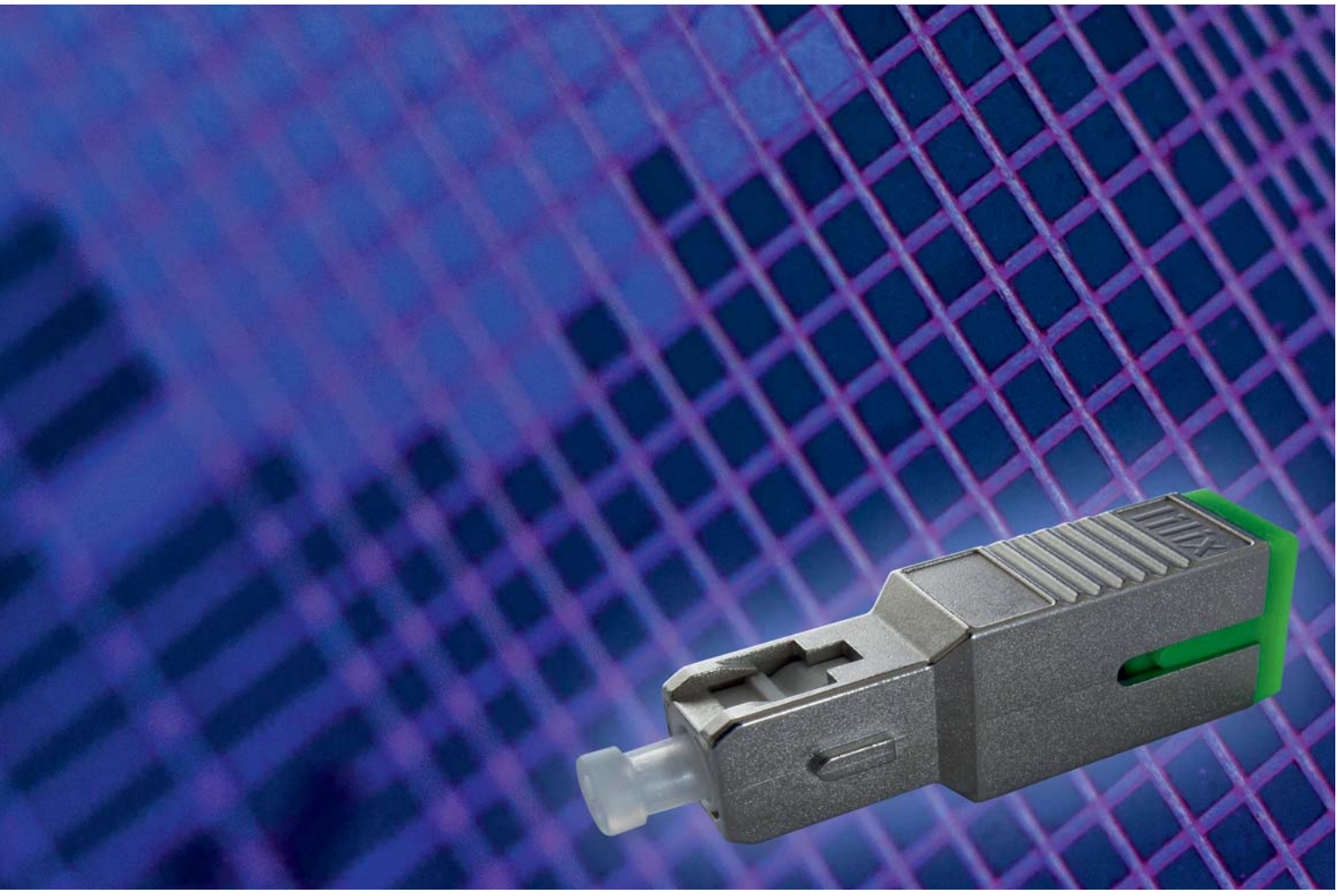
fibre optical components GmbH

At the speed of light into the future.



foc flash-light

March 2013

foc flash-light

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Editorial

Photo: Rico Prauss

The expansion of broadband networks is progressing at great speed all over the world. The politically responsible persons, the network installers, the mostly private network carriers and, above all, the users continue to be highly motivated. Today there is no doubt about the necessity.

However, when you have a look at the international map, distinct differences in network expansion can be seen. While some networks have been completely based on optical fibres to the home or the desk for some years already, there are also other strategies using a mix of technologies for broadband transmission. Certainly, the question as to what is the best solution is not easy to answer. Decisions, once taken, are not immediately recognisable in their effect; an investment for a certain network structure must then prove is technical sustainability and economic viability. Also many congresses, conferences and experience reports only partially answer the open questions.

From April 2013 there will be a system available in Berlin, Germany, which will be operated as an FTTx testing laboratory. On the occasion of the BEL 2 fair this new testing environment will be opened. There decisions-makers, engineers and potential users can see how networks are structured and what components are required and they can perform functional tests. The provisioning steps, components from different vendors, acceptance and even the service through a monitoring system should be checked for reliability and the expected advantages before an investment decision is made.

This offer can be used before deploying a network, when a technology change is imminent or when the efficiency of the network operation shall be improved.

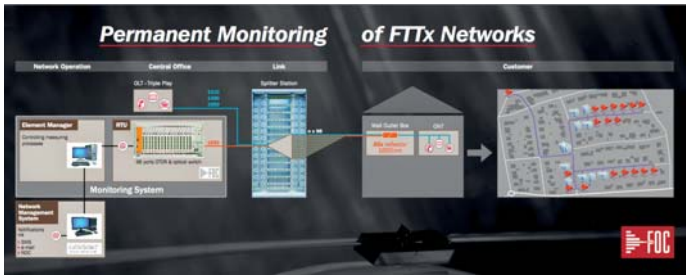
We are looking forward to an additional meeting point on the topic of broadband using optical fibres, which will be available to everybody daily in addition to the fairs.

Christian Kutza, Managing Director

Looking back on 2012 tradeshows

The JoSoft & FOC Fair Team 2012 & 2013

In 2012 FOC focussed its tradeshow activities on the topic of the permanent monitoring of FTTx networks. Early in 2012 we began combining several technologies. This resulted in the successful launch of our complete solution at ECOC in Amsterdam. Based on the systematic and successful combination of technologies and the feedback received from international customers we decided to consequently perform on-site presentations exactly where these technologies might provide the most advantages.



