

# All Silica Fibre Optic Cables

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Fibre optics for industrial applications

**FO-Systems**

The logo for FO-Systems features a stylized graphic element consisting of a thick, curved line that starts in blue on the left, transitions through green and yellow, and ends in red on the right, resembling a checkmark or a signal wave.



**FO-Systems**

# Your specialist

for the fibre optics you use in your industrial applications

## **Systems advice service**

Our product range includes cables with POF (Polymer Optical Fibre), PCF (Polymer Cladded Fibre), all silica fibres, ready-made cables, connectors and accessories. In addition to supplying these hardware items, we would also be pleased to advise you on any issues relating to active components that may arise during the development of your fibre optic system. You can tap into the more than 10 years of experience that we have accumulated in the development of fibre optic systems (and which is not limited to POF and PCF fibre optics). We also work very closely with the POF Applications Center at the University of Applied Sciences in Nuremberg.

Here are our experts and their contact information:

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We actively and regularly participate at conferences in this specialist area, and we remain in close contact with other companies in the industry. This network gives us access to a wealth of knowledge and experience, which is an advantage that our customers value very highly.



## Quality and environmental management

### **FO-Systems Quality Management**

We must consistently maintain the high quality level of our products. To accomplish this, we permanently monitor the entire process, from planning right through to the final production step of a product.

All cables that leave our factory are tested to ensure that they comply with attenuation specifications. We are one of the few manufacturers worldwide who use a method which enables us to measure attenuation over a length of 500m. This reduces measurement error, and it allows us to produce longer cables.

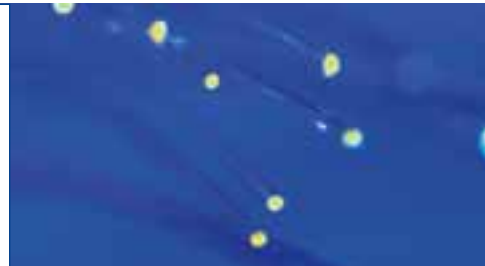
Information printed on the cable includes a combination of production order and drum number that provides complete traceability for the production process, starting from incoming inspection of the fibres right through shipment of the cable. Years later we will still be able to recall, for example, the parametric measurement data for a particular cable.

### **FO-Systems Environment Management**

We see no conflict between business success and responsibility for the environment. As a corporation with production facilities around the globe, we recognize our responsibility to make our contribution to preserving the natural basis for life. We attempt to strike a balance between what is good for the environment and what is good for the company. This makes environmental protection a compulsory element of our corporate activities.

We encourage our business partners to act according to the same environmental guidelines that we use, and we provide advice to our customers about how to use and dispose of our products in a way that is gentle on the environment.

# Step index multimode: VIS-IR



The step index fibre presents the oldest and simplest construction of silica fibres. The core of silica fibres for IR consists of pure silica with a low content of OH<sup>-</sup> with an uniform refraction index over the hole diameter. The cladding is slight homogeneous doped with an lower refraction index. The fibres are coated with acrylate, silicone or polyimide.

The light propagates through a multi mode fibre in a few hundreds of modes which limits the bandwidth of maximum 100 Mhz\*km.

The multimode fibres are not only used in optical data communication, but also in applications of sensors, spectroscopy, medicine techniques and lasers. The laser damage threshold of silica fibres are higher than POF or PCF. Those, the silica fibres are also used for power transfer. Mostly, laser sources are used in the wavelength range from about 400 and 2400 nm because of the small aperture of 0.22. A good choice of the right core diameter is given by the so-called beam parameter product: the product of the beam divergence and the beam width.

