Tooling

F780

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Pages

ASSEMBLY KITS

The assembly kits contain all the tools required to assemble the corresponding series.
They are supplied with a clear assembly procedure.

Series	Part Number
LC	**F780 850 000**
SC / FC / ST	**F780 844 000**
FSMA	**F780 454 000**

LC ASSEMBLY KIT: F780 850 000

The kit contains all the required tools to assemble LC connectors.

Kit content:

Tool	Part Number	Quantity
Curing oven (220V)	**F780 483 000**	1
Manual polishing tool (PC straight polishing)	**F780 633 000**	1
Crimp tool (print 3.4mm)	**F780 057 000**	1
Inner sleeve insertion tool	**F780 290 000**	1
Cable stripping tool	**F780 033 000**	1
“Miller” primary stripper (for 900 µm coating)	**F780 025 000**	1
Soft rubber polishing base	**F780 812 000**	1
Ceramic scoring blade	**F780 136 000**	1
Microscope X100 (LC fitted)	**F780 652 000**	1
Ceramic scissors	**F780 039 000**	1
Solvent dispenser	**F780 809 000**	1
Set of cleaning paper	**F780 527 000**	6
Waste container	**F780 811 000**	1
Bag of 10 polishing 0.3 µm films *	**F780 827 000**	1
Bag of 10 polishing 1 µm films *	**F780 826 000**	2
Bag of 10 polishing 3 µm films *	**F780 825 000**	1
Bag of 10 abrasive strips 12 µm *	**F780 508 000**	1
6 bags of epoxy resin OE184 *	**F780 242 000**	1
Bag of 5 syringes *	**F780 217 000**	1

** Consumables*

Other items included in the kit: Ruler, tweezers, adhesive paper, containers for resin preparation, thermometer.

SC / FC / ST ASSEMBLY KIT: F780 844 000

The kit contains the common tools to assemble SC, FC or ST connectors.
Kit content:

Tool	Part Number	Quantity
Curing oven (220V)	**F780 463 000**	1
"No-Nik" buffer stripper (for 250µm)	**F780 026 000**	1
"X-Cellite" outer jacket stripper (for 2.8mm cable)	**F780 037 000**	1
"Miller" primary stripper (for 900µm coating)	**F780 025 000**	1
Soft rubber polishing base	**F780 812 000**	1
Ceramic scoring blade	**F780 136 000**	1
Microscope X100	**F780 233 000**	1
Ceramic scissors	**F780 039 000**	1
Solvent dispenser	**F780 809 000**	1
Waste container	**F780 811 000**	1
Set of cleaning papers *	**F780 527 000**	1
Set of 50 cleaning tips *	**F780 584 000**	1
Bag of 10 polishing 0.3 µm films *	**F780 827 000**	1
Bag of 10 polishing 1 µm films *	**F780 826 000**	2
Bag of 10 polishing 3 µm films *	**F780 825 000**	1
Bag of 10 abrasive strips 12 µm *	**F780 508 000**	1
Bottle of abrasive solution *	**F780 318 000**	1
6 bags of epoxy resin OE184 *	**F780 242 000**	1
Bag of 5 syringes for ST connector *	**F780 243 000**	1
Bag of 5 syringes for FC / SC connectors *	**F780 219 000**	1

** Consumables*

Other items included in the kit: Ruler, tweezers, adhesive paper, containers for resin preparation, cable / fiber preparation template, thermometer.

FSMA ASSEMBLY KIT: F780 454 000

The kit contains the required tools to assemble F-SMA connectors.
Kit content:

Tool	Part Number	Quantity
Adjustment plug	**F708 900 000**	1
Polishing gauge	**F780 003 000**	1
Torque wrench	**F780 020 000**	1
10 Lapping disks 9µm	**F780 127 000**	1
10 Lapping disks 0.3µm	**F780 129 000**	1
Resin applicator	**F780 132 000**	1

CLEANING KITS

The cleaning kits are designed for cable assembly and adaptor users. They include the cleaning procedure.

Series	Part number	Content
SC/FC/ST	**F780 585 000**	50 cleaning tips, cleaning paper, adhesive roll and bottle for alcohol.
EC	**F780 532 000**	50 cleaning tips, cleaning paper, adhesive roll and bottle for alcohol.

MAINTENANCE KIT

This kit includes all the cleaning and inspection accessories required to maintain EC installations.
It includes the cleaning procedure.

Series	Part number	Content
EC	**F780 531 000**	100x microscope, 10x microscope, 3 EC adapters, dust caps for plugs and adapters, 50 cleaning tips, cleaning paper, adhesive roll and bottle for alcohol.

TUNING KIT for SC / FC series

The tuning kit contains all the required tools to "Tune" SC and FC connectors and a user friendly procedure.

The tuning technique optimizes the insertion loss by allowing the fiber cores to be very well aligned.
The tuning consists in rotating the optical ferrule to locate the core in a pre-determined permanent sector, thus reducing the off-set between fiber cores (IEC 61300-2-41).

- Reduces operating time thanks to Radiall's user-friendly tuning tools
- Reliable fiber alignment thanks to 6 locking points already adjusted and secured in the factory.
- No risks for fiber as the optical faces are separated during the tuning operation.
- PC and APC connectors can be tuned.
- The tuning kit includes an adjustment patchcord terminated with a FC connector.
- A zirconia sleeve mounted on the adjustment plug ensures that the optical ferrules are correctly aligned within the tool. This sleeve is mobile and can be easily replaced by the user.

Series	Part number	Content
SC FC	**F780 600 000** **F780 601 000**	• 1 tuning tool • 2 adjustment patchcords **(F780 610 000)** • 2 bags of 6 Zirconia alignment sleeves **(F718 113 206)** • 50 cleaning tips **(F780 584 000)** • 1 book of 6 cleaning paper **(F780 527 000)** • 1 SC housing removal tool (only in SC kit) **(F780 582 000)**

Please refer to the "technical data" section of this catalogue, for more details on the tuning technique.

CLEANER FOR CONNECTORS

Description	Series	Part number	Packaging
Set of cleaning papers	All	**F780 527 000**	6 bags
Box of cleaning papers KIMWIPES	All	**F780 552 000**	1
Set of cleaning tips	Termini	**F780 424 000**	50
Set of cleaning tips	EC	**F780 525 000**	
Set of cleaning tips	ST / FC / SC	**F780 584 000**	

GLUEING PRODUCTS

Description	Series	Part number	Packaging
Bag of epoxy OE 184	All	**F780 242 000**	6 bags
Bag of epoxy 353ND	All	**F780 242 010**	
Syringes (pink)	SC / FC	**F780 219 000**	5
Syringes (green)	ST	**F780 243 000**	
Syringes (pink)	LC	**F780 217 000**	
Resin injector	EC / LuxCis	**F780 504 000**	1
Needles	SC / FC	**F780 581 000**	10

