



# Qualified Partner Programme QPP

Fiber Optic Connector Theory

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Convincing cabling solutions

# Fiber optic theory / connection technique

**Basically, there are 3 possibilities to join optical fiber:**

- Detachable connection e.g. plugged connection
- Quasi-detachable connection e.g. mechanical splice
- Non-detachable connection e.g. fusion splice

**Which connection technique is being employed depends on:**

- the reliability or requirement of the connection
- the required or necessary flexibility
- the costs

# Overview

<b>Criteria's</b>	<b>Detachable<sup>2</sup></b>	<b>Quasi – Detachable</b>	<b>Not – Detachable</b>
Insertion loss $\alpha_s$ in [dB]	$0,05 < \alpha_s < 0,75$	$0,1 < \alpha_s < 0,5$	$0,05 < \alpha_s < 0,2$
Return loss $\alpha_R$ in [dB]	$15 < \alpha_R < 80$	$\alpha_R < 40$	$\alpha_R < 80$
Mounting on field	Appropriate	Appropriate	Appropriate
Repeated disconnect and connect	Very simple, without equipment and without the need of qualified personnel	Simple, simple equipment and qualified personnel needed.	expensive, high-quality equipment and need of very high qualified personnel.
Reliability / Lifespan	ca. 500 - 2000 Pcs. Cycles	Not	Very high
Costs <ul style="list-style-type: none"> <li>• Equipment</li> <li>• Initial Installation</li> <li>• Repeated disconnect and connect</li> </ul>	medium high very low	low high low	high low high
Alignment principle	Pins / sleeve (mech.)	V – groove (mech.)	Substance conclusive
Fiber contact	As usually a Physical Contact	Immersion between separation-surfaces	Substance conclusive

2

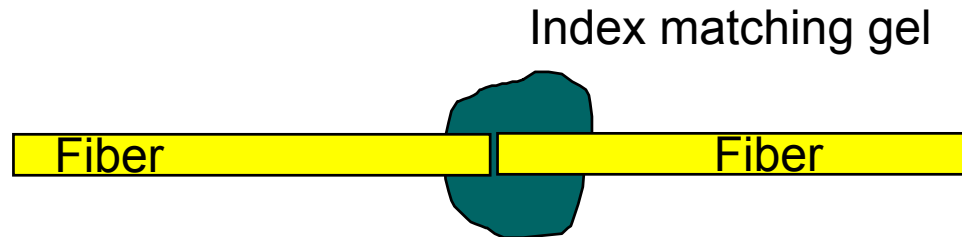
Dependent on the Connector Type and polishing (PC, SPC, UPC, APV = HRL)

- PC** Physical Contact, Return loss of approximately 30 dB, can be reached by manual polishing  
**SPC** Super Physical Contact, Return loss of approximately 40dB, can be reached by machine polishing  
**UPC** Ultra Physical Contact, Return loss of approximately 50 dB, can be reached by machine polishing and optical testing of the fiber positioning  
**APC (HRL)** Angle Physical Contact (High Return Loss), Return loss of approximately 60 dB, can be reached by machine polishing (usuallyl R. 8° Angle Polished)

# Quasi-detachable connection

## Operational principle

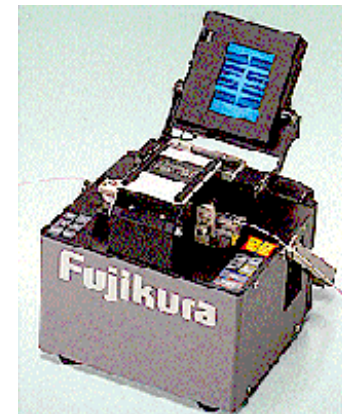
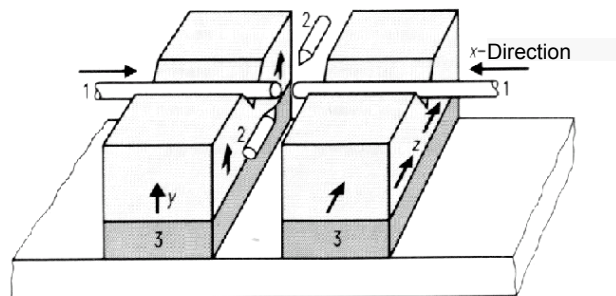
- Two precisely cleaved pieces of fiber are butt-joint
- To improve the performance there is a so-called index matching gel between the two fiber
- Drawing