The key technologies

- ***lilix*** reflector
- Monitoring system consisting of:
  Element Manager (EM) with Remote Test Unit (RTU)
- Central Network Management System (NMS)
  based on cableScout®

ECOC the leading forum of the fibre-optical industry in Amsterdam

September 2012

The ECOC fair is the biggest meeting point of the optical communications industry and thus the leading European forum for this technology. With more than 5,500 visitors and 325 exhibitors this event was a major success.

The technological solution presented by JoSoft and FOC received much attention, since such a complete solution consisting of reflectors, measuring unit and a unique NMS has never been on display before on the market as a holistically functioning system.

On the right the 32 port demo system

GITEX in Dubai

October 2012

GITEX, which was first held in 1981, makes Dubai the gateway to the Middle East, North Africa and South Asia region (MEASA).

The one-week event focuses on high-potential exhibitors and continuously identifies the latest and most promising ICT trends. The great number of technical experts, managers and decision makers as well as the resulting quality of talks held were impressive. Thus GITEX is a major player in the ICT environment and one of the most important platforms for all companies looking to conduct business in the MEASA region.

As the No 1 technology event in the MEASA region GITEX attracts:

- 138,000 ICT professionals from 144 countries and 18,000 managers
- 3,500 ICT companies
- 80% of the top ICT brands

The big demand for such an overall concept surprised both companies. The expectations of the potential contacts and customers will lead to further talks and on-site pilot installations.

TeleNetfair in Lucerne

October 2012

TeleNetfair was held for the sixth time at the Exhibition Centre of Lucerne, Switzerland. This tradeshow has established its reputation as an information platform for networkers, telematics professionals, system engineers, system administrators, building technicians and installers. The "family atmosphere" and the high quality of the talks were far above average, also compared to bigger events.

Although TeleNetfair is much less complex than GITEX, it was of similar value for FOC.

This success is mostly due to the many customer contacts of Jo Software Engineering as well as the fact that both companies have been maintaining close contacts with the top 10 companies from the Swiss telecommunications industry for more than 10 years.

61 exhibitors presented their products to the interested 3,000 visitors. Thus TeleNetfair is the most comprehensive tradeshow in the areas of fibre-optics, network equipment, measuring instrumentation and telematics in Switzerland!

Satisfied exhibitors and interested professional visitors used this fair once again for an exchange of technical knowledge and for establishing business contacts. Because of the family atmosphere, where all the participants knew one another in person, the fair had the character of a workshop held at the highest technical level.

Interestingly more than 40% of the visitors arrived at the fair with detailed investment plans. The reaction to the fair was clearly positive, so that a number of exhibitors expressed their active interest in participating in the next TeleNetfair, too. More than 90% of the visitors interviewed said they would surely be visiting the fair again in 2014.

Maximum transparency = maximum quality

Future prospects of FTTx monitoring using reflectors in 2013

In addition to the permanent network monitoring system (NMS) already mentioned a commissioning version will be on display. The result is a holistic system ranging:

- **from installation,**
  including the taking of the fingerprint and automatic data acquisition,
- **via acceptance tests and commissioning,**
  including independent control measurements and pre-verification of the measurement traces as well as providing proof of a flawless network;
- **to network operation,**
  including permanent monitoring of active/dark fibres, central fault isolation from the call centre and reduction of truck-rolls to the customer.

This approach provides a maximum control

- by automatic acquisition, pre-verification and archiving of measurement data.
- as well as speedy fault isolation and division of responsibilities.

This approach creates efficiencies by:

- full control over your own infrastructure independent of cabling.
- proactive fault management by early fault detection.
- reduction of downtime by efficient fault analysis.
- continuous proof of the functional operation of the infrastructure.

This offer is completed by state of the art technologies, including the possible integration of already available OTDR technologies, and by ensuring conformity with relevant ITU standards.

The overall system can be used in any existing network topology (PTP, PTMP) and also be flexibly integrated with existing NMS systems.

Future prospects of FTTx monitoring using reflectors in 2013

Jo Software Engineering & FOC would be pleased to welcome you for a demonstration of their overall system:

- from 04 – 06 June 2013 at ANGA Cable in Cologne, Germany
- from 20 – 24 October 2013 at GITEX in Dubai

For further dates and tradeshows please consult the FOC website.

Frank Sommerfeld, FOC

Breakout cables

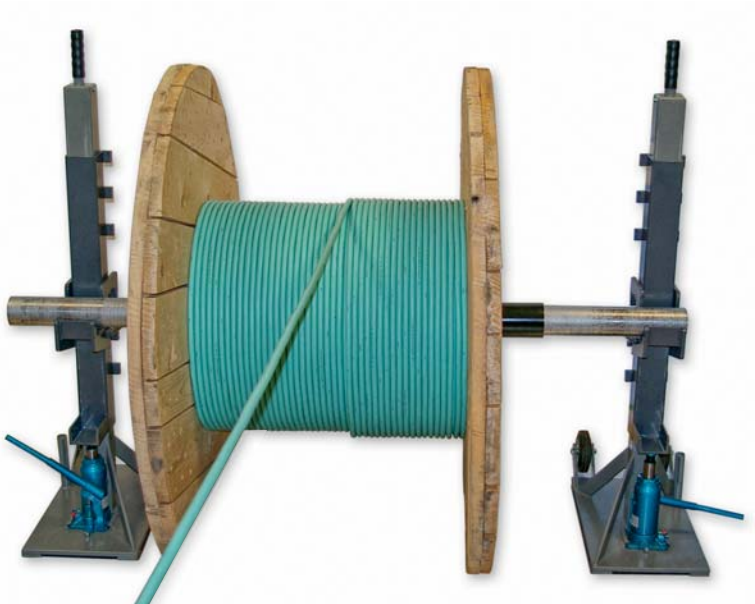


Figure 4 Winding facility for breakout cables

Efficiency = Cost saving

Figure 1 Routing cables via a grid to the distribution cabinet

Figure 2 Cabling of wind and power installations

Figure 3 Breakout cable with fibre and connector protection

This is the motto which could be used to describe the applications which are implemented using the so-called breakout or multi-jumper cables.

Actually, breakout cables are specially protected patch cords for many applications. In contrast to other multi-fibre solutions, breakout cables combine the quality of factory-assembled connectors and the temperature stability of patch cords with a rugged and installation-optimized design.