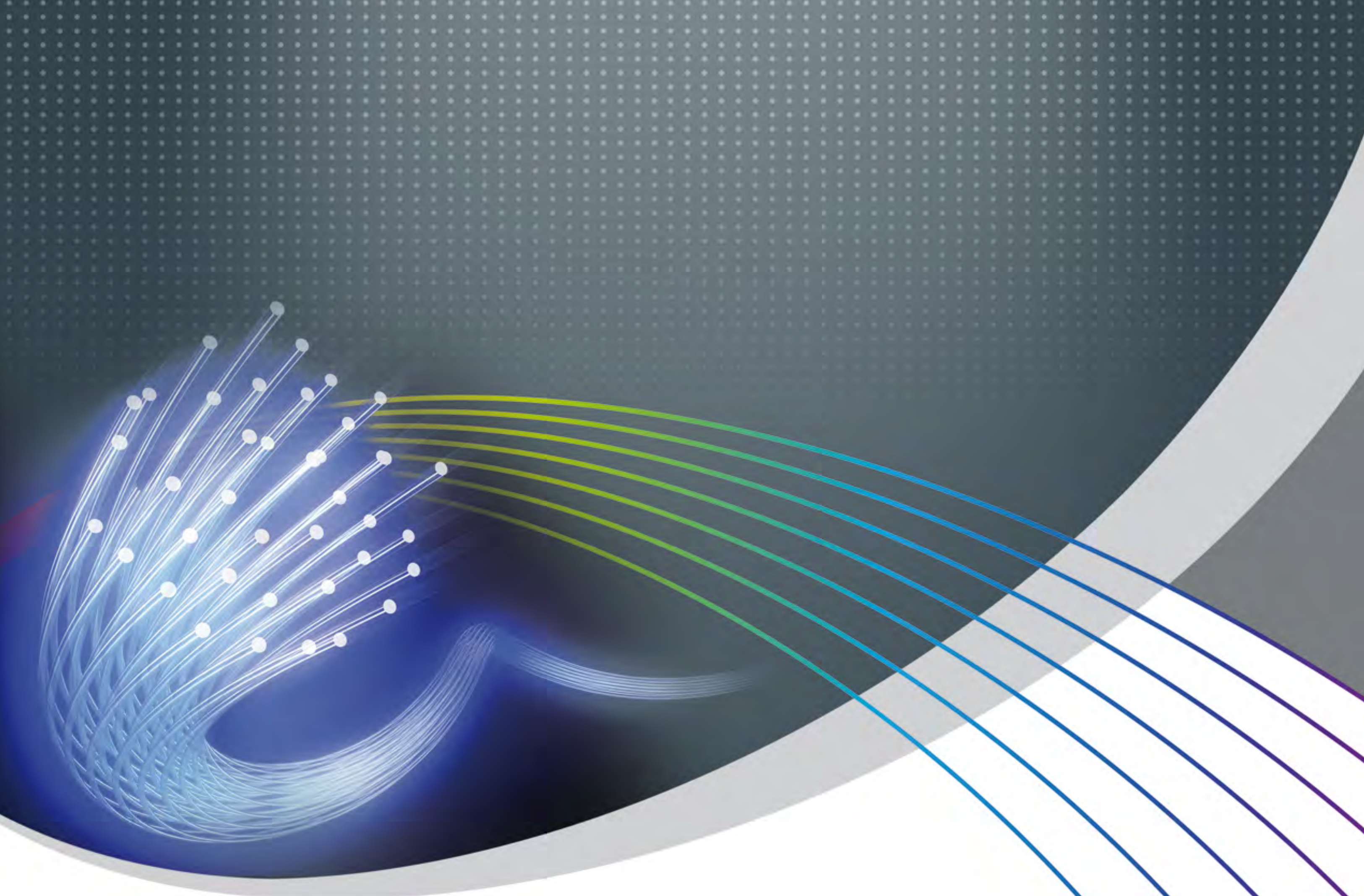
MISCELLANEOUS TOOLS

Description	Part number	Packaging
Ceramic scissors	**F780 039 000**	1
Bottle of index matching gel	**F780 134 000**	
Ceramic scoring blade	**F780 136 000**	
Solvent dispenser	**F780 809 000**	

Please consult Radiall for information on jigs for polishing machines, accessories, consumables and procedures.

NOTES

NOTES



Technical Information and Glossary of terms

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CONTENTS

OPTICAL FIBERS

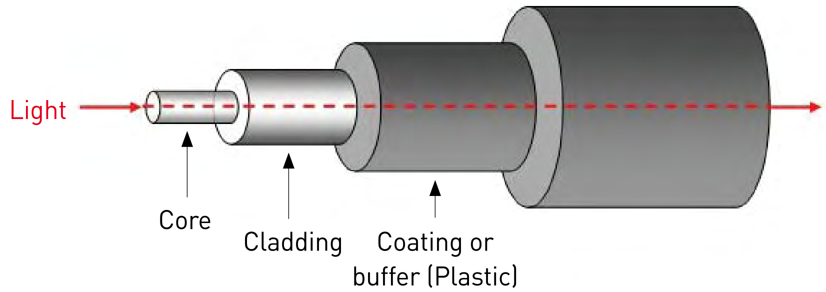
DEFINITION

Optical fiber is a "light pipe" carrying pulses of light generated by lasers or other optical sources to a receiving sensor.

Optical fibers are widely used in communications as they permit transmission over longer distances and at higher bandwidths (data rates) than other forms of communication. Fibers are used instead of metal wires because signals travel along them with less loss and are also immune to electromagnetic interference.
Most of the fibers are manufactured from high purity silica glass-like rods drawn into fine hair-like strands and covered with a thin protective plastic coating.

An optical fiber consists of:

- A transparent core in which the light propagates
- A transparent optical cladding that confines light in the core
- An outer coating (plastic buffer) acts as a protection and allows the glass rod to be curved.



Then, fibers are subsequently packaged in various cable configurations (Jacket) before installation in the external or internal networks.

LIGHT PROPAGATION

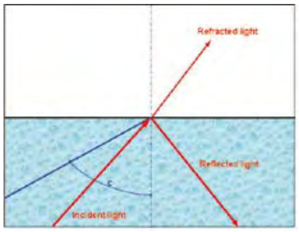
Light pulses are launched into the core region. The surrounding cladding layer keeps the light traveling down the core and prevents light from leaking out. This phenomenon is called: Total internal Reflection.

When light crosses a boundary between 2 mediums with different refractive index (n1 & n2), the light beam is partially refracted and partially reflected. This depends on the incidence angle and the refractive index of each medium.

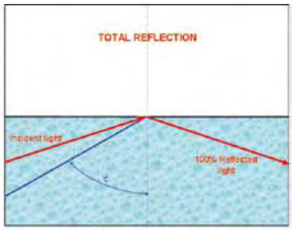
If light comes from a more optical dense medium (n1) and with an angle bigger than the "critical angle", then all the light is reflected.

Let's take an example: reflection of the light at the surface of water – light is coming from the water:

air n2 = 1
water n1 = 1.3
n1>n2



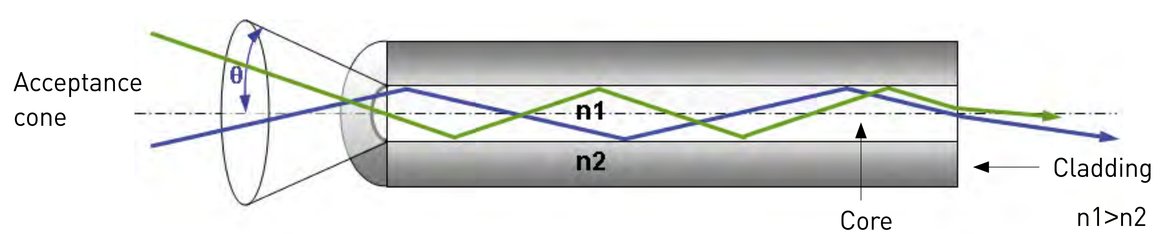
Light is partially reflected
and partially refracted because
its angle of incidence is < c (critical angle)



Light is totally reflected because
its angle of incidence is > c (critical angle)

The light rays are totally reflected by the interface between the air and the water (different refractive index n1>n2) if the incident angle is larger than the critical angle (c) with respect to the normal to the surface.

In an optical fiber, the light travels through the core (n1 high index of refraction) by constantly reflecting from the cladding (n2, lower index of refraction) because the angle of the light is always greater than the critical angle.



The light rays are totally reflected by the cylindrical surface between the core and the cladding because of their different refractive index: To confine the light (the optical signal) into the core, the **refractive index** of the cladding must be lower than that of the core: **n1 > n2.**

Light travels along the fiber bouncing back and forth off of the boundary. Because the light must strike the boundary with an angle bigger than the critical angle, only light that enters the fiber within a certain range of angles can travel down the fiber without leaking out. This range of angles is called the acceptance cone of the fiber. The size of this **acceptance cone** is a function of the refractive index difference between the fiber's core and cladding.

In simpler terms, there is a **maximum angle** from the fiber axis at which light may enter the fiber so that it will propagate in the core of the fiber. The sine of this maximum angle is the **Numerical Aperture** (NA) of the fiber. Fiber with a larger NA requires less precision to splice and work with than fiber with a smaller NA. *(SingleMode fiber has a small NA)*.

REFRACTIVE INDEX

The refractive index (n) describes the way light travels into a substance. It is expressed as a ratio of the speed of light in vacuum relative to that in the considered substance.

n = velocity of light in a vacuum / velocity of light in medium

For example, the refractive index of water is 1.33, meaning that light travels 1.33 times as fast in a vacuum as it does in water.

Typical refractive index:

refractive index of vacuum : n = 1 (reference/minimum value that cannot be improved)
refractive index of air : n = 1.0003 (value very close to the vacuum)
refractive index of glass : n ≈ 1.5

DISPERSION

This is the main cause of bandwidth limitations in a fiber. Dispersion causes a broadening of input pulses along the length of the fiber.