# Non-detachable connection

## Operational principle

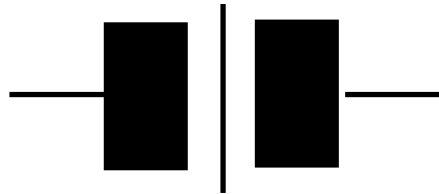
- The cleaned and cleaved fiber are brought together as closely as possible in a splicing device (if possible without horizontal or vertical displacement). Subsequently, the splice area is protected with a so-called splice protection and then deposited.



# Detachable connection

## Operating principle

- Connector/adaptor/connector principle



There are various types of end face polishes, differing in performance (RL, IL). They are:

- Flat
- Physical contact (PC)
- Angled physical contact (APC)
- Lens



# Insertion loss

Relative position:



Axial separation

Preparation of end face:

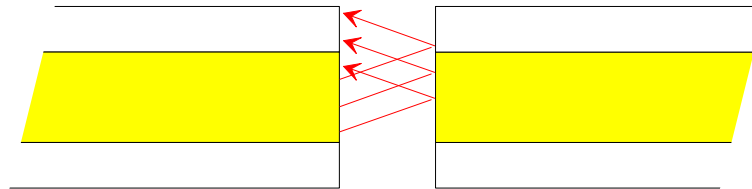


Surface roughness

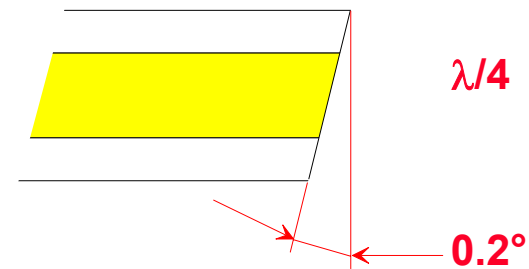


Angle

## Extrinsic



4% reflection on each endface is 0.36 dB loss



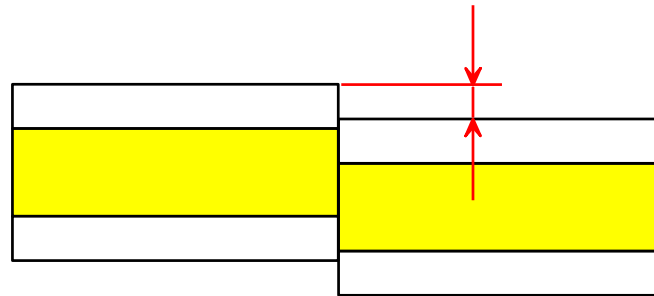
# Insertion loss

## Extrinsic

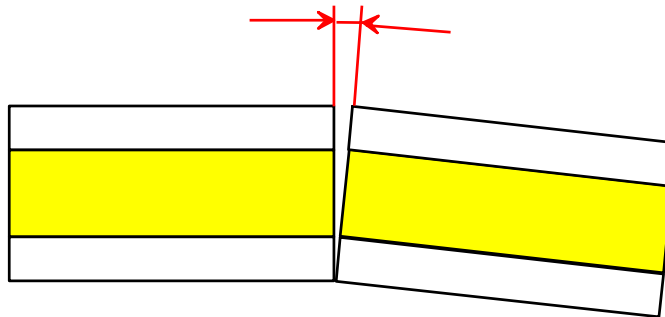
Relative position:



