference) insertion loss test. Usually the solution is to do a three cable (Method C) reference.



Volition

3M's Volition is a slick, inexpensive duplex connector that uses no ferrule at all. It aligns fibers in a V-groove like a splice. Plug and jack versions, but field terminate jacks only.

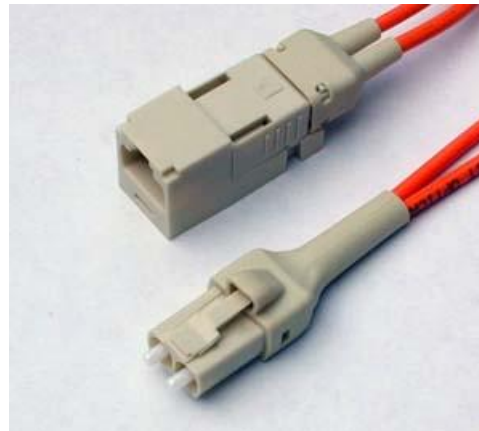
Volition is covered in the TIA connector intermateability standard [FOCIS-7](#) (TIA-604-7).



Opti-Jack

The Panduit Opti-Jack is a neat, rugged duplex connector cleverly designed around two ST-type ferrules in a package the size of a RJ-45. It has male and female (plug and jack) versions.

Opti-Jack is covered in the TIA connector intermateability standard [FOCIS-6](#) (TIA-604-6).



And More...

And there were more - TRW built a connector that had an internal mechanical splice, Kodak entered the game with the LAMDEK, an expanded beam connector using molded lens technology from their cameras and many more - more than 100 by our count!

Here is a list of some of the fiber optic connectors of the past taken from a listing of fiber optic connector adapters for FOTEC fiber optic power meters:

- AMP Optimate single fiber connector
- SMA (905 & 906 Style, NATO Standard)
- Augat OK & CL Series
- H-P HFBR-4000
- H-P HFBR-0500
- AMP Optimate DNP
- Deutsch 1000
- Deutsch 4000
- Siecor
- ITT FOT/OCN 101/201
- WECO LB1B
- Biconic:WECO LA1A, Dorrn,Auto Conn,OFTI
- NRC fiber holder
- Bare fiber adapter
- Radiall F705-017-000
- Switchcraft
- Diamond, Interoptics
- Stratos, Holtek
- Hughes
- NEC D4

GTE Expanded Beam
Hughes Contact
AMP Optimate Duplex
Deutsch 6000 Expanded Beam
Plessey
Plessey Ferrule
NTT FC
LEE TEC Single Mode
Amphenol Bayonet
G+H/Breechlok Contact
Sumitomo Mini BNC
Deutsch 3000, Expanded Beam SMA
AT&T ST
Lamdek (Kodak)
Philips 2000 Series
Radiall Optoball F-714
Seimens LWL (DIN 47255)
Socapex
ITT FOSCLN5C
AT&T Rotary Splice
T&B Ansley (Plastic Fiber)
Amphenol Mini Bayonet (906-200-5000)
Radiall VFO 710
Diamond Interoptic Din
Cannon duplex (FOTC)
FDDI Duplex
Serti Bayonet Biconic
Sony Seiko
Methode Size 16 Contact
Dupont Duplex
TELLAB/MOLEX
IBM DUPLEX
NTT SC-P
NTT SC2-P
European RACE
Diamond ES2000
Amphenol MFM
H-P HFBR-4516
AMP Mini DNP
Siemens SV400
F07 Duplex
Panduit OptiJack
MIL-T029504/14
Lucent LC
MT-RJ
3M Volition

Also see [Fiber Optic Connector Terminology](#) and [The FOA Online Reference Guide to Fiber Optics](#).

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