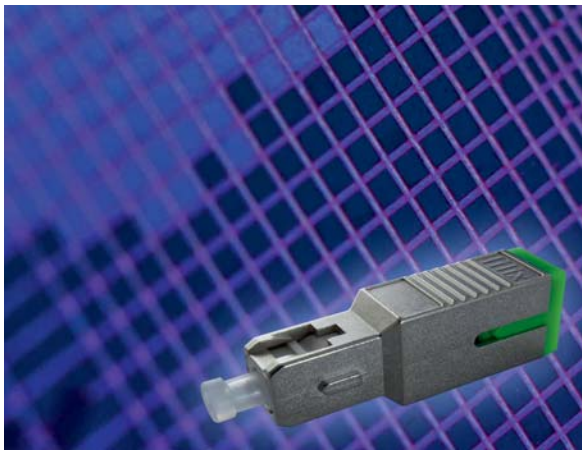
Among others they are used for the speedy and simple "cabling" of MDF locations, in particular for connecting the active equipment with the outside plant.
Here most of the connections must be routed via cable grids to the distributor cabinets and the patch panels (Fig. 1).

While it is possible to use individual simplex and/or duplex patch cords, the routing on the grid is simplified when one or several multi-fibre breakout cables are taken. This is due to the fact that the cable is filled with 24 fibres—and thus 24 fibres can be routed simultaneously along the grid. At the same time using multi-fibre breakout cables provides a more orderly layout on the cable routes and interim ceilings.

Other applications include the cabling of wind power plants, where fibre-optical cables are routed within the tower from the turbine down to the base.

Another advantage when using breakout cables from FOC is that the cables are terminated with connectors at the factory already. They can (on the customer's request) also be provided with a connector protection and a pull-in aid. Thus the optical connectors are completely protected during on-site laying (Fig 3).
In order to be able not only to offer our customers the technical advantages of breakout cables, FOC GmbH invested in advanced winding facilities in 2012 (Fig. 4). They allow us to manufacture cost-efficient breakout cables in almost any length without having to rely on the lengths supplied by the cable manufacturers.

Tilo Kühnel / Axel Thiel



FOC expands *lilix* reflector product family by two more models

Reflectors, which selectively reflect only the light of a defined monitoring channel, are used as an optical link termination in FTTx networks in order to facilitate the remote maintenance of the subscriber line. For the massive roll-out of new FTTx networks FOC offers the reflector integrated in SC or LC connectors at a particularly attractive price (see FOC flashlight September/2012).

Optimum form factor for each application

Talks with our customers and discussions within standardisation bodies show that in addition to the need for permanently installed reflectors there is also a need for reflectors, which are plugged on as a measuring aid during installation or commissioning at the customer's side and removed after testing by the technician.

And the customers also wish to have a reflector which can be inserted inline just like an optical attenuator. Such an inline reflector can provide a more cost-efficient solution when upgrading existing FTTx networks with reflectors than, e. g. pigtails, which would have to be retrofitted by splicing at the customer's place and be integrated into the wall socket. In order to satisfy the need for temporarily installable or retrofittable reflectors as well as for reflectors used as a measuring aid, e. g. for commissioning links, FOC GmbH has expanded its lilix reflector product range by two new models.

The pluggable reflector in the form of a terminating connector is a low-cost and pragmatic solution designed primarily for use as a measuring aid or as a commissioning tool. The reflector reflects selectively only the wavelength of the monitoring channel while all other signals will be "absorbed" by the terminating connector. For this reason the terminating connector is not suited for permanent installation in the network. Figure 1 shows a reflector in the form of a terminating connector. This model can be supplied as a wavelength-selective reflector with reflection ranges of 1620…1675 nm or 1645…1675 nm. It is available for all connector standards based on 2.5 mm or 1.25 mm ferrules.

Figure 1 SC-APC reflector in the form of a terminating connector

The reflector for inline insertion in the form of an optical attenuator (attenuator type) has a second optical port as an output in addition to the input port. This reflector also reflects only the wavelength of the monitoring channel, but the traffic wavelengths are passed through to the output port. The inline type has been primarily designed for retrofitting existing networks and is also suited for permanent installation in the network. However, due to its particularly rugged design the attenuator-type reflector is also ideally suited for measuring purposes in the laboratory or at the construction site. Figure 2 shows a reflector in the form of an attenuator. This model can be supplied as a wavelength-selective reflector with reflection ranges of 1620… 1675 nm or 1645… 1675 nm. It is available for SC-APC, SC-PC, LC-APC and LC-PC connector standards.

Figure 2 SC-APC reflector in the form of an attenuator

Axel Thiel (Head of Development)
and Dr. Martina Vitt (lilix Product Manager)

How much additional return loss do reflectors cause?

Wavelength-selective reflectors are used to terminate optical links in FTTx networks in order to facilitate the monitoring of the access network on a purely passive level.

Figure 1 illustrates the basic monitoring principle using reflectors. This network architecture allows you to verify the proper functioning of the passive infrastructure down to the end-customer by means of a remote-controlled backscatter measurement at 1650 nm from the Central Office (CO) at any time without interfering with the data traffic. This method can be applied both to P2P and to P2MP networks.

By employing a software-based system monitoring the reflectors a direct connection between a fault and the network infrastructure can be shown – or excluded – at the push of a button and without much cost. In particular by excluding faults in the network infrastructure it is possible to make significant OPEX savings, since during the construction phase and also during later network operation the number of truck rolls to the subscriber can be greatly reduced.

Where P_{in} is the input power of the reflector and P_{ref} the power reflected by the reflector in the range of the traffic wavelengths, the reflector's return loss is defined[2] as

$$RL^{Refl.} = 10 \log_{10} [P_{in}/P_{ref}], \quad (1)$$

i. e. as a positive number, if $P_{ref} < P_{in}$ applies (see Figure 2).

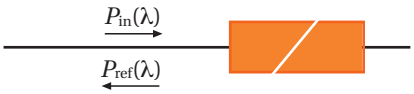


Figure 2 Schematic diagram for defining return loss

The return loss is a wavelength-dependent value. However, within the framework of the *worst-case* assessment this wavelength dependency shall be ignored and *the worst value in the range of the traffic wavelengths* be taken instead (Assumption 2).

What return loss should be specified for reflectors in FTTx networks?