Lateral off-set



Axial tilt





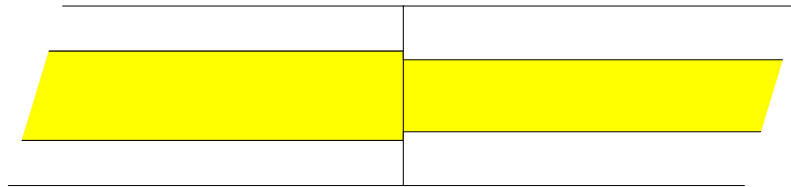
# Insertion loss

## Intrinsic

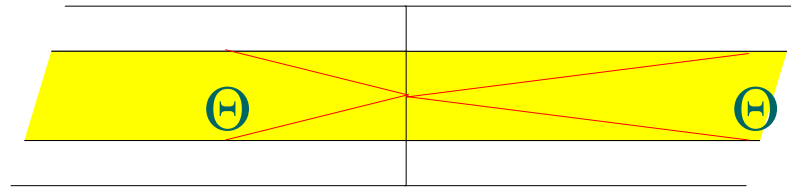
Differences in:



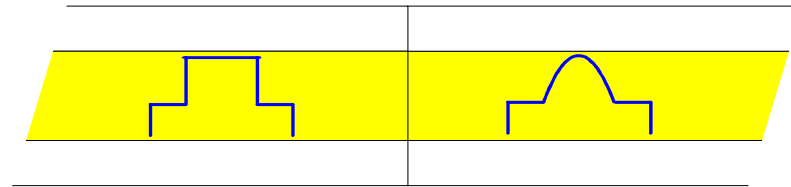
Core diameter



Numerical aperture



Refractive index profile



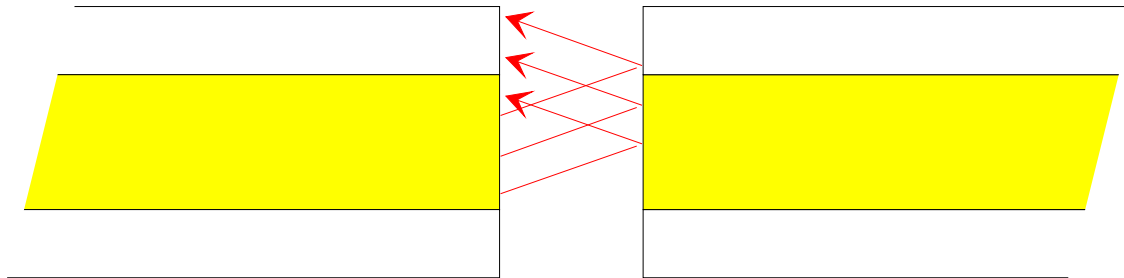
# Flat polish

**Non - butting ferrules**  
**No physical contact**

**Transmission specifications**

**Insertion loss < 1.0 dB**

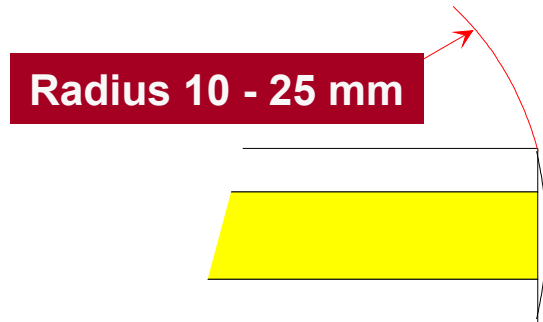
**Return loss ~ 15 dB**



**4% reflection on each endface results in 0.36 dB of loss**

# Physical contact (PC) polish

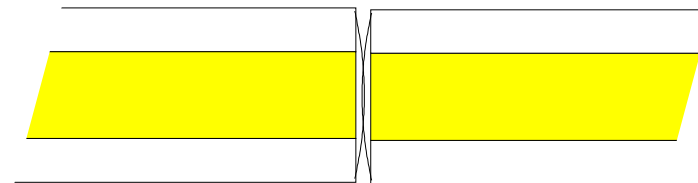
## Butting ferrules Spherical physical contact