## Labelling

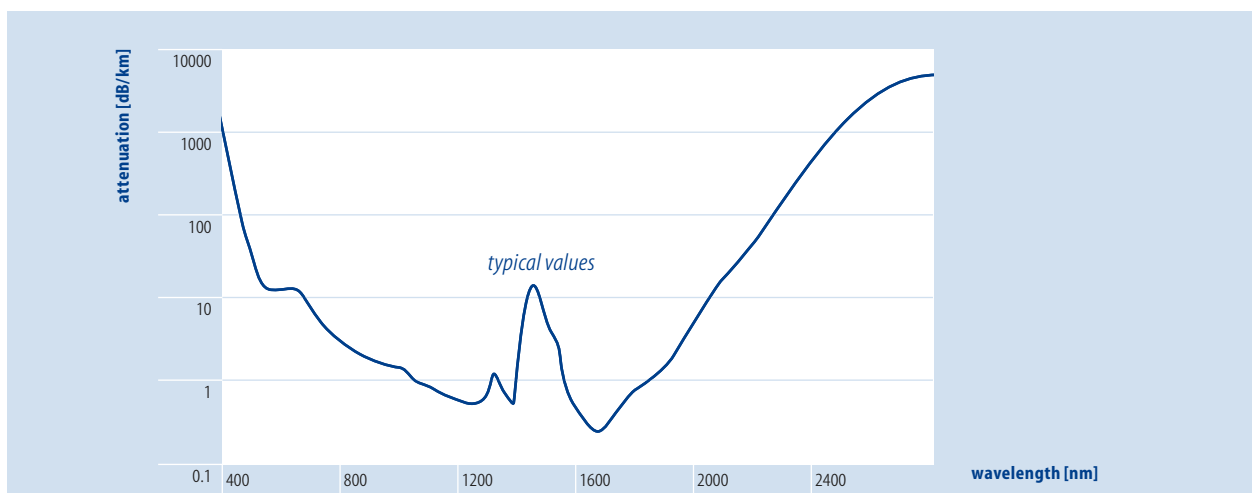
Silica-silica fibres for VIS-IR: S-core-cladding-buffer IR buffer material; e.g.: S-100-120-140 IR 3

### Geometry: core and cladding

Core diameter (µm)	50	100	100	150	200	200	300	400	500	600	800	1000	1500
Cladding diameter (µm)	70	120	140	165	220	280	330	440	550	660	880	1100	1650

### Geometry: buffer

Buffer diameter (µm) acrylate	125	180	200	280	350	500	500	550	700	800	1000	1250	1800
Buffer diameter (µm) silicone	125	180	200	280	350	500	500	550	700	800	1000	1250	1800
Buffer diameter (µm) polyimide	85	140	155	195	235	295	345	460	590	680	900		



# Step index multimode: UV-VIS



The core and cladding of these step index fibres consist of pure silica with an high OH<sup>-</sup> content. They are used for wavelength between 180 and 1100 nm (UV to NIR). The fibres themselves are coated with acrylate, silicon or polyimide.

The multi mode fibres are not only used in optical data communication, but also in applications of sensors, spectroscopy, medicine techniques and lasers. The laser damage threshold of silica fibres

are higher than POF or PCF. Those, the silica fibres are also used for power transfer. Mostly, laser sources are used in the wavelength range from about 400 and 2400 nm because of the small aperture of 0.22. We offer fibres with different transmission behaviour especially in the UV-range. Other core and buffer diameter are available under request. Please indicate the wavelength range when you order.

## Labelling

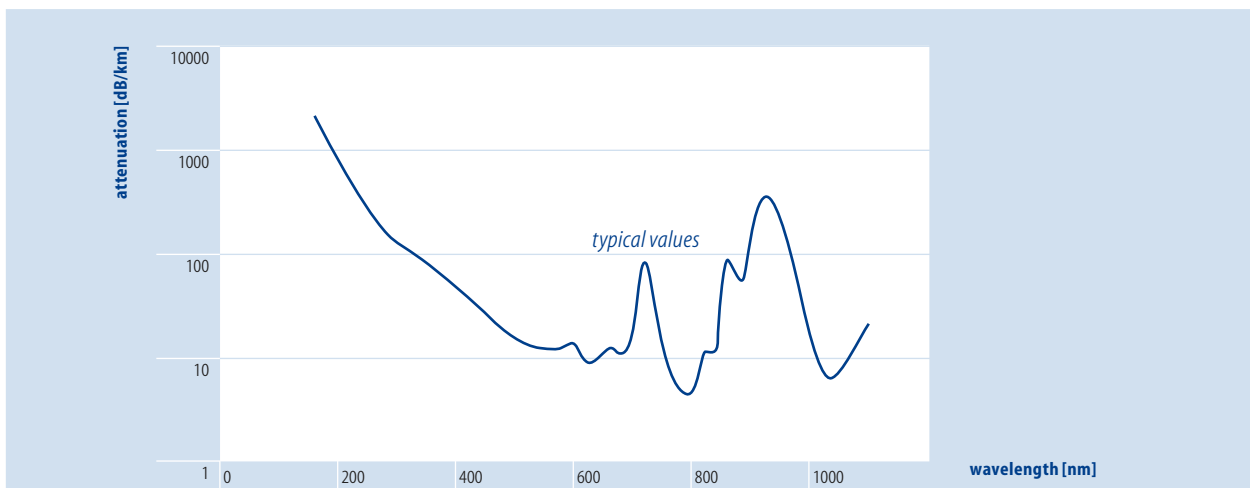
Silica-silica fibres for VIS-IR: S-core-cladding-buffer UV buffer material; e.g.: S-200-220-350 UV1