Three major types are:

- modal dispersion caused by differential optical path lengths in a MultiMode fiber
- material dispersion caused by a differential delay of various wavelengths of light in a waveguide material
- waveguide dispersion caused by light travelling in both the core and cladding materials in SingleMode fibers
- As a result of the dispersion, the light pulses spread out over time and thereby restrict the bit rate and/or the length of efficient optical link.

OPTICAL FIBERS

MAIN FIBER TYPES

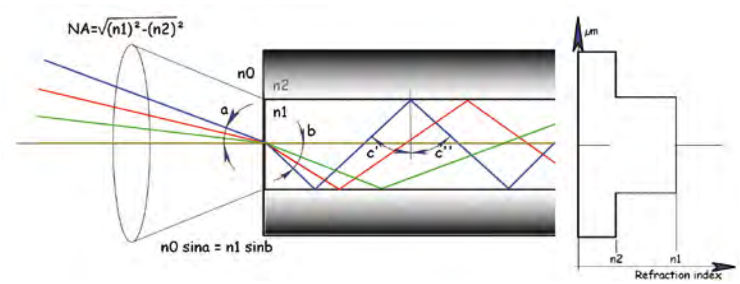
There are 2 types of optical fibers:

- MultiMode (MM) fibers where the fiber core can receive several light rays (or several propagation modes).
  2 technologies exist for MultiMode fibers: Step index and graded index fibers.
- SingleMode (SM) fibers with only one propagation mode

Step-index MultiMode fiber

In a step-index MultiMode fiber, many rays of light are guided along the fiber core by total internal reflection. Rays that meet the core-cladding boundary at a high angle, bigger than the critical angle for this boundary, are completely reflected. The critical angle (minimum angle for total internal reflection) is determined by the difference in refractive index between the core and cladding materials. Rays that meet the boundary at a low angle are refracted from the core into the cladding, and do not convey light and thus information along the fiber.

The critical angle determines the acceptance angle of the fiber, often reported as the Numerical Aperture. A high numerical aperture allows light to propagate down the fiber in rays both close to the axis and at various angles, allowing efficient coupling of light into the fiber. However, this high numerical aperture increases the amount of dispersion as rays, at different angles, have different path lengths and therefore take different times to traverse the fiber.



" step " index profile:
speed light is constant
inside the fiber core

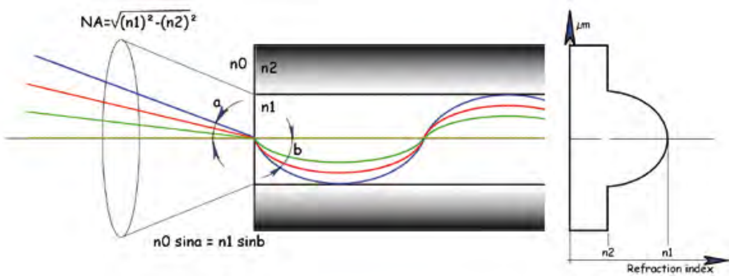
Shorter path (thus shorter propagation time)
Longer path (thus longer propagation time)

In short:

- Different light pathways (modes)
- Light rays arrive separately at a receiving point
- Space between pulses to prevent overlapping limits bandwidth
- Best suited for transmission over short distance
- Widely used, low cost
- High numerical aperture adapted to wide optical source (LED)

Graded index MultiMode fiber

A graded-index MultiMode fiber contains a core in which the refractive index decreases gradually from the center axis out toward the cladding. The higher refractive index at the center makes the light rays moving down the axis advance more slowly than those near the cladding. Also, rather than zigzagging off the cladding, light in the core curves helically because of the graded index, reducing its travel distance. The shortened path and the higher speed allow light at the periphery to arrive at a receiver at about the same time as the slow but straight rays in the core axis. As a result: the light rays suffer less dispersion.



" gradient " index profile: speed light changes from center to edge inside the fiber core (speed higher for longer ways)

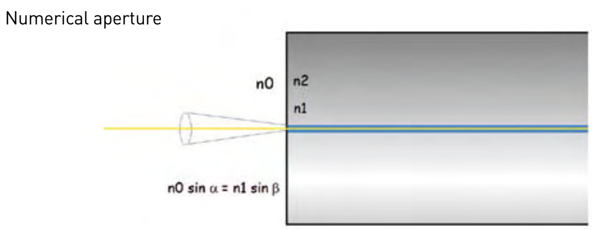
In short:

- Different light pathways (modes)
- Arriving at the same time at a receiving point
- Digital pulse is affected by less dispersion. Offers hundred of times more bandwidth than step index fibers.
- Best suited for transmission over medium short distance
- More expensive than step index fiber
- High numerical aperture adapted to wide optical source (LED)

SingleMode fiber

SingleMode fiber only supports one light ray (one mode of light propagation), because of the reduced dimension of the core.

For instance, the core diameter is 9 µm for a SingleMode propagation of wavelength from 1300 nm to 1550 nm. For such a core size, only one propagation mode is possible in the fiber, removing modal dispersion and giving higher transmission rate.

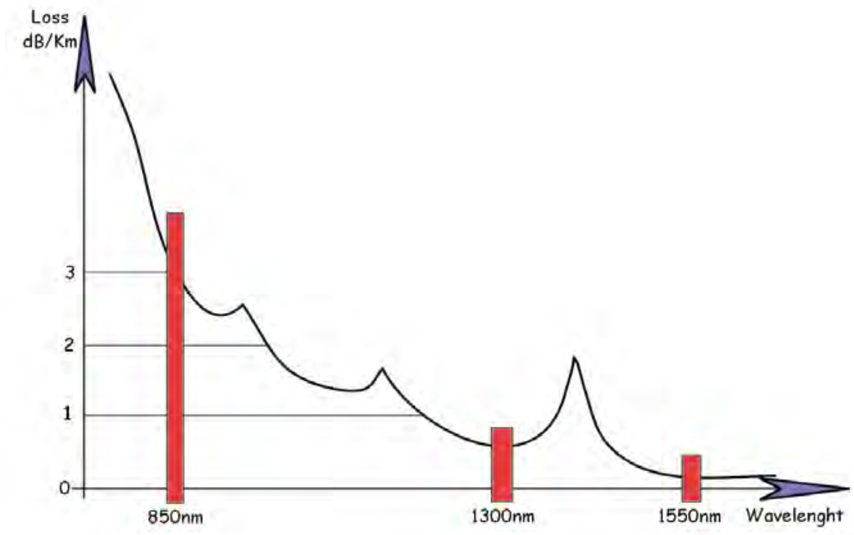


Core is so small that the light has only one way to propagate into the fiber

In short:

- 1 light pathway (mode) parallel to the axis
- Very limited pulse dispersion
- Adapted for long distance transmission
- Very widely used, not expansive for telecom wavelengths expensive
- Small numerical aperture adapted to high coherence optical source (Laser)

TYPICAL TRANSMISSION PROPERTIES OF GLASS FIBERS



For Telecommunication and for glass optical fibers, we use light in the infrared region, typically around 850, 1300 and 1550 nm due to low attenuation of the glass fiber at those wavelengths.

Glass fiber are the most common fibers used for telecom applications.

The ISO/IEC11801 specification describes the data rate and reach of optical fiber grades referred to as OS1, OS2, OM1, OM2, OM3 and OM4. The MultiMode fibers are prefixed with “OM” and the SingleMode mode “OS”.

The related performances of existing fibers at the standard telecom used wavelength are summarized below:

				Minimum modal bandwidth MHz x km		
		Maximum attenuation dB/km		Overfilled launch bandwidth (LED source)		Effective Laser Launch bandwidth
Optical fiber type	Core diameter µm	850 nm	1300 nm	850 nm	1300 nm	850 nm
OM1	62.5	3.5	1.5	200	500	-
OM2	50	3.5	1.5	500	500	-
OM3	50	3.5	1.5	1 500	500	2 000
OM4	50	2.5	0.8	3 500	500	4 700

		Maximum attenuation dB/km	
Optical fiber type	Core diameter µm	1 310 nm	1 550 nm
OS1	9	1	1
OS2	9	0.4	0.4

The distance capability of the fibers is expressed below according to the different Gigabit Ethernet standards:

	1000BASE-SX 1 Gbit/s	10GBASE-S 10 GBit/s	40GBASE-SR4 40 Gbit/s	100GBASE-SR10 100 GBit/s
OM1	275 m	33 m	-	-
OM2	550 m	82 m	-	-
OM3	-	300 m	100 m	100 m
OM4	-	550 m	150 m	150 m
OS2	-	-	10 km	10 km

Multi-mode fiber has higher "light-gathering" capacity than SingleMode optical fiber. In practical terms, the larger core size simplifies connections and also allows the use of lower-cost electronics which operate at the 850 nm and 1300 nm wavelength (SingleMode fibers used in telecommunications operate at 1310 or 1550 nm and require more expensive laser sources).