### Transmission specifications

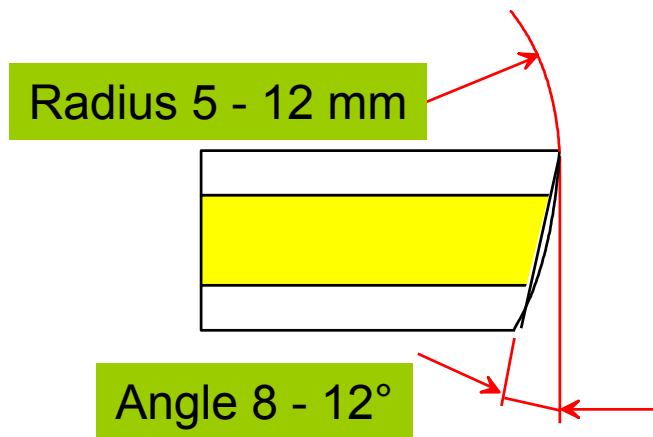
Insertion loss  $< 0.5$  dB

Return loss  $> 20$  dB



# Angled physical contact (APC) polish

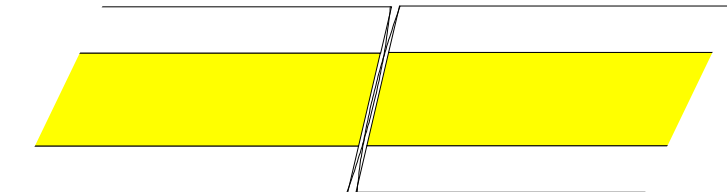
## Butting ferrules Angled spherical physical contact



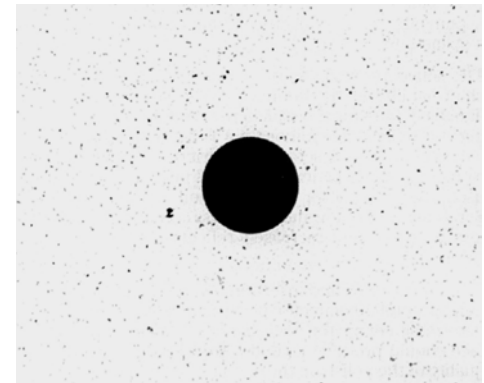
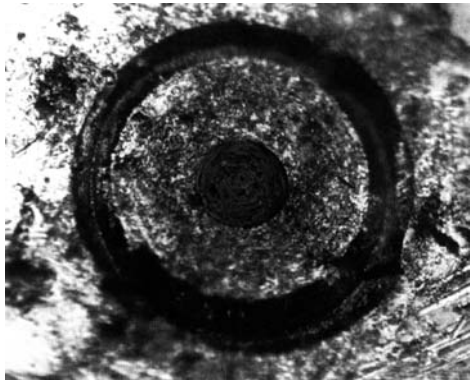
### Transmission specifications

Insertion loss < 0.3 dB

Return loss > 60 dB



# Connector cleaning



# Fiber optic theory / connection technique

- The 2 connectors are plugged into 1 adapter
- Structure principle (of 2.5 mm ferrule)

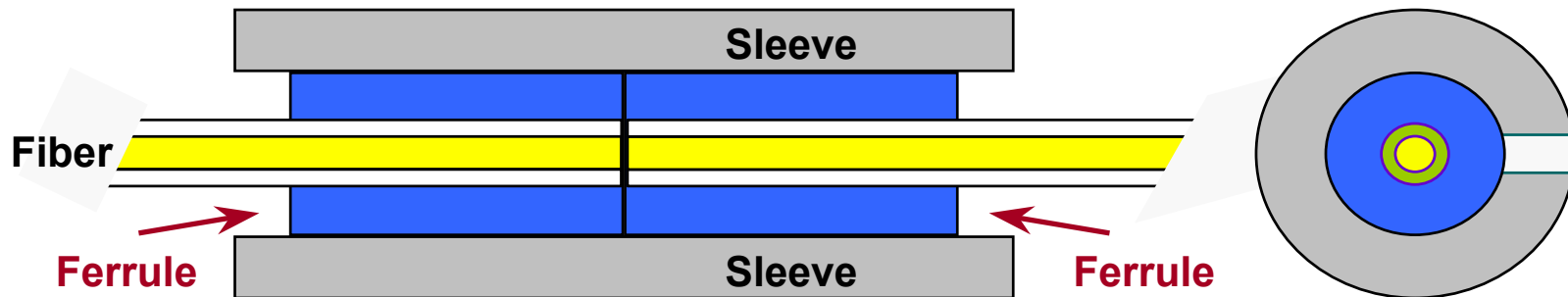
## Alignment technologies resilient sleeve

