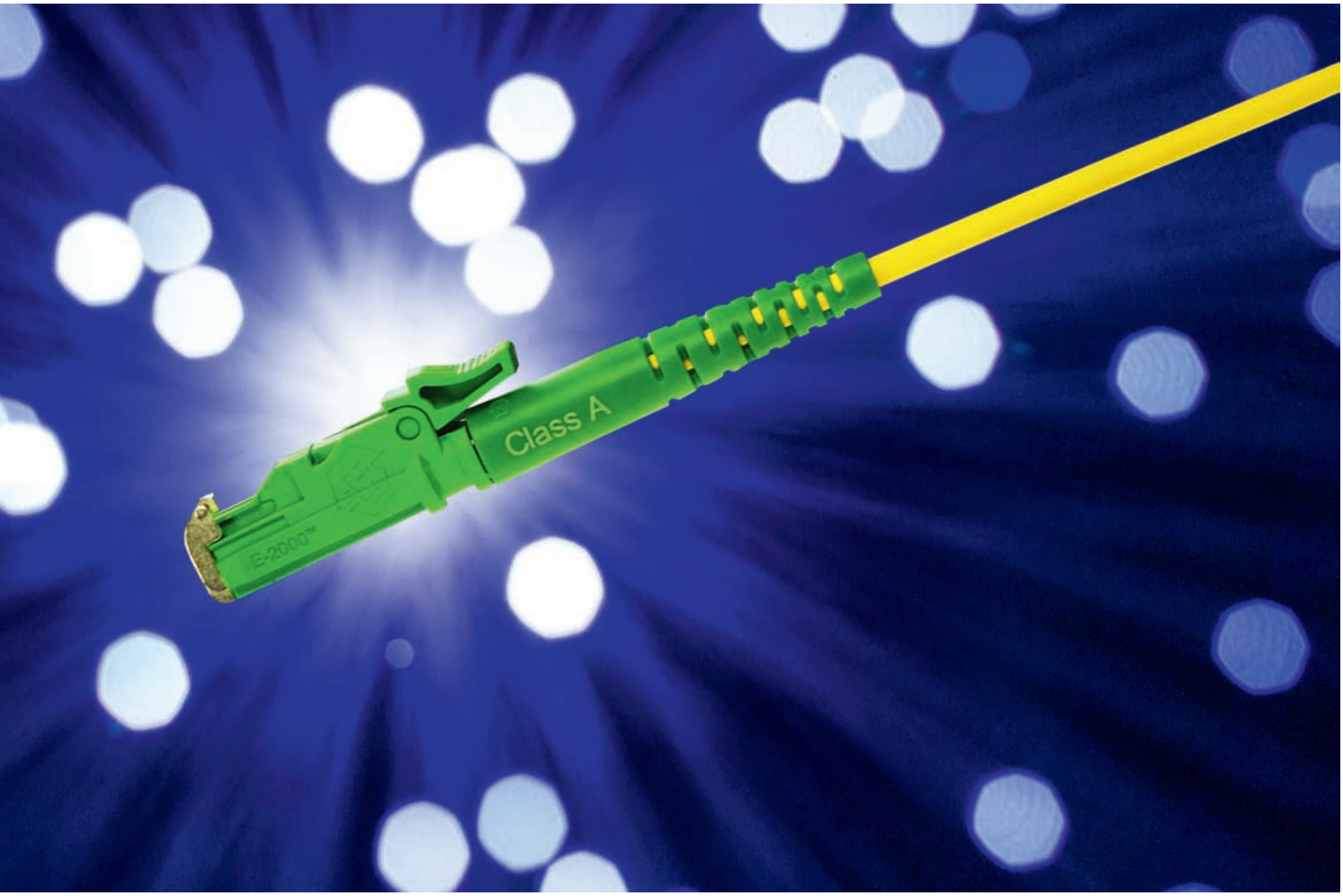
fibre optical components GmbH **At the speed of light into the future.**



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Contents

Editorial

Photo: Stephanie Eißrig

Broadband transmission is a technology of the future" – this undoubtedly correct statement has received an additional facet in Germany. The connection of subscribers via optical fibres is to be expected in the far future only in this country. The right step of privatising the telecommunication networks, accompanied by a Federal Network Agency and political declarations of intent, has resulted in relegation from the broadband league, which can be seen on the international scale. The stipulation of strict technology neutrality has produced a windmill blade but no guide post: nowhere on the world is there a sustainable alternative technology to fibre-optics in broadband networks available.