Losses caused by bend:

Bending a fiber leads to some leakages of the high-order modes out of the fiber. The smaller the bending radius is the greater the losses are. Fibers with a low numerical aperture (as SingleMode fibers) are more sensitive to the bending than fibers with a high N.A. A minimum bending radius is specified for each type of fiber. Some fibers, like the G657 SingleMode fiber are optimized to decrease the sensitivity of performances to bends.

The minimum bending radius will vary with different cable designs. The manufacturer specifies the minimum radius to which the cable may safely be bent during installation, and for the long term. The former is somewhat shorter than the latter. The minimum bend radius is in general also a function of tensile stresses, e.g., during installation, while being bent around a sheave while the fiber or cable is under tension. If no minimum bend radius is specified, one is usually safe in assuming a minimum long-term low-stress radius not less than 10 times overall diameter for MultiMode cables, and 20 times overall diameter for SingleMode cables.

Beside mechanical destruction, another reason why one should avoid excessive bending of fiber-optic cables is to minimize microbending and macrobending losses. Microbending causes light attenuation induced by deformation of the fiber while macrobending causes the leakage of light through the fiber cladding and this is more likely to happen where the fiber is excessively bent.

CONNECTORS

According to Telcordia Generic Requirements for SingleMode Optical Connectors and Jumper Assemblies, optical fiber connectors are used to join optical fibers where a connect/disconnect capability is required.

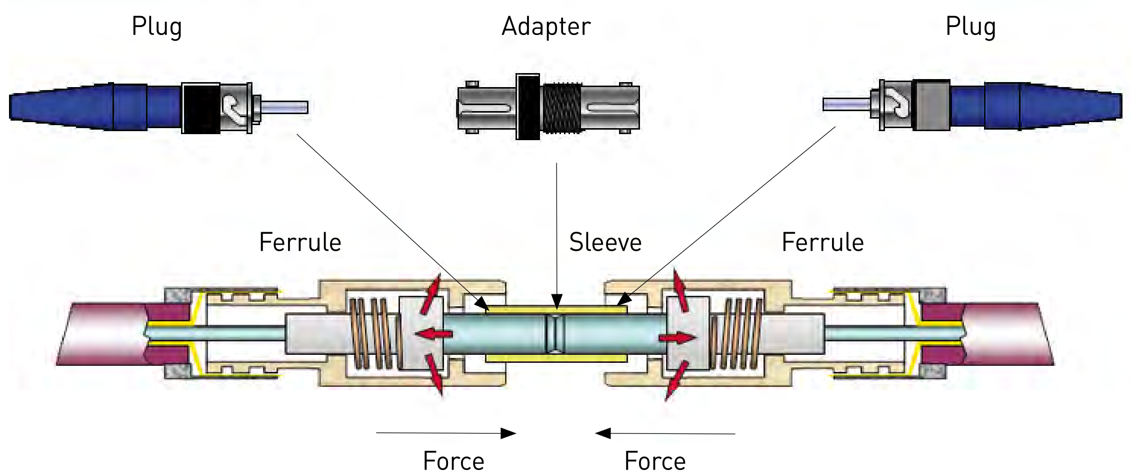
ALIGNMENT TECHNOLOGIES

There are several alignment technologies to connect the cores of fibers so that light can pass:

- Physical Contact: Fibers are core to core mechanically contacted
- Expanded beam: Beams are shaped by lens ; no contact
- Matching membrane: Fibers are mechanically aligned and fibers ends are immerged in optical index adaptation medium ; no contact
- Air gap : Fibers are not in contact. Light goes through air.

Physical contact (PC, UPC and APC): e.g. LC, SC, FC, ST, ODC, R2CT, OSIS series and LuxCis

For that technology, a connector assembly consists of an adapter and two connector plugs.
Fibers are core to core mechanically contacted. The ferrule of the plugs are aligned into a guiding sleeve belonging to the adapter. Optical losses depend on the quality of the optical interface and the accuracy of the alignment between the 2 ferrules.

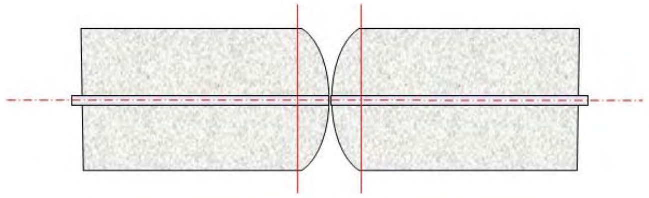


End face polishing techniques:

The fiber is glued into the ferule and the end faces of ferrule and fiber are polished.
3 types of polishing are available: PC, UPC and APC providing different performances levels.

- PC and UPC polishing:

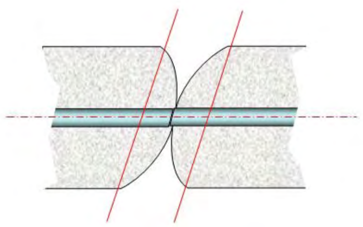
Available for all types of fibers, SingleMode or MultiMode, the PC (Physical Contact) is a curved polishing, centered on the optical axis.



PC: RL > 30 dB
UPC: RL > 50 dB

The UPC (Ultra Physical Contact) polishing may be required for SingleMode fibers: the geometry is the same as PC and leads to the same level of insertion losses but the quality of polishing is higher and provides Return Losses of 50 dB (compared to 30 dB in PC).

- APC polishing:

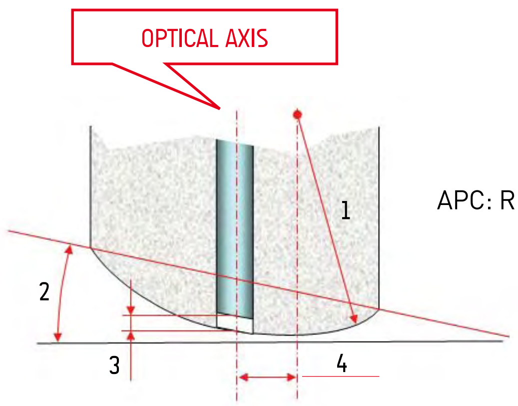


APC (Angled Physical Contact) is a tilted curved polishing required for SingleMode fibers.

This type of technology achieves excellent Return Losses (60 dB), useful to protect sensitive light sources like laser diode from optical feedback.

The polishing angle enables to reject the part of the return losses generated by the optical face reflection (Fresnel loss).

1/ End face Radius 5≤R≤ 12mm
2/ Polishing Angle 8° or 9°
3/ Fiber Extension ± 0.1µm
4/ Apex Offset < 50µm

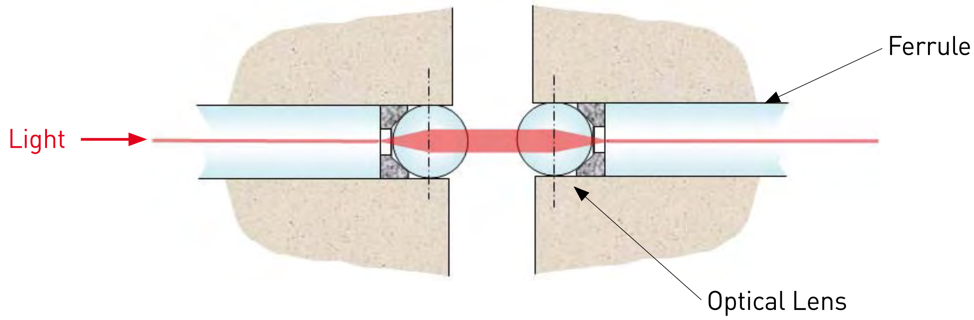


APC: RL > 60 dB

CONNECTORS

Expanded beam: e.g. Probeam series

In that technology, light is expanded at the output of the fiber thanks to a ball lens, collimated and transmitted across an air gap.
By using a symmetric system for the opposite plug, the light can be refocused back down to the core of the receiving fiber.