### Tolerance fields

Ferrule 2.4985 - 2.4995 mm  
Sleeve gauge retention force 2.9 - 5.9 N

### Materials

Ferrule ceramic (Zirconia)  
Sleeve ceramic (Zirconia) ⇒ SM  
PhBr ⇒ MM

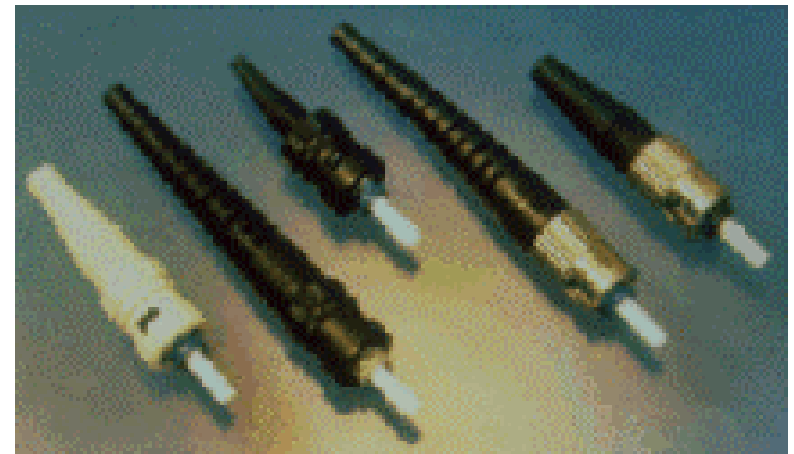


# Multimode connector set

## Specifications:

- Coupling mechanism
- Configuration
- Ferrule dimension
- Fiber category
- Fiber retention
- Cable retention
- Optical coupling
- Alignment
- Bayonet
- Plug-adapter-plug
- 2.500 mm nominal
- ceramic
- A, IEC 60793-2
- Adhesive
- Crimp
- Physical contact (PC)
- Resilient sleeve spring loaded ferrule

**ST-PC**  
**(ATT)**

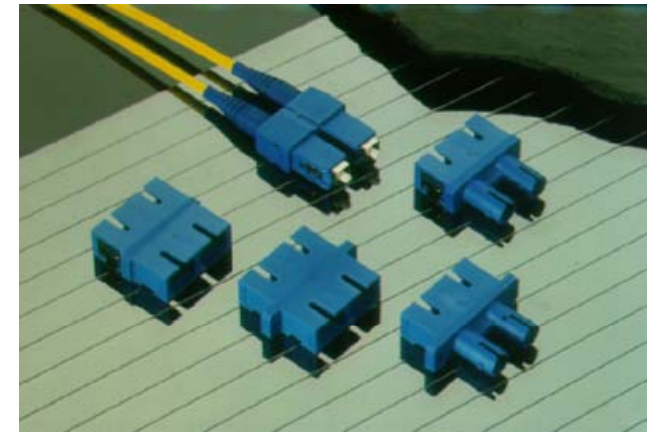


# Multimode / Single mode connector set

## Specifications:

- Coupling mechanism
- Configuration
- Ferrule dimension
- Fiber category
- Fiber retention
- Cable retention
- Optical coupling
- Alignment
- Colour coding
- Push-Pull
- Plug-adapter-plug
- 2.500 mm nominal
- ceramic
- A, IEC 60793-2
- B, IEC 60793-2
- Adhesive
- Crimp
- Physical contact (PC)
- Resilient sleeve
- Spring loaded ferrule
- Beige: Multimode, Blue: Single mode