Let's have an optimistic look at the clear aim of abandoning nuclear energy. Here completely new concepts of energy distribution, management and the controlled energy consumption will be needed. This requires very reliable telecommunication networks and opens the eyes for practical new data services. Of course, the energy requirement of the information networks should be put to test, too. Current studies suggest that there is a clear driver for fibre-optic networks.

In other regions and countries new tasks are on the agenda: secure operation and fast service at affordable prices. Compatibility of components and new monitoring technologies as well as simple, but meaningful measurement techniques are in the focus of this issue. Here the (international) development is making fast progress.

We are looking forward to a good joint final sprint to the end of the year and would be pleased to welcome you for some interesting talks at ECOC in Geneva or at Gitex in Dubai.

If you don't find the time for visiting the fairs, we would like to invite you to take part in our Workshop Talks at our facilities, or you come to our premises in Berlin and watch the "transparent" manufacture of an LSH Class A connector.

Christian Kutza, Managing Director

»Class A« connector systems

Market requirement or technical nonsense?

It is to be adopted in the coming months… I mean the long-discussed loss class "A" (standing for 0.1dB max. or better) in the IEC 61755-1 standard. The following article highlights the efforts FOC has already made in this field.

Figure 1 New Class A connector with label

The new Class A technology from FOC - fibre optical components GmbH is an E-2000™* connector system which is fully geared to the work of the IEC international standardisation body.

The background of the whole issue is the unspoken fact that currently only one manufacturer can supply "true" 0.1dB technologies with the E-2000™ in an economically viable manner. With this in mind FOC GmbH has invested 12 months into a project under the working title of "Class A connector".

FOC fully relies on compatibility and IEC Grade A

The result is a connector which is fully compatible with the E-2000™ of the inventor and manufacturer DIAMOND and which:

1. is based on a full-ceramic ferrule and the E-2000™ connector system from the Huber und Suhner company, guaranteeing highly precise fibre bores in the ferrules by employing improved technologies. These bores already position the fibre in the ferrule's centre, thus not requiring any fibre-core alignment as a manufacturing step.
2. is fully compatible with E-2000™ connector systems from the companies FOC and DIAMOND already installed in the field.
3. fully complies with all optical and mechanical specifications of the international IEC 61755-1 Grade A standard (currently in draft status), see data sheet.
4. currently can only be manufactured by FOC based on the long years of connectorization experience applying DIAMOND and full-ceramic technologies.
5. guarantees an optimum use also under difficult environmental conditions by using a full-ceramic ferrule.
6. prevents accumulation of dirt in the groove produced in the core-alignment process by not requiring any such core alignment.
7. provides improved cleaning options for the ferrule.

Since the specified 0.1dB loss values are only partly linked with the manufacture of the connector assembly and are produced only when connectorizing, i. e. installing the connector assembly, it is particularly important to use optimised manufacturing workflows and procedures.

These are in particular:

1. The use of only one fibre manufacturer which permanently and with the least variation guarantees the physical geometries of the fibre within the international standards also for different fibre types (G.657 and G.652) and supplied batches.
2. Glueing the fibre in place in the already fibre-aligned full-ceramic ferrule.
3. A two-step curing cycle of the glue which prevents that the glue cures too fast and does not run in an optimum way along the fibre in the ferrule thus producing microbendings (stress) causing wavelength-dependent losses in the connector.
4. The use of an automatic laser cutter for removing the needless fibre protrusion directly on the ferrule.
5. An improved multi-step grinding and polishing procedure optimized for a compatible polishing radius and fibre protrusion as well as avoiding polymorphous intermediate layers on the glass surface.
6. The control and monitoring of the geometric and optical values during each step of the manufacturing process.
7. The optical final inspection prior to delivery to the customer (apex offset, loss measured against DIAMOND reference).