One question, which is asked again and again, relates to the amount of additional, disruptive return loss at traffic wavelength range produced by the permanent installation of reflectors in the network and/or to what amount of return loss must be kept by the reflectors in order to ensure the flawless functioning of the (potentially reflection-sensitive) transmit laser in the CO in the long run.

This question shall be answered in the following for both network topologies frequently used in the last mile with the help of a worst case assessment. For the sake of simplicity a link loss of 0 dB is assumed for all links (Assumption 1), since this situation exactly satisfies the worst case condition for a transmit laser[1].

Figure 3 shows the situation of a P2P network with n subscribers, where P_0 is the transmit laser output power in the CO, and P_{back} the power reflected back to the laser. Since only the traffic wavelengths shall be assessed her, the OTDR and the WDM have been removed from the drawing (cf. Figure 1).

For an *assumed link loss of 0 dB* in this case the whole amount of the reflector's return loss will act on the transmit laser. With the back reflection P_{back} acting on the transmit laser the return loss of the P2P network relevant to the laser (see Figure 3 with equation (1) equals):

$$RL^{PTP} = 10 \log_{10} [P_0/P_{back}] = 10 \log_{10} [P_{in}/P_{ref}] = RL^{Refl.} \quad (2)$$

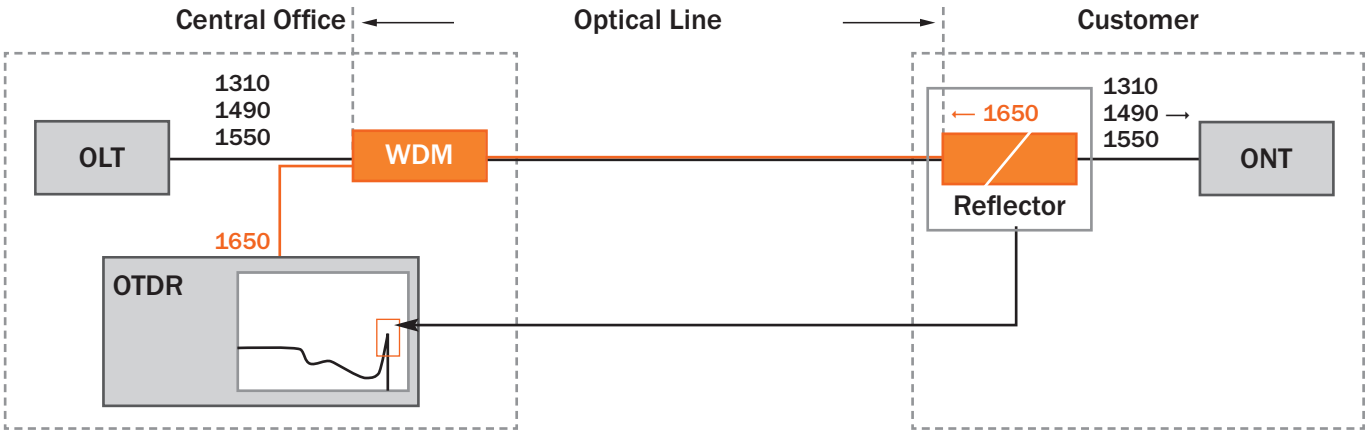


Figure 1 Monitoring principle using reflectors

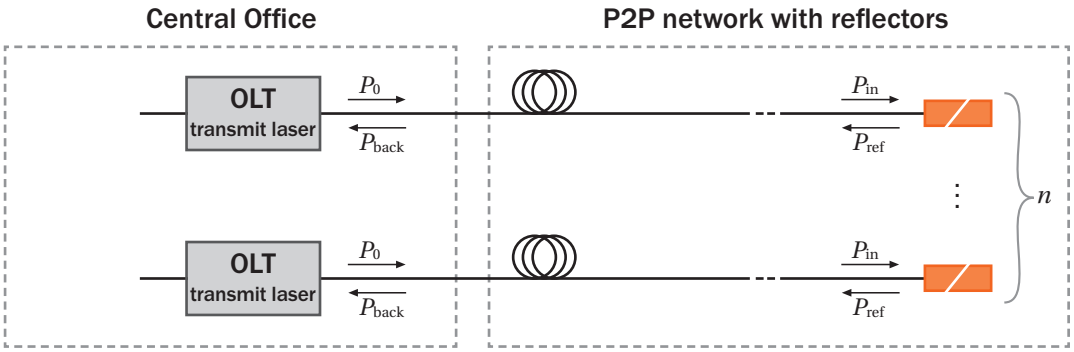


Figure 3 Worst-case assessment of return loss for a P2P topology

Consequently, in the worst case for a P2P topology the whole power reflected back by the reflector will act on the transmit laser. The return loss of the whole laser-relevant system is thus just equivalent to the return loss of the individual reflector.
The respective assessment for a PON topology is basically different. Here, on the one hand, the splitter will act (in both directions) as an additional attenuator and, on the other hand, it has to be taken into consideration that the back reflection of all the PON's reflectors will jointly act on the transmit laser, i. e. has to be added up. This situation is illustrated in Figure 4 (again ignoring OTDR and WDM).

In the case of the PON topology thus the overall system's return loss acting on the laser will increase by just 10 log10[n] compared to the return loss of a single reflector, where n indicates the splitting factor of the PON. With a splitting factor of 64, for example, the system's return loss will be increased by at least 18 dB compared to the return loss of the individual reflector. In reality link losses further increase the return loss.
Due to the basically different situation depending on the network topology the standardization currently demands two different values for the reflector's return loss:
> 26 dB (grade A) and > 35 dB (grade B)[3].