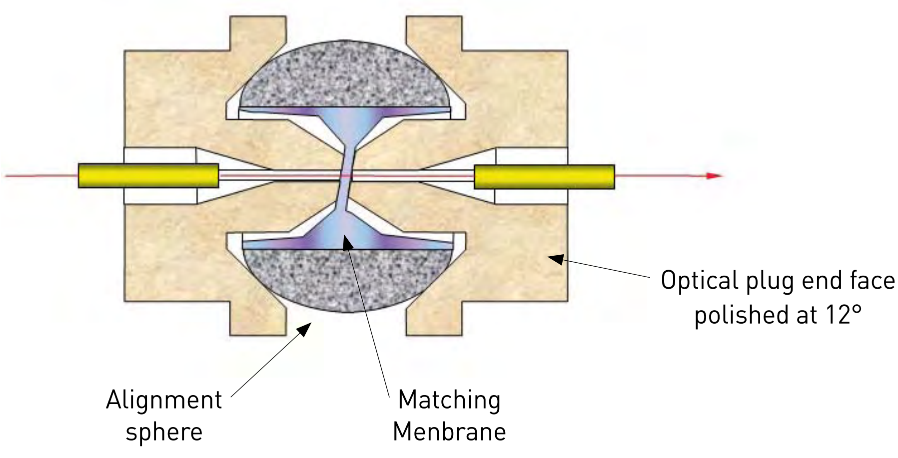


Most of the time, no adaptor is required for that type of assembly: the plugs are able to connect to each other.

Thanks to the beam expansion, the optical connection is less sensitive to dust and lateral misalignment.
As the optical ends are not in physical contact, there is no damage to the fiber even after repeated matings: These optical connectors allow a high number of mating.
Optical losses are mainly due to air gap (Fresnel loss). They also depend on the accuracy of the positioning of the ferrule to the lens (focal distance).

Matching membrane: e.g. EC series

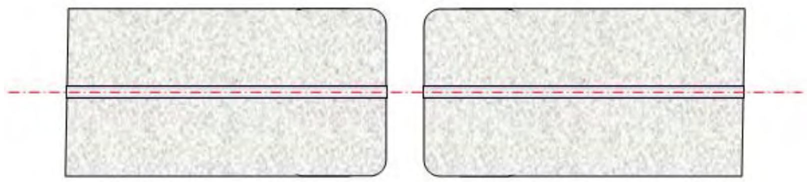
For that type of connection, the plugs are pushed one to each other inside a sleeve of an adaptor but are not in physical contact. An index matching medium is set between the fibers' ends, ensuring optical continuity for the light traveling from the first fiber to the second one. This matching element acts as a light bridge transferring light without significant losses.



Because the optical fiber ends are not in physical contact, there is no damage to the fiber end. This technology offers a high number of mating with no degradation of optical performance.

Air gap: e.g. F-SMA series

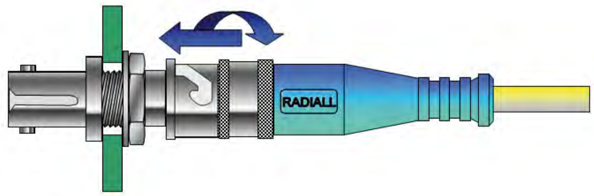
Air gap technology was used in early connectors. Because they didn't have keyed ferrules and could rotate in mating adapters, they needed an air gap, between the connectors, to prevent them rotating and grinding scratches into the optical faces of the fibers.



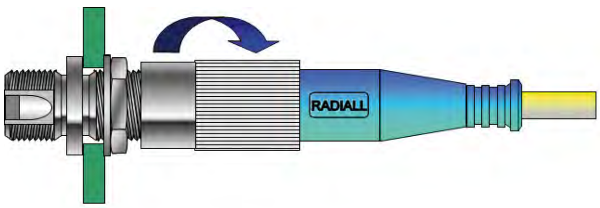
LOCKING TECHNOLOGIES

There are numerous types of plugs and sockets to connect optical fibers, using threaded, bayonet, push-pull and snap-lock connections.

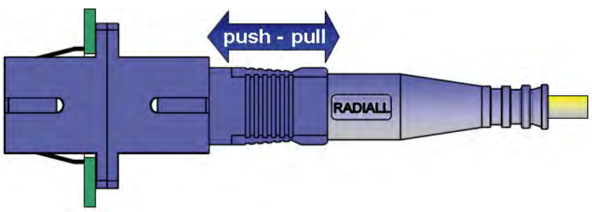
Bayonets: e.g. ST series



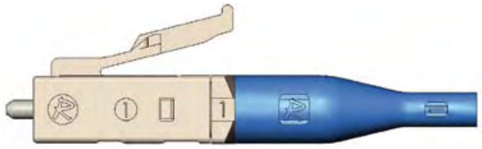
Screw-in: e.g. FC, ODC series



Push-pull snap-in: e.g. SC, EC series



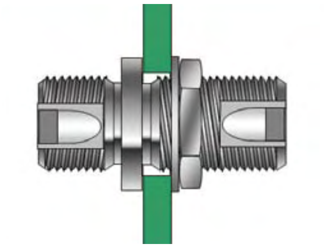
Push pull latched: e.g. LC series



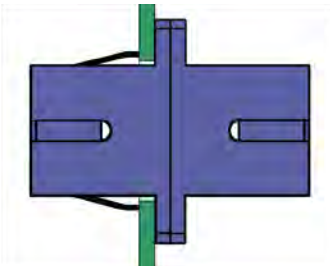
CONNECTORS

PANEL MOUNTS TECHNOLOGIES

Bulkhead: screw and nut feed through technology



Snap-in: elastic spring technology

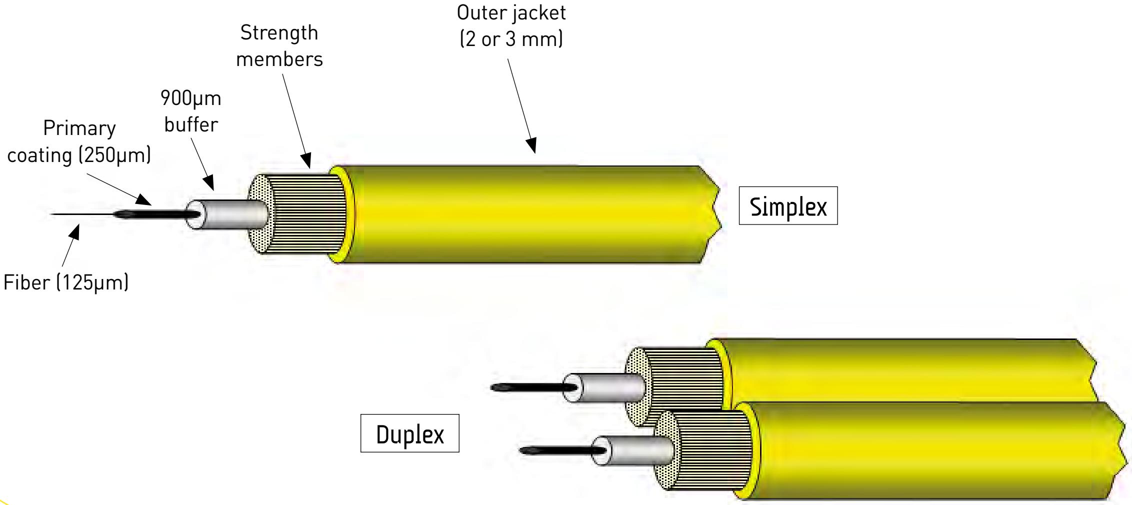


CABLES

In order to cope with any stress (tensile, bending, torsion...) or environmental conditions (weather, abrasion, chemical, thermal...), fiber optics need to be protected by a suitable cable structure.

TYPICAL INDOOR CABLES

For inside buildings, houses, equipments. Typical temperature range: -20°C / +70°C



For indoor cables, there are 2 basic designs of cable structures: loose and tight. Both contain some strength members, such as aramid yarn or glass fibers.

Loose structure cables

- The optical fiber (250µm) is inside a plastic protective tube that allows limited movements of the fiber
- Usually contains a water resistant gel surrounding the fiber
- Usually dedicated to pigtails

Tight structure cables:

- The fiber is strictly immobilized inside the jacket. This structure allows no movement of the buffered fiber with respect to the outer jacket and strength members
- Good behavior with temperature changes
- More robust than loose-tube cables, they are best suited for moderate length LAN or WAN connections, long indoor runs, direct burial and for underwater use.

Simplex

Sindex

Duplex

Multiples fibers

Indoor Fiber Optic Cable Fire prevention:
Fire prevention standards are not the same for European and US markets.

For European market, communications cables must typically comply with IEC 60332-3 (EN 50266) or IEC 60332-1 (UL VW1) fire tests depending on application. In most of the countries LSZH (Low Smoke Zero Halogen) material are mandatory. LSZH (low smoke zero halogen) cable jackets are composed of fire retardant materials that reduces the amount of smoke emitted when combusted. A feature in LSZH is that they contain zero halogen during combustion. They have been cited as an ideal cable jacket in high risk areas of fire or crowded public locations.