### Geometry: core and cladding

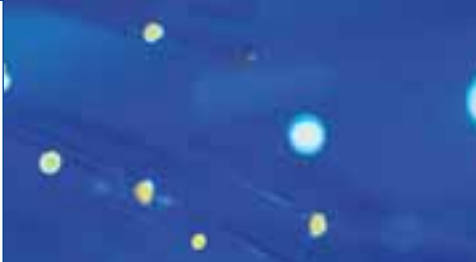
Core diameter (µm)	50	100	100	150	200	200	300	400	500	600	800	1000	1500
Cladding diameter (µm)	55	110	120	165	220	240	330	440	550	660	880	1100	1650

### Geometrie: Buffer

Buffer diameter (µm) acrylate	125	180	200	280	350	450	500	550	700	800	1000	1250	1800
Buffer diameter (µm) silicone	125	180	200	280	350	450	500	550	700	800	1000	1250	1800
Buffer diameter (µm) polyimide	65	120	140	195	235	280	345	460	590	680	900		



# Step index monomode: UV-IR



The monomode fibres (called also singlemode fibres) are used for the standard laser wavelength between 400 and 1550 nm. The small core diameter allows a propagation of only one mode in the fibres. This mode is directed parallel to the optical axis. Therefore nearly no mode dispersion appears. The monomode fibres are mainly applied in sensor applications and data transfer like LAN. Higher bandwidth with more than 1 GHz-km are reached and exceeds the values of the multimode fibres. The fibres are matched cladding type with an 125 or 80 micron cladding.

A low attenuation sensitivity due bending can be achieved at a large numerical aperture. The 125 µm cladding diameter is compatible to the low cost telecommunication connectors.

**Labelling**

Silica-silica monomode fibres: S-cut off wavelength-numerical aperture-cladding SM buffer material; e.g. S-780-0,12-125 SM 1

**Transmission properties**

Wavelength (nm)	400	480	630	630	780	810	810	980	980/1060	1300	1300	1550	1550
Cut-off-wavelength (nm)	340	420	620	620	720	780	780	950	950	1260	1270	1500	1500
attenuation (dB/km)	65	30	12	12	5	5	5	3.5	8	0.8	2	2	2
Numerical aperture	0.12	0.12	0.12	0.16	0.12	0.12	0.16	0.13	0.24	0.12	0.16	0.19	0.16

**Geometry: core and cladding**

Core diameter (µm)	2.7	3.2	4	3.3	5.5	5.5	4.3	6.6	3	9.5	6.6	6	7.8
Cladding diameter (µm)	125	125	125	80	125	125	80	125	125	125	125	80	125

**Geometry: buffer**

Buffer diameter (µm) acrylate	250	250	250	200	250	250	200	250	250	250	250	165	250
Buffer diameter (µm) silicone	145	145	145		145	145		145		145			

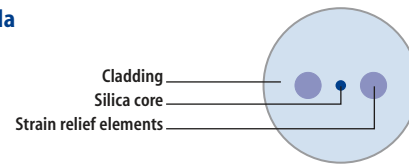
# Polarisation maintaining fibres: VIS-NIR



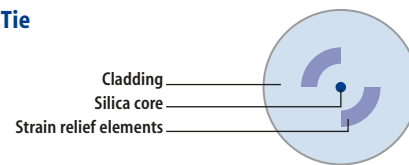
Optical measurement systems use the interference of two waves, which must have the same polarisation. In case of transmission of polarized light in optical wave guides the polarisation maintaining fibres has to be chosen. These are special produced single mode fibres, where mechanical stress induces a high birefringence in the fibre core. Different types of strain relief elements are available (see above).

Polarisation maintaining fibres are available from the visible to the NIR range. The cut off wavelength is the wavelength where one mode can be transmitted in the fibre. The fibre acts optimal like a single mode fibre in the wavelength range between the cut-off wavelength and the 1.3 time of the cut off wavelength. Because of the large tolerance of the cut-off-wavelength it is recommended the give the working wavelength when ordering. We chose the optimal fibre for you.