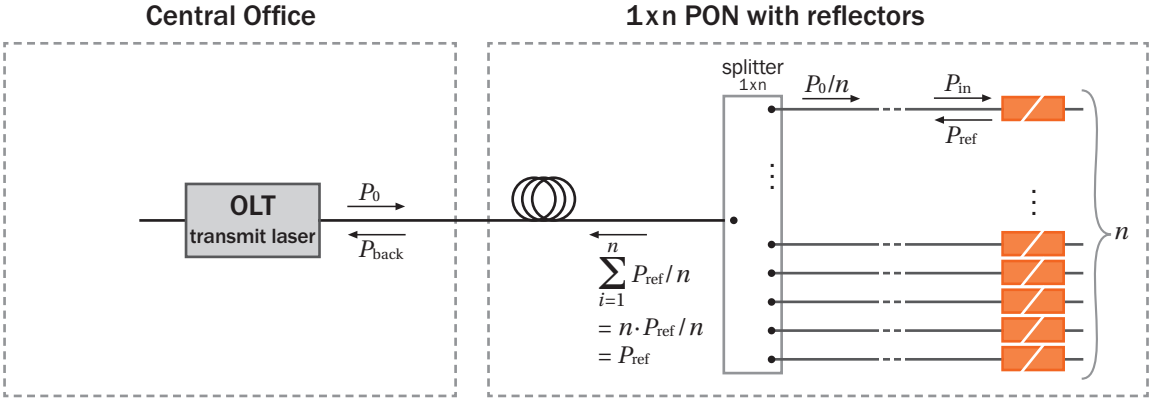


Figure 4 Worst-case assessment of return loss for a PON topology

Due to the splitter loss the input power P_{in} of each individual reflector is reduced by the splitting factor n against the laser output power P_0. With the link loss ignored the following equation applies (see Figure 4):

$$P_{in} = P_0 / n \quad (3)$$

While the back-reflected power of each reflector will be reduced again by the splitting factor, at the same time the sum of the back-reflected power from all the PON's reflectors will act on the laser. Both effects just compensate each other:

$$P_{back} = \sum_{i=1}^{n} [P_{ref}/n] = n \cdot P_{ref}/n = P_{ref} \quad (4)$$

The PON network's return loss relevant to the laser can be calculated as follows taking equations (1), (3) and (4) into consideration:

$$RL^{PON} = 10 \log_{10}[P_0/P_{back}] = 10 \log_{10}[n \cdot P_{in}/P_{ref}] = 10 \log_{10}[n] + RL^{Refl.} \quad (5)$$

Due to the installation at the end-customer's place the main focus when designing the lilix reflector was to create a component with a strictly optimised price-performance ratio. The thoughts presented above show that an excessive return loss specification for the reflectors used in FTTx link monitoring applications is not constructive – at least not for PON topologies. An unnecessarily high return loss will increase the cost of production without producing any noticeable advantages for the application.

Dr. Martina Vitt, Product Manager, lilix product group

1 The worst case applies if a low link loss is present, because with a P2P structure all the power reflected by the reflector in the range of the traffic wavelengths will return almost without any attenuation to the transmit laser.
2 See Bird, Trevor S.: *"Definition and Misuse of Return Loss"*, IEEE Antennas & Propagation Magazine Vol. 51 (2009), p. 166-167, and others.
3 Future IEC Document 61753-041-2 Ed. 1.0: Non-connectorised single-mode FTTx reflector device for Category C - controlled environment

Guaranteeing the highest quality also during commissioning

Also high-quality products require attention during installation

Over almost the past two years many customers have decided in favour of the high-quality LSH-HRL Class A connectors from FOC. On the one hand, these customers decided more than 10 years ago to use only connectors of a maximum insertion loss of 0.1 dB in certain network areas. On the other hand, these customers are new customers, which either have been newly founded or which we have been able to convince of the benefits of the LSH-HRL Class A connectors over the past two years.

However, such high-quality products bring the customer the desired advantages in network operation only, if all stakeholders, beginning with our manufacture in Berlin up to the installation contractors, jointly know how to implement and maintain this quality. But also the end customer can make his contribution here.

The below article is meant to give some food for thought.

1. The market has changed

In the past the installation contractors frequently simply used to be convinced of the quality of the products delivered by FOC. If there happened to be problems, such as high insertion loss values when measuring the optical links, no attempt was made to simply put the blame on bad connectors. The root causes were either found by systematic fault isolation and rework or the bad values were accepted, e. g. because of mismatching fibres, and could be plausibly explained to the end customer.

But today two basic conditions have changed: On the one hand, for almost two years we have been delivering connectors based on a full-ceramic ferrule, on the other hand, the competition between the installation contractors has clearly aggravated. Often there is no time for systematic troubleshooting and/or the competitive price pressure is too high to always have the optimum equipment and tools available.

For us the changeover to connectors with a full-ceramic ferrule has simplified the final manufacturing inspection (each connector end-face is verified using a video microscope prior to delivery), because the connectors are easier to clean, the video microscopes have clearly improved and there is less damage to the end-faces. In return, our customers can also benefit from the availability of high-resolution, high-intensity video microscopes.

Training and systematic fault analysis will cost the contractor a lot of time, optimum or appropriately maintained equipment and tools will cost him money. Frequently he cannot take both into consideration in his offer: maybe another competitor does not do it and will get the order. For this reason, today any problems with increased insertion loss values detected at the final OTDR measurement are attributed much more often to the quality of the connectors delivered e. g. in splice boxes. However, this occasionally simple solution is risky for the contractor, because after a counter-check performed by the connector supplier, especially in the presence of the end customer, the contractor might lose this end customer.

Using a typical example I would like to show, how it is possible to break this seemingly vicious circle at a reasonable effort.