For the US market, communication cables must comply with the National Electrical Code (NEC) requirements. There are three types of indoor spaces identified by NEC: plenums, risers and general purpose areas.

- What is a plenum area and plenum rated fiber optic cable?
  Plenum is an air-handling, air flowing and air distribution system space such as that found above drop ceiling tiles or heating and ventilation ducts. Plenum rated cables must meet UL-910 specification and their outer jacket are made of materials that retard the spread of flame, produce little smoke and protect electronic equipment from damage in fires.
- What is a riser area and riser rated fiber optic cable?
  Riser is a pathway such as floor opening, shaft or duct that runs vertically through floors. Riser rated cables can be run through building vertical shafts (risers) or from one floor to another floor. Riser rated cables must meet UL-1666 fire-resistance specification and cannot be installed in plenum area. However plenum rated cables can be used as a substitute for it and installed in riser spaces.
- What is a general purpose area?
  Any space on the same floor which is not plenum or rise is identified as general purpose area.

CABLES

Based on NEC code, indoor fiber optic cables can be categorized as six types. You can see their designation and respective UL test below:

NEC Code	Description	Cable Application	UL Test	Possible Substitute
OFNP	Optical Fiber Nonconductive Plenum Cable	Plenum, overhead, fiber only	UL - 910	
OFCP	Optical Fiber Conductive Plenum Cable	Plenum, overhead, hybrid (fiber/wire)	UL - 910	
OFNR	Optical Fiber Nonconductive Rise Cable	Riser, backbone, fiber only	UL - 1666	OFNP
OFCR	Optical Fiber Conductive Rise Cable	Riser, backbone, hybrid	UL - 1666	OFCP
OFN	Optical Fiber Nonconductive	General purpose, horizontal, fiber only	UL - 1581	OFNP, OFNR
OFC	Optical Fiber Conductive	General purpose, horizontal, hybrid	UL - 1581	OFCP, OFCR

TYPICAL OUTDOOR CABLES OR AEROSPACE

Cable structure definition per ARINC 802:

- Loose structure: a fiber optic cable structure that allows limited movement of the buffered fiber (usually the 900 µm) with respect to the outer jacket and strength member.
- Tight structure: a fiber optic cable structure that allows no movement of the buffered fiber with respect to the outer jacket and strength member.

For communication uses:

- Distribution fiber cables: this compact building cable consist of individual 900 microns buffered fiber. For connectors mounting the fibers ends are generally re-tubed with a 2 mm buffer.
- Breakout fiber cables: breakout cables are also called fanout cables. In tight buffered cables each fiber is only a 900um tight buffered fiber, but in breakout cables every fiber is a subcable by itself. Each fiber has a 2~3mm jacket, then outer jacket covers these subcables, aramid yarn and ripcord inside. This design allows users to divide the cable to serve users with individual fibers, without the need for patch panel. Breakout cable enables the quick installation of connectors onto 2+mm robust jacketed fiber.

For aerospace application, fiber optic cables are ruggedized to withstand harsher environment conditions, such as temperature range, abrasions resistance. Flammability and toxicity are also major requirements.

COLOR CODING

The buffer or jacket on indoor patchcord is often color-coded to indicate the type of fiber used:

Buffer / jacket color	Designation
Yellow	SingleMode optical fiber
Orange	MultiMode optical fiber
Aqua	MultiMode OM3 optical fiber (optimised for 850nm)
Purple	For aerospace cables

Outdoor patchcords are most of the time, black.

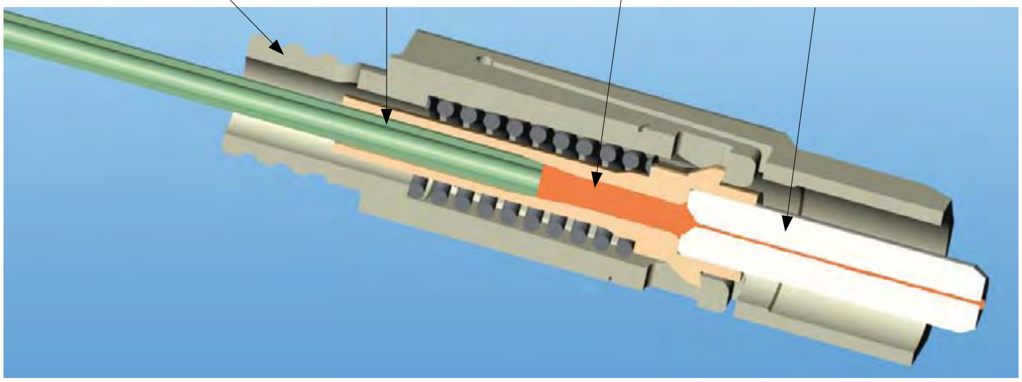
TERMINATION PROCESS AND RADIALL TECHNOLOGIES

Different technologies to terminate connectors on optical fibers exist. In all the cases, the connector mounting should be performed following supplier's instructions.

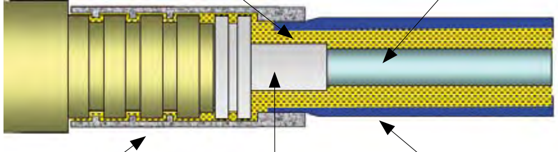
There are different criteria that should be considered for these different techniques: connector performance, mounting time, connector price, mounting easiness, yield, and required tooling...

Steps to terminate connectors onto fibers:

- Stripping: remove the protective polymer coating around the optical fiber itself
- Gluing: glue the fiber inside the ferule
- **Secure bonding®**: an exclusive RADIALL patented system protects the floating mechanism during the resin-injection process. A slot on the crimping body allows removing the syringe freely without the needle touching any sensitive inner surface.
  This system avoids calibrating the volume with a dispenser. The resin will be injected inside the cavity, with no risk of excess or insufficient volume, thus guarantying proper fiber retention.
  (Too much resin can break the fiber during the connection while not enough resin does not properly maintain the fiber).



- Crimping: secure the fiber position inside the connector
  Crimping reliability® (RADIALL patent): Only one crimp operation is required for both strength members and jacket retention. A mini metallic tube (inner sleeve) is inserted between the fiber and the cable jacket to protect the fiber and avoid any stress. The shape of the crimping ring is adapted to ensure excellent cable retention.



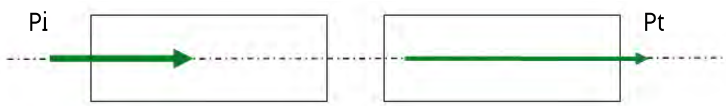
CONNECTOR MOUNTING

- Polymerization: cure the fiber/ferule assembly. Polymerization is most of the time made with hot process, but can be done also with cold one, for field installation for instance.
- Polishing: Different techniques for different performance: PC, UPC or APC.
  PC Polishing can be manual, whereas it is recommended to use automatic polishing machines for UPC and APC. RADIALL proposes pre-angled connectors (LC & SC series) with a 8° pre-polishing of the ferule for faster fiber termination process.
  Inspection: Visual inspection of the fiber end face to detect any crack or dust that would impact the connection.

IL AND RL MEASUREMENTS

In order to qualify how efficiently light is transmitted in a connection, we measure two key characteristics:

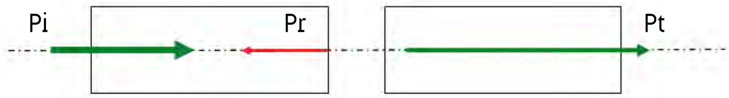
- Insertion Loss (IL or attenuation) refers to the loss of signal power (light) resulting from the insertion of a device (for example a connector) in a transmission line or optical fiber. Insertion loss can result from absorption, misalignment or air gap between the fiber optic components. The smaller the Il, the better.



IL= - 10log (Pt/Pi)

Pi: incident Power
Pt: transferred Power

- Return loss (RL) is the ratio of the reflected optical power to the incident power. When light is transmitted into a connector, a portion of light is reflected back from the fiber end face. It is desirable for this figure to be as high as possible (meaning to have as little reflected light as possible) to avoid problems with transmission lasers.



RL (dB) = -10 log (Pr/Pi)

Pi: incident Power
Pt: transferred Power
Pr: reflected Power

IL and RL measurement methods are described in IEC 61300 standards (Fiber optic interconnecting devices and passive components – Basic test and measurement procedures).