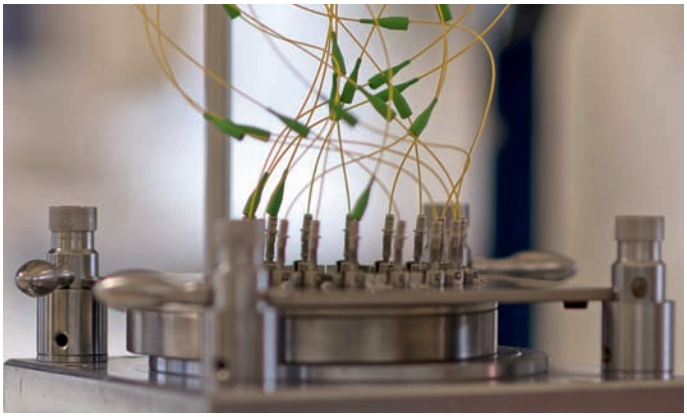


Figure 2 Polishing machine for achieving optimum polishing patterns and fibre endfaces

In view of the above mentioned criteria we as FOC do not see any compatibility or interoperability risks when using the "Class A" connectors, neither in combination with E-2000™ assemblies which were previously delivered by FOC.

The development of the E-2000™ connector more than 17 years ago was a ground-breaking step towards reliable and precise fibre-optic connections for telecommunication networks.

Since then the manufacturing technologies for the connector materials and the semi-finished connector products of all E-2000™ manufacturers have evolved. Thus today we can use fabricated materials from suppliers allowing us without any restriction to guarantee fibre assemblies in 0.1dB quality using the "Class A" as we have done in the years before on the basis of the core-alignment procedure.

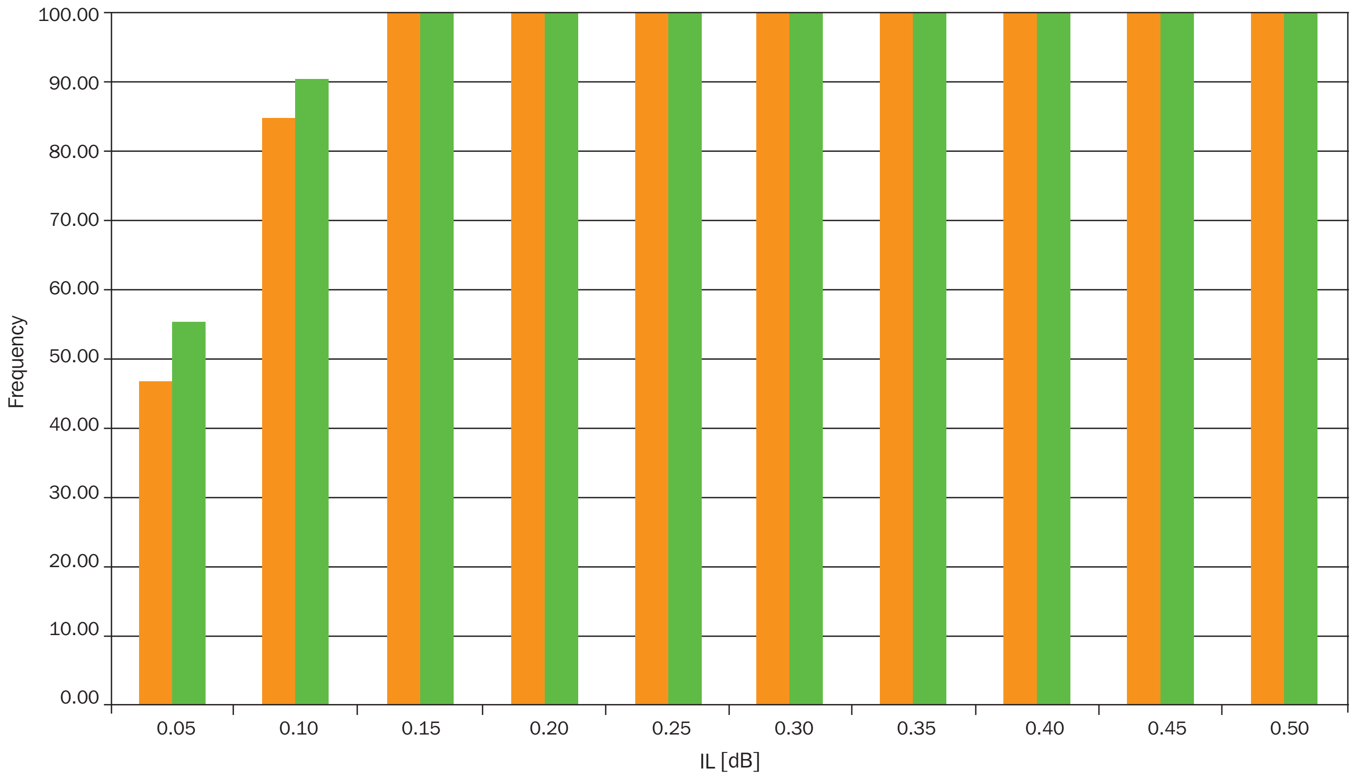
For these reasons since May this year FOC has been delivering exclusively "Class A connecting systems", in particular also to well-known major customers previously using E-2000™ from us, such as: Primacom, htp GmbH Hannover, Teleste.