## SC- Duplex Japan (NTT)



Singlemode version shown above



# Other connectors used for LAN applications

## FDDI connectors

- FDDI/ST adapters
- FDDI/FDDI adapters



## ESCON connectors (IBM applications)

- ESCON/ST adapters
- ESCON/ESCON adapters



## FC/PC connectors

- FC/FC adapters
- FC/ST adapters



## SMA connectors

- SM/SMA adapters



# New standard for connectors

## Small form factor connectors

# New standard for connectors?



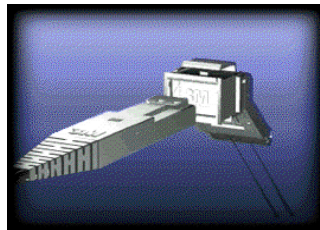
SC-DC/QC



Compact SC



LC

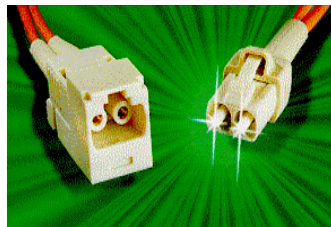


SG

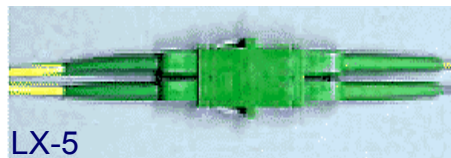
**Which  
one???**



Mini-MPO



Opti-Jack



LX-5



MT-RJ

# Duplex SC

Duplex SC is "The" approved connector for cabling solutions!!

If you want to have a standard compliant installation, you have to use a Duplex SC solution.....

....but....

What about the SFF?

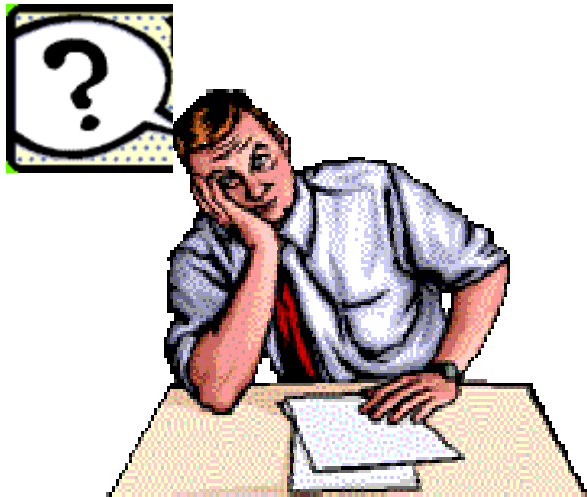
- Due to insufficient support for a change they'd initially **ALL** been rejected by the TIA/EIA and ISO/IEC 11801.