Specifically:

- IEC 61300-3-4: Examinations and measurements - Attenuation
- IEC 61300-3-34: Examinations and measurements - Attenuation of random mated connectors
- IEC 61300-3-6: Examinations and measurements - Return loss

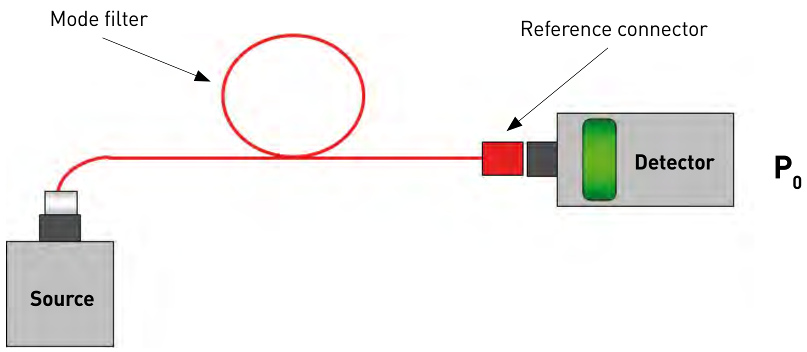
Radiall connectors are tested according to these methods:
- IEC 61300-3-4 method B: This method describes the procedure to the insertion loss due to one cabled end (or attenuation) based on a master reference.

This measurement is based on the use of an optical power meter. The power meter consists of an optical detector and associated electronics for processing the signal.
2 measurements of power are required for each measurement of attenuation, A:

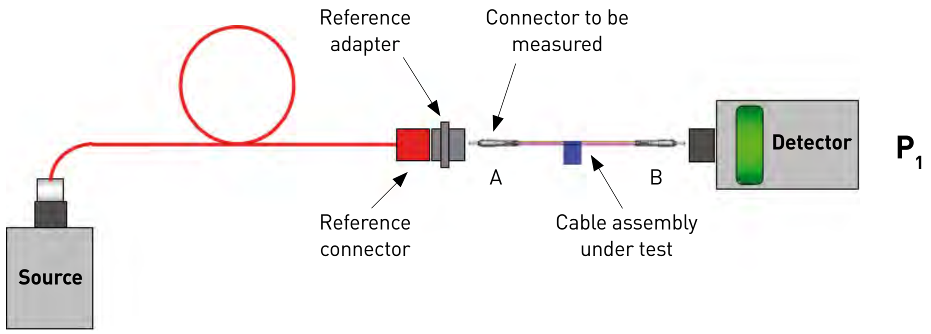
$$A= -10 \log (P_1/P_0) \text{ dB}$$

Where P_1 is the measurement of power with the Device Under Test (DUT) in the circuit
Where P_0 is the measurement of power without the DUT in the circuit

1st step: Measure of P_0 - calibration of the measurement tools
- Connect the reference connector on the Detector
- Measure P_0 power



2nd step: Measure
- Insert the cable assembly between the reference connector and the detector
- Measure P_1 to get the connector extremity A insertion loss
- Turn the cable assembly and measure P_1 to get the connector extremity B insertion loss



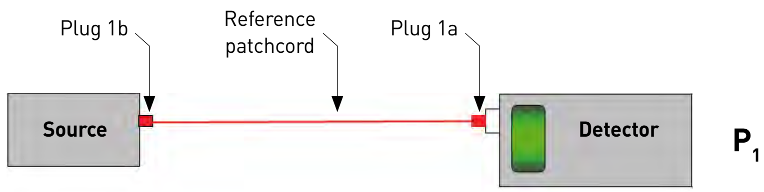
This measurement only includes the plug on the source end of the DUT in the measurement. To measure both ends of the DUT the measurement shall be repeated with the patchcord reversed.

- IEC 61300-3-34: This method describes the procedure to measure the statistical distribution and mean attenuation for random mated optical connectors.

This method is based on the use of random patchcords and adaptors. All the connectors are sequentially used as “reference” plugs and all the remaining are tested against them.

CONNECTOR MOUNTING

1st step: Measure of P_1



2nd step: Measure

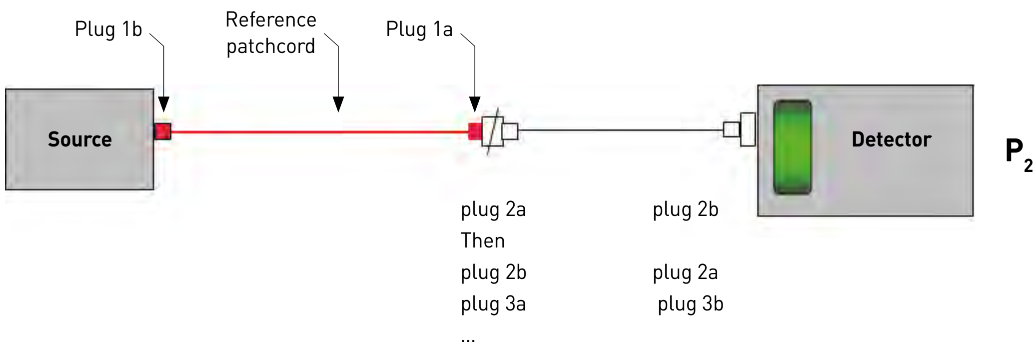
The loss of each mated connector pair (1a/2a, 1a/2b, 1a/3a, ... 1b/2a, ..., 2a/3a, ...) is calculated with the following equation:

A = -10 log (P1/P2) dB – (AxL) dB

Where A is the fiber attenuation per kilometre

L is the length of fiber in km

Note: the product (AxL) may be ignored when patchcord length is <10 m

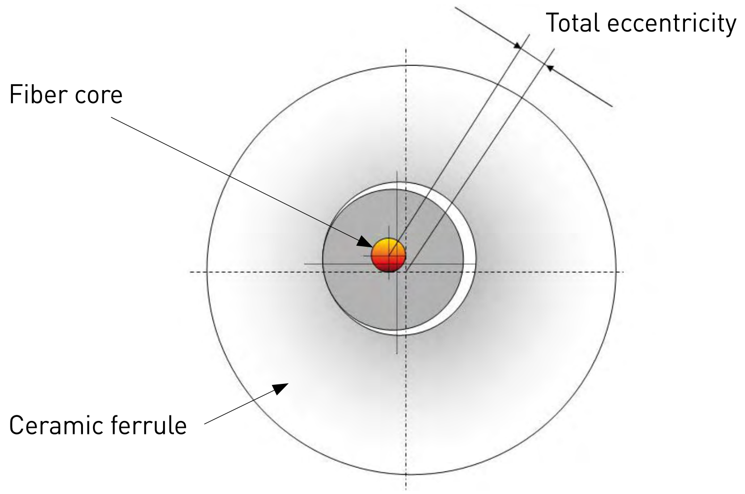


TUNING OF CONNECTORS TO MINIMIZE RANDOM IL

Radiall **SC and FC series** can be tuned to optimise fibers' core alignment and thus highly reduce Insertion Loss on random connections.

This competitive advantage is based on providing one-piece tuneable connectors®, a radiall exclusivity, which can be tuned to 1 of 6 angular positions.

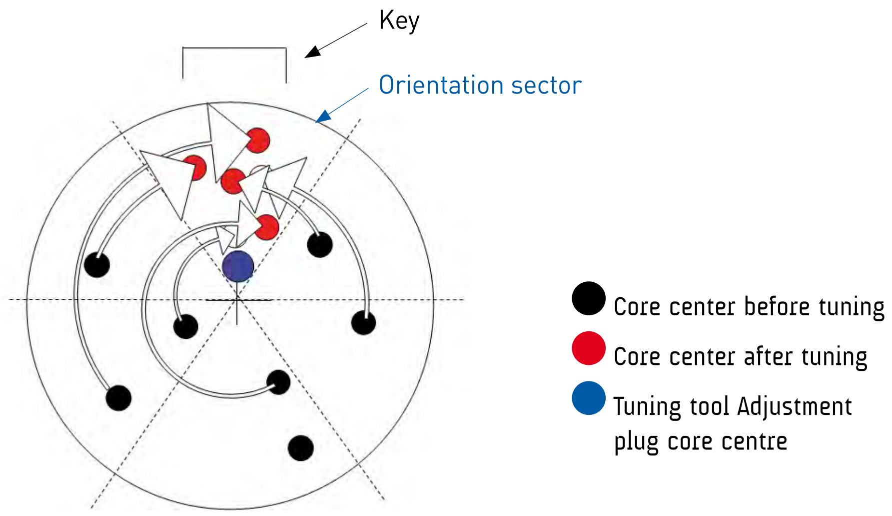
In standard connectors, the fiber core is randomly positioned around the ferrule axis.