The additional benefit for the customer is that he will be able to formulate his tenders now without specifying a particular manufacturer. This is especially important if these tenders are placed in the public environment such as from public authorities.

We as FOC would be pleased if the above mentioned facts had convinced you of the benefits provided by the FOC "Class A connector systems" and if you would allow us to become your reliable partner for: technical reliability and expertise; short and dependable delivery deadlines.

Tilo Kühnel, Sales FOC

Figure 3 Production yield measured at 1310/1550 nm



* E-2000™ is a registered trademark of DIAMOND S.A.

Fast assignment of faults through reflector cascades

Today optical network infrastructures frequently consist of networks or links belonging to different owners. This fact has to be taken into consideration by using a superordinate fault management system on the network operator's side. In order to guarantee minimum downtime in case of fault it is imperative to determine the relevant contact person responsible for the network segment as fast as possible. The smart cascading of reflectors can help saving valuable time here.

Wavelength-selective reflectors are used as optical link terminations for link monitoring purposes at monitoring wavelengths of 1620 or 1650 nm. Monitoring is executed via optical time domain reflectometer (OTDR) measurements from the Central Office (CO). Since the reflectors are transparent in the operating wavelength range an in-service monitoring of the link is possible any time. Using the end reflexion produced by the reflector each link can be assigned to a particular subscriber. In case of a fiber break the affected link can quickly be determined due to the missing reflexion. This principle has already been largely taken into consideration in the relevant standards. However, reflectors can make a much more sophisticated contribution to fault analysis, as the following examples will show.

Detecting faults on every network level

In case of fault it is imperative to restore the network infrastructure as fast as possible. Particularly in the local loop, which is characterised by a series of link segments with different responsibilities in quick succession, it is frequently not sufficient just to locate the affected link, but in fact essential to determine the faulty link segment in order to contact the responsible person.

However, a precise localization of the fault using OTDR measurements proves to be difficult, if individual partial links are so short that they fall within the resolution limit range of the OTDR, e.g. 1 - 2 m long patchcords. One typical example is the link segment between the wall outlet box and the terminal equipment interface (ONU) in the subscriber's apartment.

Another difficulty arises, if the OTDR traces of different links are overlaying each other, as is regularly the case with PON structures due to their network architecture containing couplers. The overlaid traces make the numerical analysis of the OTDR trace much more difficult. In many cases an additional, time-consuming manual measurement and analysis by experienced technicians is required.

In order to accelerate the service workflow it would already be beneficial at least to localise the affected link segment (and thus the responsible person) automatically and with a high degree of reliability. Such information would make it possible to contact the competent person and/or company and to initiate an early troubleshooting.