**They have now been recognised!!!!**

# Shall we forget about SFF connectors?

**Definitely not !!!**

# Predominant SFF connectors



**MT-RJ**



**LC**



**SC-DC**

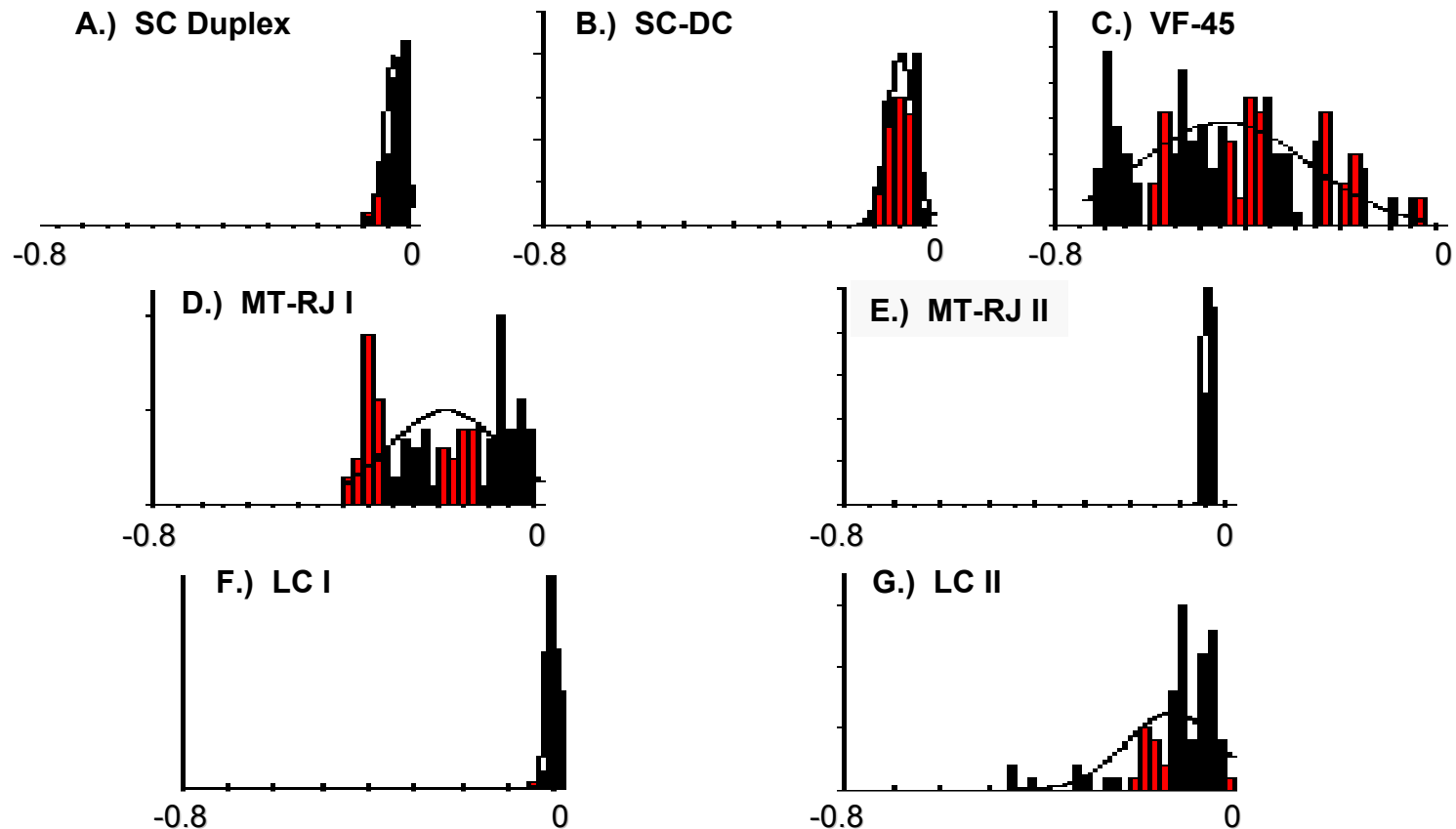


**VF-45**

# SFF mechanical comparison

	<b>LC</b>	<b>MT-RJ</b>	<b>SC-DC</b>	<b>VF-45</b>
Fiber spacing	6.25 mm	0.75 mm	0.75 mm	4.5 mm
# of ferrules	2	1	1	NA
Ferrule material	Ceramic	Plastic	Plastic	None
Alignment	Bore & Ferrule	Pin & Ferrule	Rail & Ferrule	V-Groove
Ferule size	Ø 1.25 mm	2.5 x 4.4 mm	2.5 mm	NA
Width	11.1 mm	7.2 mm	11 mm	12.1 mm
Height	5.7 mm	5.7 mm	7.5 mm	8 mm
Length	14.6 mm	14.0 mm	12.7 mm	21 mm
Fiber cable	Duplex Zip	Duplex / Ribbon	Duplex / Ribbon	GGP Polymer Coated
Field termination	Pot & Polish	Pre-polish Crimp	Pre-polish Stub	Cleave & Polish Socket
Latch style	2 RJ Latches	1 RJ Latch	SC Push Pull	1 RJ Latch

# SFF optical loss comparison

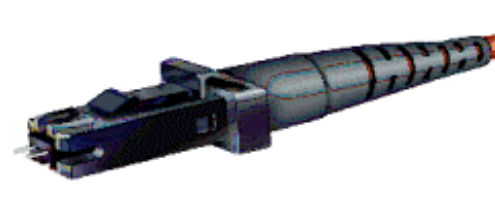


D & E are different connector hardware's from different manufactures  
F & G is the same connector but from different manufactures



# MT-RJ connectors?

- SFF connector with dimensions and locking system like RJ45
- No ceramic ferrule=> lower cost
- High port density, half size of Duplex SC
- Multimode or singlemode
- Male and female connectors + adapter
- Two or four channels
- Meet ISO/IEC 11801 and TIA/EIA 568A specs
- RJ latching provides audible and tactile feedback when mated
- Insertion loss typical: 0.2dB.