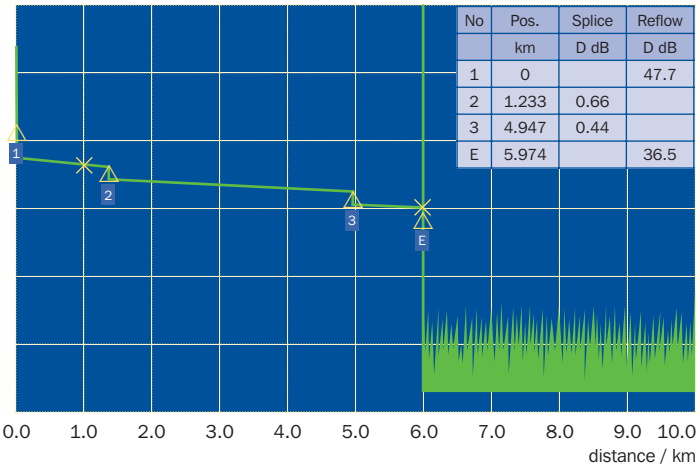


Figure 1 OTDR measurement trace of a link at 1302 nm

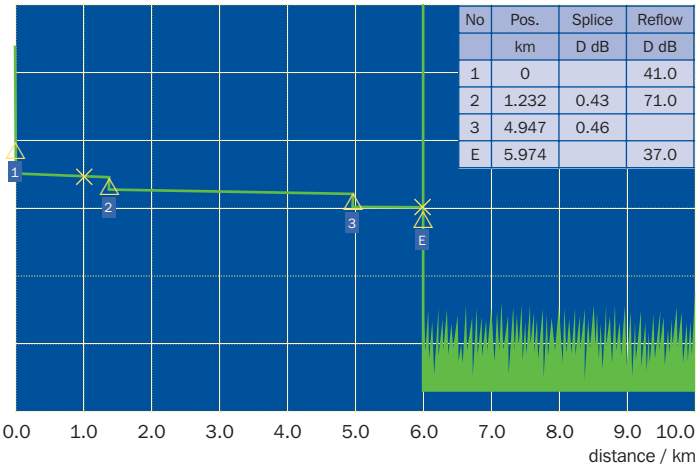


Figure 2 OTDR measurement trace of the same link at 1548 nm

2. A short fault analysis

In Figures 1 and 2 typical OTDR measurement traces of such a seemingly faulty link, measured using launch and receive fibres, are presented.

In view of loss values at the beginning of the link of 0.66 dB (at 1302 nm) and 0.43 dB (at 1548 nm) and of 0.46 dB (at 1302 nm) and 0.46 dB (at 1548 nm) at the end, at first sight the loud protest by the installing contractor putting the blame on the connectors seems to be justified.

We, too, would probably have agreed with the installer and exchanged the 2 pigtails, if there had not been other measurements performed on the other 23 fibres, producing similar bad values. But since there were these other measurements available, a systematic fault analysis was possible just by analysing the OTDR measurement traces.

This systematic fault analysis gave rise to simple questions, which resulted in some justified doubts as to the installer's statement:

- What is the probability that, when testing from Site 1 to Site 2, the consecutive connectors are good, when they are at the beginning of the link, but bad, when at the link end?
- What is the probability that consecutive connectors, when tested in the same direction (from Site 1 to Site 2), are good, when they are at the end of the link, but bad, when at the link beginning?

If you additionally know that other customers, who have received pigtails from the same lots, do not complain, and that the splice boxes contain coloured pigtail sets, the installer's statement seems questionable.

While, due to some fibre mismatching it may well be possible that a connector is good in one direction and bad in the other, the chances that both fault situations mentioned above appear are close to zero.

3. General fault analysis

I must admit, the link in the above example is a very simple one. But it is just on this simple link with the relatively high number of faults on parallel fibres (only 4 fibres showed very good values), that possible causes of fault could be detected and assessed well. Fault Cause **1** can be rapidly isolated by asking other customers, who have received the same pigtails in the same period of time. Because of the great number of faults Fault Cause **2** can definitely be excluded due to the 100% final inspection and the images taken and archived from the connector end-faces.

Fault Causes **3** and **4** are based on the fact, that each event, for example the loss value of 0.66 dB in Figure 1, is composed of the fibre transition from launch fibre to pigtail fibre (connector) and from pigtail fibre to single loose tube (splice).

We were able to quickly analyse Fault Cause **3** and exclude this cause in cooperation with the customer and the cable manufacturer.

Fault Cause **5** is not probable, because the insertion loss at 1550 nm is not higher than at 1310 nm. This cause could be completely excluded after on-site measurements with the customer.

OTDR operating errors, (Fault Cause **7**) could be excluded, because it was a well-known unit and the settings indicated the use of the auto mode.

All in all, from our perspective, Fault Causes **4** and **6** seemed to be relevant. In order to finally resolve the issue we met with the end customer on site.

Quality—joint aim of supplier, installer and end customer

4. On-site fault analysis

Checking the second connector with the video microscope already made clear what the probable cause of the fault was. Consecutive connectors showed an almost identical contamination of the connector end-faces.

In Figure 3 the image of the input connector of fibre 12 is shown as an example. It is the input connector of the link which is presented in Figures 1 and 2. Dirt residues, as can be found when wet-cleaning connectors, are clearly recognisable.

It was possible to clean all connector end-faces using a simple cleaning tape. As an example Figure 4 shows the connector from Figure 3 after cleaning.

	Fault Causes
1	Damaged or low-quality pigtail connector
2	Contaminated pigtail connector
3	Type 1 fibre geometry mismatch, different fibres in the pigtails and in the spliced multifibre loose buffer cables
4	Type 2 fibre geometry mismatch, different fibres in the pigtails and in the measurement fibres (launch or receive fibres).
5	Pigtail routing issues in the splice box
6	Damaged or contaminated measurement fibre connectors
7	OTDR operating error

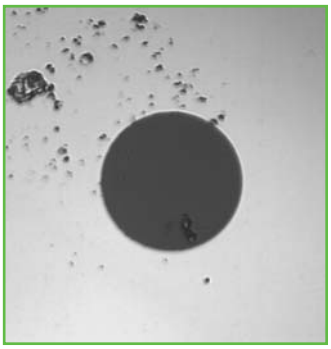


Figure 3 Connector end-face of fibre 12 before cleaning

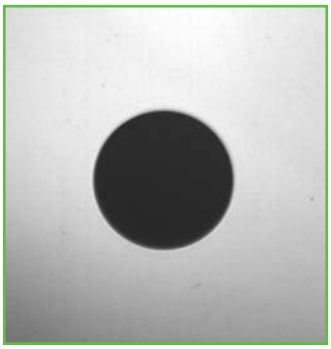


Figure 4 Connector end-face of fibre 12 after cleaning

Finally all links were measured again. No link presented any abnormalities such as excessive insertion loss values. Figures 5 and 6 show the same fibres, which in Figures 1 and 2 had loss values of > 0.4 dB.
It was possible to attribute the bad measurement results of the installer without any doubt to contaminated connectors on the technicians launch and receive fibres.