Such an assignment of fault can be easily achieved by cascading reflectors. To do so, several reflectors are installed consecutively on the link. In order to be able to differentiate between the link segments in questions, the reflectors should be installed at the points of interconnection. Their reflexions then provide information on the status of the upstream link segments.

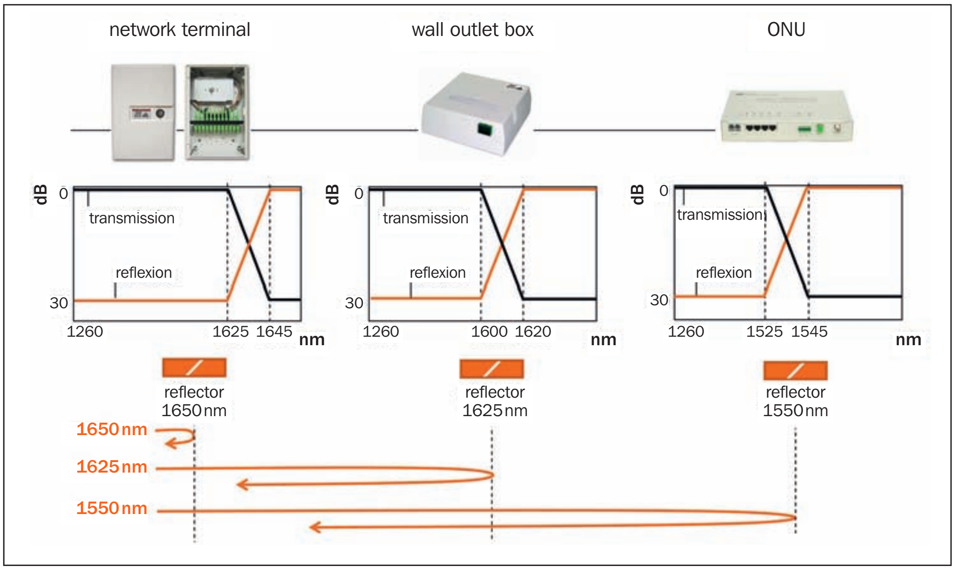


Figure 1
Cascading reflectors with different filter edge positions

On principal such a cascade can be implemented in two ways. One possibility is to use cascaded reflectors which differ in the position of their filter edge, i. e. in the portion of the wavelength range which is reflected or allowed to pass. Consequently, depending on the wavelength of the injected test signal, each time a different reflector will "respond", i. e. produce a reflexion in the OTDR trace. Due to their distinctiveness, even in a PON configuration, these reflexions can easily and reliably be detected by a monitoring system using numerical methods. Figure 1 shows an example with reflectors for test signals at 1550 nm, 1625 nm and 1650 nm. However, the configuration shown is only practical, if the 1550 nm channel can be used as an additional test wavelength, i. e. if only the wavelength range below 1525 nm is used for data transmission. In this case no video signals can be transmitted at 1550 nm.

For a differentiated fault assignment the link must be tested consecutively at all three wavelengths. If none of the three reflexions is detected, the fault must have occurred already in the access network before the network terminal. If a reflexion occurs at 1650nm only, the fault is to be found between the network terminal and the subscriber's terminal equipment (ONU), i. e. in the in-house network. If reflexions are detected both at 1650 nm and at 1625 nm, but not at 1550 nm, the fault should be located in the subscriber's apartment.

Another possibility is to use a cascade which requires just one test wavelength. This configuration employs reflectors with a relatively low reflectance R of 20-30% and a correspondingly high transmittance of 70-80%. Since in each case the bigger light portion of the test signal is allowed to pass each single reflector, it can reach the next reflector. However, all in all, the test signal is subject to some attenuation at each reflector. Thus the reflexions in the backscatter trace will lose in height from one reflector to the next. Here, for fault assignment just one single measurement is required: Depending on which of the three reflexions appears in the trace, it is possible to determine the faulty link segment analogous with the above procedure.