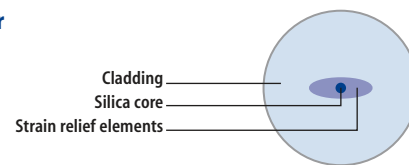
## Panda



## Bow Tie



## Tiger



## Labelling

Polarisation maintaining fibres: S-Cut-off-wavelength-numerical aperture-cladding PM buffer material: e.g. S-780-0,16-125 PM 1

### Transmission properties

Designed wavelength (nm)	488	514	633	688	780	810	810	980	1064	1300	1300	1550	1550
Cut-off-wavelength (nm)	400	450	600	620	720	720	720	910	1000	1200	1200	1500	1500
Attenuation (dB/km)	100	90	15	15	8	4	4	3	3	2	2	2	2
Numerical aperture	0.12	0.12	0.14	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16

### Geometry: core and cladding

Mode field diameter (µm)	3.6	3.6	3.2	3.2	3.6	4	4	4.2	6	6.6	6.6	7.9	7.9
Cladding diameter (µm)	125	125	125	125	125	125	80	125	125	125	80	125	80

### Geometry: buffer

Buffer diameter (µm) 2xAcrylat	245	245	245	245	245	245	245	250	245	245	245	245	245
Buffer diameter (µm) 2xAcrylat	400	400	400	400	400	400	400	400	400	400	400	400	400
Coating diameter (µm) Nylon			900	900	900	900	900	900	900	900	900	900	900

# Gradient index multimode: UV-IR



Due to its core profile the gradient index multimode fibre is a silica fibre possessing a reduced mode dispersion compared to a normal step index multimode fibre. The optical density of the core material decreases continuously in a gradient fibre from the middle to the borders. Because of this the mode 0 along the optical axis which possesses the shortest path in the fibre will propagate in the densest medium. Higher modes with longer paths will propagate mostly in the less dense medium. Thus the propagation velocity and the dispersion will be reduced. A bandwidth of up to 1GHz\*km is reached. Due to the core profile the light does not propagate in zigzag paths but in bended paths.

The pulse form in the gradient index fibre stays more stable compared to the pulse form observed at the end of a step index fibre. If the gradient index fibre is for example not completely illuminated the diameter of the beam will be nearly kept until the end of the fibre. There exist fibres of different quality and cladding designed for power delivery and data transfer.

## Labelling

Gradient index multimode fibre: G-core-cladding-buffer GI buffer material; e.g.. S-200-280-450 GI 1

### Transmission properties

Numerical aperture	0.2	0.275	0.26	0.29	0.29	0.29	0.29
Attenuation at 850 nm (dB/km)	3/2.7*	3.5/3.2*	3.5/3*	4/3.5*	6	8	10
Attenuation at 1300 nm (dB/km)	1/0.7*	1/0.9*	1/0.9*	1.5/1.0	3	4	5
Bandwidth at 850 nm (MHz·km)	300/600*	300/400*	200	200	150	100	100
Bandwidth at 1300 nm (MHz·km)	600/1200*	550/1000*	200	200	150	100	100

### Geometry: core and cladding

Core diameter (µm)	50	62,5	85	100	200	400	600
Cladding diameter (µm)	125	125	125	140	280	560	840

### Geometry: buffer

Buffer diameter (µm) acrylate	250□	250□	250□	200	450	700	1000
Buffer diameter (µm) silicone				200	450	700	1000
Buffer diameter (µm) Polyimid	140	140	140	155	300	580	

\* double acrylate cladding, for telecommunication

## Assembled fibre-optic cables

One main focus of FO-Systems GmbH is the assembly of fibre optic cables. Practically all typical connectors are assembled like e.g. ST, FCPC and FSMA. On customer demand we also develop new connectors or adapt already existing ones. For assembly necessary tools are developed, tested and improved by our company. We produce individual items up to small and big series.

During assembly the cables are cut to the desired length, the connector fixed and the fibre scored with a cleave tool, broken, grinded and polished. To cover the aspects of price, accuracy of centring, attenuation or the temperature stability, the ferrule of the connectors are made out of metal, ceramics or copper. Multi strand cables are often build for segmenting, whereat each strand may have another connector.



Coupler from one strand on two strands for example are build in different couple ratios. These couplers are passive elements and used to divide optical signals or laser pulses into several signals or separated pulses. They protect for example against to high optical signals or allow the measurement of a coupled portion.