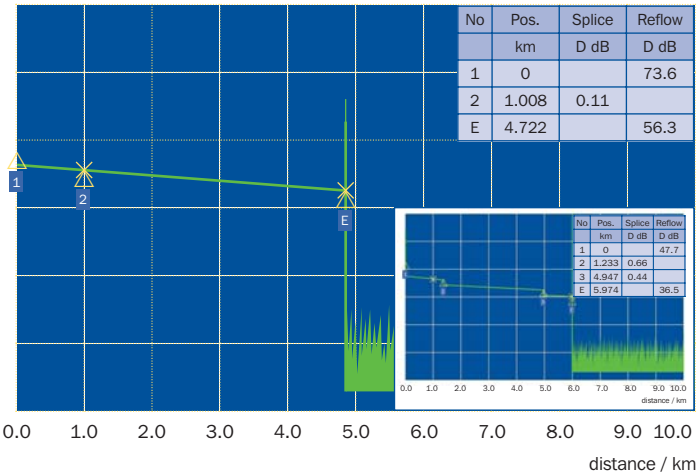


Figure 5 OTDR measurement trace of the link from Figure 1 after cleaning

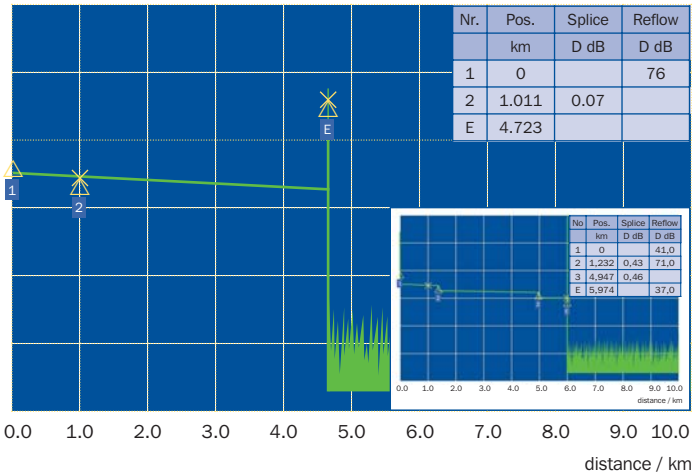


Figure 6 OTDR measurement trace of the link from Figure 2 after cleaning

5. Conclusion and recommendations

The above problems can be avoided, if the installer inspects the connectors of the launch and receive fibres before and after each measurement using an appropriate video microscope.
Here all end customers can make their contribution to the quality of their networks by integrating this inspection in their requests for proposal (RFP), by making the installer confirm the availability of the respective tools by demanding the images as a proof.

Additionally, by recording the serial numbers of the launch and receive fibres, it is possible to trace back which fibre type is used in the launch and receive fibres. If the customer additionally requires the installer to prove the maintenance status and the fibre type of the launch and receive fibres, further fibre risks can be minimized. Everybody should be aware that fibres older than 4 or 5 years are rather not suited to properly measure today's advanced fibres, as they are used in the pigtails of the splice boxes.

In view of the number of different fibre types and manufacturers the fibre data sheet should be an integral part of each RFP and of each delivery today. Thus fibre mismatches can be avoided from the beginning or at least be detected. However, it is important that the fibre manufacturer and the trade name of the fibre are indicated in addition to the ITU or IEC fibre type.

And, to come back to the beginning of the article, not only the ferrule structure or the connector set manufacturer are responsible for the quality of the optical connector, but also the assembler with his selection of materials and technologies. In order to ensure that the customer can benefit from this quality, the assembler, installer and end customer should cooperate.

Axel Thiel, FOC Head of Development and Manufacture

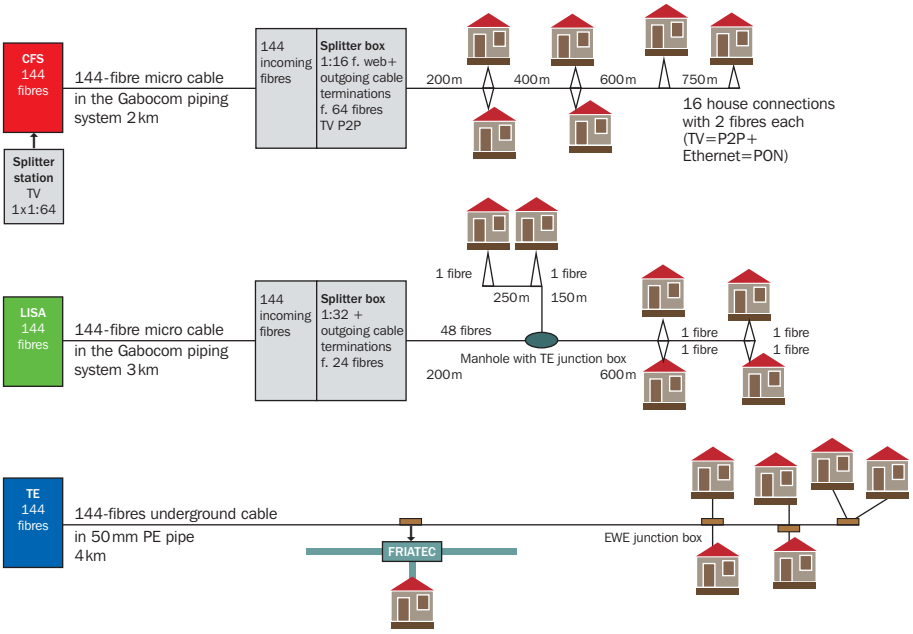
Correction on the report on E-2000™ pigtails for FIST on page 9 of our September 2012 edition

In the article on E-2000™ pigtails for FIST in flash-light 09 the impression was given that this product was in cooperation with TE Connectivity. This is not the case. TE Connectivity does not supply or sell E-2000™ adapters or pigtails from FOC.
TE Connectivity itself supplies adequate E-2000™ connectors for its splicing/patching cassettes.
The connector proposed by FOC with a shorter boot is not required.The transient-protected FOPT pigtails have been delivered by TE Connectivity since the market launch of FIST already. They are specified for FIST assemblies in order to ensure a flawless transmission during switching and maintenance work on the network.
In Figure 2 the use of the FOPT pigtail was wrongly illustrated. The correct use can be found in the assembly instructions published by TE Connectivity.
The FOPT pigtails from FOC have neither been tested nor approved by TE Connectivity. TE Connectivity does not assume any liability for the proper function of these pigtails in FIST assemblies. FIST is a trademark of the TE Connectivity Ltd. group of companies.
Tyco Electronics Raychem GmbH
Telecom Networks

We would like to apologize for the unclear description.
FOC-fibre optical components GmbH
Christian Kutza

One BEL··2· highlight

Fibre-to-the-X LAB
will be opened for use



Over the past months there has been much thinking, drawing and designing. But, first and foremost, we have been looking for manufacturer sponsors for implementing the FTTx-LAB in Berlin-Adlershof, Germany.