The tuning technique consists of rotating the optical ferrule, after cabling, in order to locate the core in a pre-determined permanent sector, thus reducing the offset between fiber core (IEC 61300-2-41 definition).

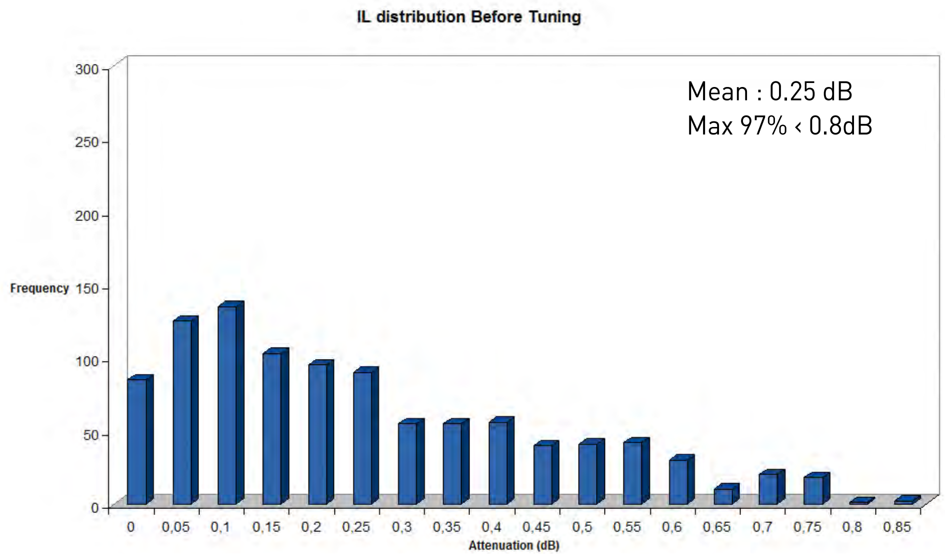
6 angular positions are available to locate the core of the fiber in a reduced sector range. The offset between the connected fibers is then reduced and the attenuation of 2 connectors is statistically divided by 2.

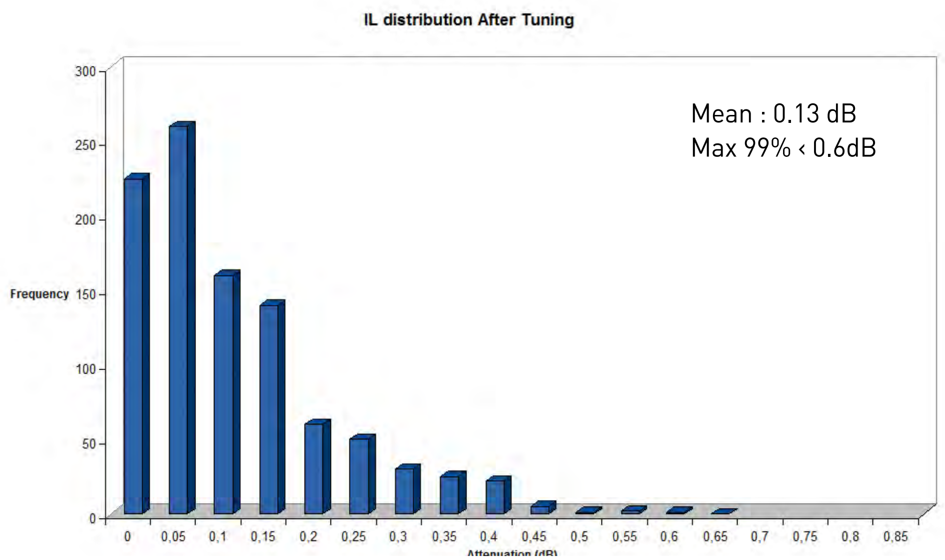
The misalignment between the different optical cores is reduced after tuning each connector:



CONNECTOR MOUNTING

These graphs show the typical statistical distribution of SingleMode SC connector before and after tuning:





PC and APC connectors can be tuned.

To enable its customers to benefits from the tuning technique, Radiall also provides a precision and user friendly tuning tool with short operating time. There is no risk to the fiber as the optical faces are not in contact during the tuning operation.

Please, refer to "Tooling" section for more detail on this tuning kit.

APC connector: **A**ngled **P**hysical **C**ontact connector with the end-face polished at 8° (or 9° in some cases). This polishing profile provides very low back reflection (RL>60 dB).

Attenuation: Reduction in the optical signal power in a fiber (expressed in dB at a specific wavelength) due to scattering, absorption, mode conversion or at a coupling point (connector, splice).

Bending radius: Maximum radius of bending for a fiber without breaking and not exceeding a predetermined attenuation value.

Bonding: Gluing technology to immobilize the fiber inside the optical ferrule.

Buffer coating: A protective layer, such as an acrylic polymer, applied over the fiber cladding.

Bulkhead panel mounting: Panel attachment of a connector using a screw and nut feed through technology.

Cladding: The outer concentric layer that surrounds the fiber core and has a lower index of refraction such that light at sufficiently large angles of incidence is totally reflected back into the core.
In other words: the entire, optically transparent material of a fiber, except the core.

Core: The central area of an optical fiber which serves as a waveguide.
It has a refractive index higher than the surrounding cladding.

dB: Decibels. Unit of measurement of optical power.

Duplex connector: Consists of two simplex connectors.

Ferrule: A cylindrical part, usually ceramic, which holds and aligns the fiber in a connector.

Fiber buffer: Consists of one or more materials that is used for protecting the individual fibers from damage and provides mechanical isolation and/or mechanical protection.

Flange mount: Panel connector screwed into the wall and requiring several holes (5 holes for square flange, 3 holes for rectangular flange).

Graded-index fiber: An optical fiber where the core has a non-uniform refractive index. The core is composed of the glass where the refractive index decreases from the center axis with a predetermined profile. The purpose is to reduce modal dispersion and thereby increase fiber bandwidth.

HCS fiber: Hard-Clad Silica fiber. Fiber with a silica/silica or plastic core and hard polymer cladding, which is tightly bonded to the core.

IEC: International Electro technical Commission.

Insertion Loss: The loss of power that results from inserting a component, such as a connector or splice, into a previously continuous path.

Jacket: Outer part of the buffer. A protective covering over a fiber optic cable, usually the very outermost layer of the cable.

GLOSSARY OF TERMS

Key : A feature of a terminus that prevents the terminus from rotating when it is installed in a connector. This ensures proper alignment of tuned termini and termini that use an APC polish. The key also prevents torsion stress from being applied to the portion of the fiber that is within the terminus.

Loose structure cable : A fiber optic cable structure that allows limited movement of the fiber with respect to the outer jacket and strength member.

Mechanical ferrule / crimp ferrule : Immobilization technology used to secure the connector at the extremity of the fiber.

Mode : In guided-wave propagation, such as through a waveguide or optical fiber, a distribution of electromagnetic energy that satisfies Maxwell's equations and boundary conditions. Loosely, a possible path followed by light rays.

Optical ferrule : Guide pin for fiber connectors in which the fiber is secured (generally ceramics).

PC connector : Physical Contact connector. A specific ferrule end finish profile in which a plane that is tangent to the end face at the center of the fiber core is normal to the axis of the fiber.

PCF : Polymer Cladded Fiber.

POF : Plastic/Polymer Optical Fiber. Usually a large core (1mm) MultiMode fiber.

Pull-proof : A fiber optic cable and connector construction such that a pull applied to a single fiber behind the connector will not move or separate the ferrule end-faces.

Refraction : The change in direction experienced by a ray (wave) when it passes between different materials having different refractive indices.

Refractive index : The ratio of the velocity of light in free space to the velocity of light in a given material.

Removable duplex brace : Used to attach 2 simplex connectors in a duplex one.

Snap-in mounting : Panel attachment of a connector using an elastic spring feed through technology.

Screw-in mounting : Type of fastener characterized by a helical ridge, known as a thread, wrapped around a cylinder.

Step-index : An optical fiber core that has a uniform refractive index. This construction has a large modal dispersion as compared to graded-index fiber. This leads to pulse widening and limits the bandwidth as the pulses blur into one another.

Tight structure cable : A fiber optic cable structure that allows no movement of the fiber with respect to the outer jacket.

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