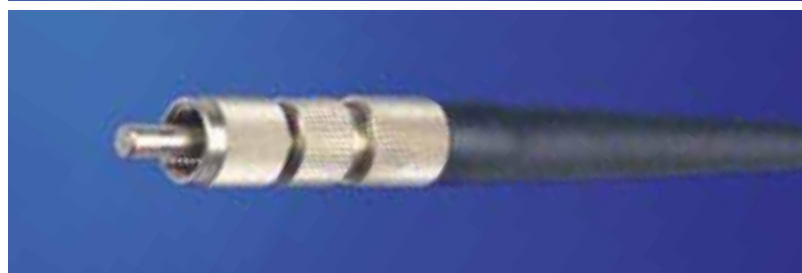
## Connectors

FO-Systems provides for you all kind of different connectors like e.g. ST, FSMA, FCPC or also hybrid connectors single or already assembled to a cable. The ferrule materials are metal or ceramics. On customer requirement we also develop special connectors or we adapt already existing connectors.

The catalogue: „POF and PCF Fibre Optic Cables Assemblies, Connectors and Accessories“ of FO-Systems presents different connector types that are also suitable for silica fibres. The accessories for assembling can also be found there.

**The current product range and latest news can be viewed on our website**

[www.fo-systems.com](http://www.fo-systems.com)



## Cable examples

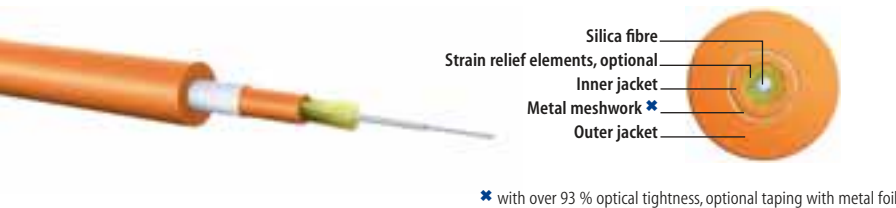
Simplex cable with an outer jacket made of PUR, PVC or or halogen-free and flame retardant material (FRNC)



Duplex cable with an outer jacket made of PVC or FRNC



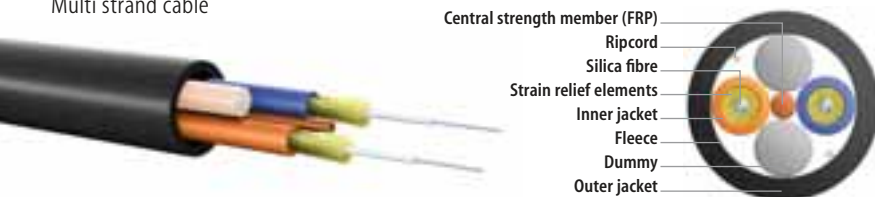
Laser protection cable with metal meshwork



Laser protection cable with metal pipe



Multi strand cable



Cable with silica fibre lose tube construction




The glas fibres presented here are available in different types and materials. Some examples are:

As different types we produce simplex-, duplex- und multiplex cables. The cables possess strands for mechanical reinforcement as the jacket, non-metallic pull elements, blind and support elements. The metal meshwork or the flexible metal tube are a protection against potentially leaking laser light, as protection for the case that the silica fibre guiding the laser light breaks.

We provide cables for all kinds of applications, for high temperatures, for chemical aggressive or fire endangered environments, for high mechanical demands like in trailing chains or for applications in robots, for laying directly in the ground or in water; or for your special application. Hybrid cables are build up taylor-made by different optical fibres and copper wires.

The length of the produced cables range up to several kilometres.

## FO-Systems keeps you up to date ...



1998, 152 pages, 94 illustrations,  
25 tables, 14.3 cm x 22.5 cm,  
hardcover, ISBN 3-89578-135-5

### We have the latest information for you

Our up-to-date information services including FO-Systems *news* or FO-Systems *info mail* provide current information by post or e-mail about the latest developments at FO-Systems and in the market, and we will also tell you about important dates and events.

It is also always worth having a look at our website:

[www.fo-systems.com](http://www.fo-systems.com)

### Here is our insider tip on books about POF

Author: **Weinert, Andreas**

Title: **Plastic Optical Fibres**

Fundamentals, Components, Installation

The book guides you through the basic physics of this new technology, describing materials, the plastic fibre manufacturing process and the structure of plastic fibre optics.

It gives you an insight into various types of cables as well as transmitting and receiving components on a transmission path, and it gives you tips on working with and installing plastic fibre optics. It also presents important national and international regulations. The book is targeted at anyone who is involved in the development, planning or installation of plastic fibre optic systems.

**FO-Systems GmbH**  
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