In April we will have reached our aim: We will have a Fibre-to-the-Home laboratory. The new facility can be used by the Joint Seminar group for lecture demos and training seminars.

Here you will get a clear hands-on overview of network topologies and terminal unit variants, although not all the peculiarities and versions created in the different German federal states will be available.

The below illustration will give you a first impression of the network topology on display. You are cordially invited to visit us on the occasion of the LAB opening during the BEL 2 fair on 24 and 25 April 2013.

Tilo Kühnel / Axel Thiel

We care about your opinion!

Please take a few minutes of your time. We would like to know, how important/neutral/unimportant the below criteria are for you in your contact with your business partner and how satisfied/neutral/dissatisfied you are with us, FOC GmbH. Your feedback will allow us to serve you better.

	important	neutral	unimportant	satisfied	neutral	dissatisfied
1. Polite customer support	1	2	3	1	2	3
2. Competent advice through office / field representatives	1	2	3	1	2	3
3. Interest in customized solutions outside the standard portfolio	1	2	3	1	2	3
4. Rapid processing of customer inquiries and orders	1	2	3	1	2	3
5. Satisfactory visiting frequency through field representatives	1	2	3	1	2	3
6. Reliable meeting of delivery deadlines	1	2	3	1	2	3
7. Ease of use of the products	1	2	3	1	2	3
8. Product quality meets expectations	1	2	3	1	2	3
9. Attractive pricing	1	2	3	1	2	3
10. Easily comprehensible design and implementation of information material	1	2	3	1	2	3
11. Smooth processing of possible complaints	1	2	3	1	2	3
12. Efficient and fast problem solving	1	2	3	1	2	3
13. Regular information about new products and updates	1	2	3	1	2	3
14. Use of 0.1dB network connections from FOC as a manufacturer	1	2	3	1	2	3
15. Use of similar products from other vendors	1	2	3	1	2	3
16. Regular reception of the “flash-light” customer magazine	1	2	3	1	2	3

Would you like to make any further comments on our products or services?

This feedback comes from:

Name:

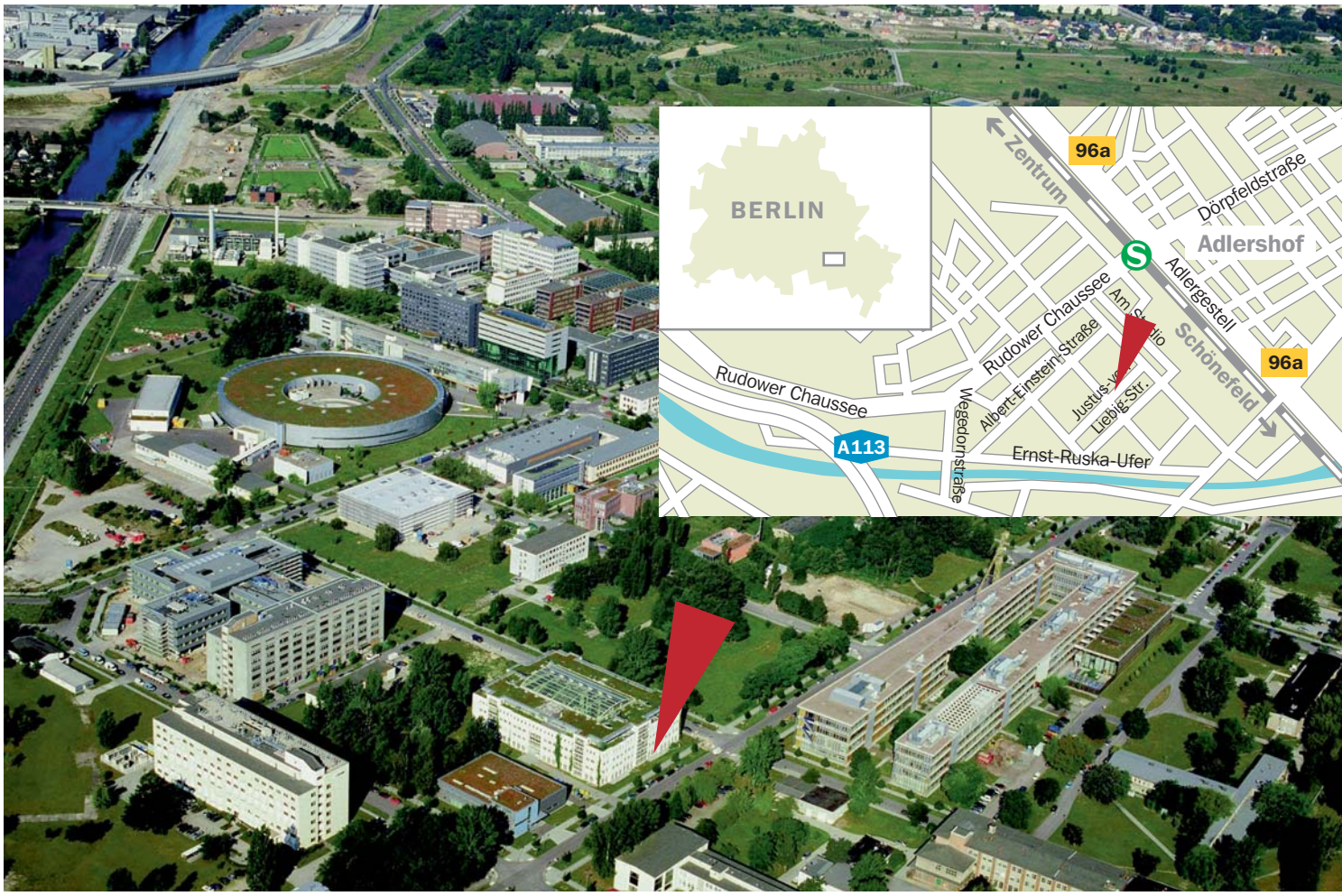
Company:

Please fax your answers and comments, if any, to FOC:
+ 49 30 56 55 07-19
or e-mail them to
info@foc-fo.de

Of course, we will treat your personal and business data confidentially. We will ensure that your anonymity will be respected in the analysis and assessment of your feedback.
Your FOC team thanks you very much for your kind support.

fibre optical components GmbH

In the Berlin-Adlershof Technology Park.



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