# Structure principle (e.g. of multi-fiber cables)

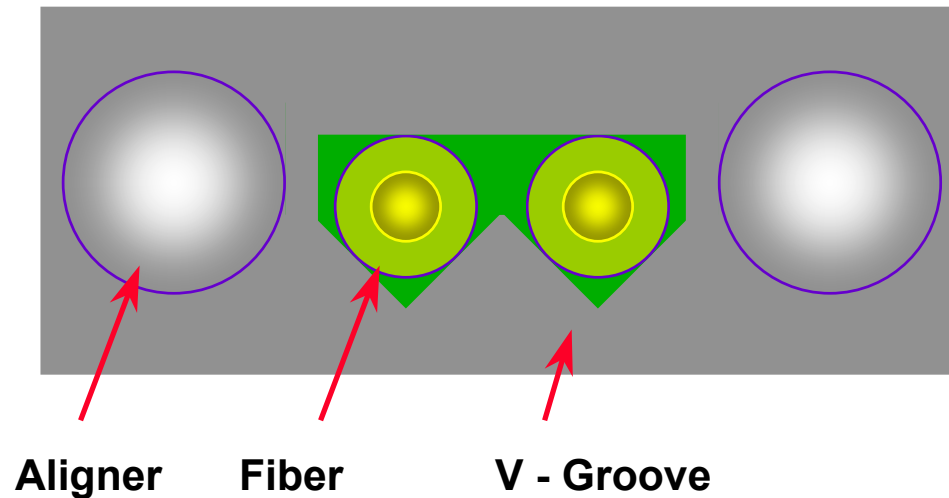
## New alignment technologies

### V - Groove

#### Materials

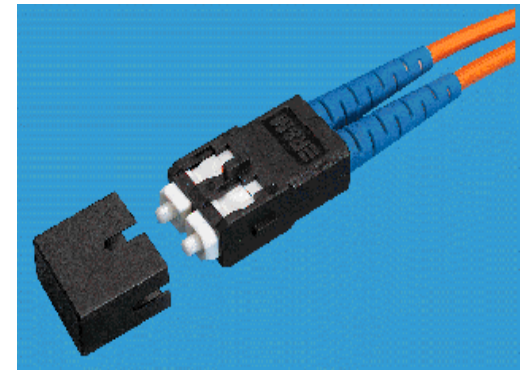
V - Groove **silicium wafer**

aligner **tungsten carbide**



# SC-RJ connectors?

- SFF connector with dimensions and locking system like RJ45
- Ceramic ferrule -> Well known on the market
- High port density, approximately half size of Duplex SC
- Multimode or Single mode
- Backward compatible to SC
- One connector type + adapter
- Meet ISO/IEC 11801 and TIA/EIA 568A specs
- *SCcompact* (or SC-RJ) is based on the SC connector
- (according to. CECC 86265-xxx, IEC 60874-14)  
Also possible to connect an SC Simplex
- Insertion loss typical: < 0.2dB.



# Which Termination technique?

- Fiber fixed to ferrule by adhesive and polishing
- Fiber mechanically fixed to ferrule and polishing
- Fiber mechanically fixed and no polishing

# Adhesive fixing

## Epoxy

- Two compounds
- Precise dosage
- Short time to fix after mixing
- Curing necessary

## Anaerobic

- Two compounds
- No precise dosage
- Time and curing less critical

# Adhesive fixing

## Ultra-violet

- Single compound
- Special connector (ferrule transmitting UV)
- UV curing and power

## Pre-injected

- Compound melting oven
- Power for oven
- No critical curing
- Expiring connector (compound limited life)

# Mechanical connectors

## Fiber mechanically retained inside ferrule and polishing

- Quick termination
- Same polishing

## Mechanical splice with pigtail (no polishing)

- Quick termination
- No polishing

# Alternatives

## Quality and reliability

## Workmanship

- Skill
- Time
- Chemicals

## Expiring

- Connectors
- Chemicals

## Cost

- Connectors
- Termination time

## Tools





**Any Questions?**