If it is desired to have reflexions of almost identical height in the backscatter trace, each reflector should have a different reflectance (see Figure 2). If R1, R2 and R3 indicate the reflectance values of the three reflectors at the test wavelength, a simple calculation shows that the optimum reflectances for three reflexions of identical height in the backscatter trace are R1 = 23%, R2 = 38% and R3 = 100% (link attenuation is neglected).

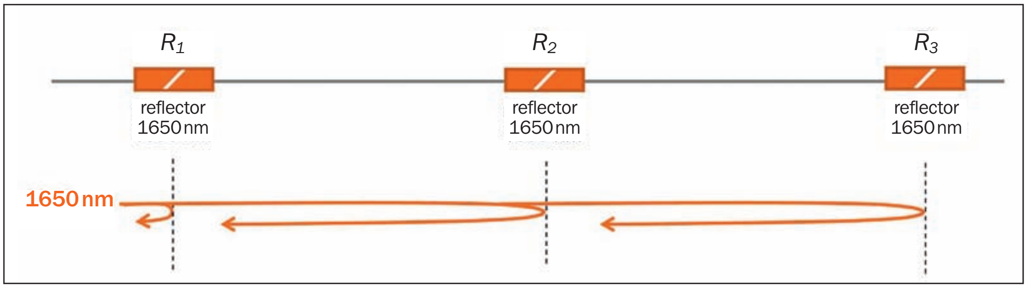


Figure 2
Cascading reflectors with different reflectances

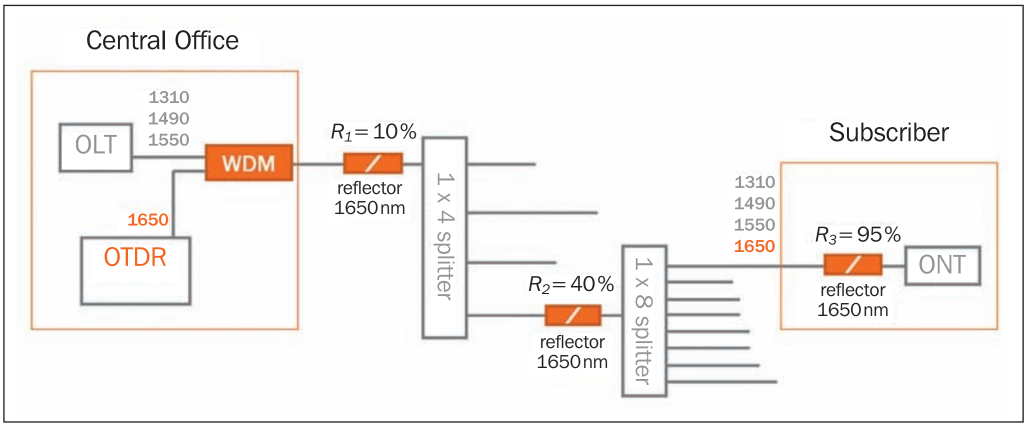


Figure 3
Practical example of cascading reflectors with individually dimensioned reflectances

However, if significant losses occur at certain locations between the reflectors, it might make sense to take them into consideration when dimensioning the reflectors in the first place. Figure 3 shows one example of such a configuration.

Of course, the two illustrated possibilities of cascading reflectors can also be combined. FOC offers reflectors of the *lilix* family of products with different filter edge positions and/or reflectances. Thus there is almost no limit set to the creativity of the network designers. Due to their extremely low insertion loss (<0.5dB) the *lilix* FTTx reflectors only marginally affect the loss budget. With their small size (2.8mm x 25mm) they can easily be installed permanently on the link, for example in the wall outlet box. Alternatively it is possible to integrate reflectors in optical connectors.

Dr. Martina Vitt, Product Manager lilix, FOC

Patchcords

with connector-integrated reflectors

Following the almost world-wide perception that new concepts and components are required for monitoring future fiber-optic networks in the local loop, the question is not only how to implement a cost-optimized mass production of reflectors but also how to integrate them efficiently in established network structures. To this end FOC has embarked on a new way.

Introduction

In future network monitoring and surveillance in fiber-optic networks will become a more and more decisive criterion for ensuring customer satisfaction, on the one hand, and for lowering the operating and maintenance costs, on the other hand.

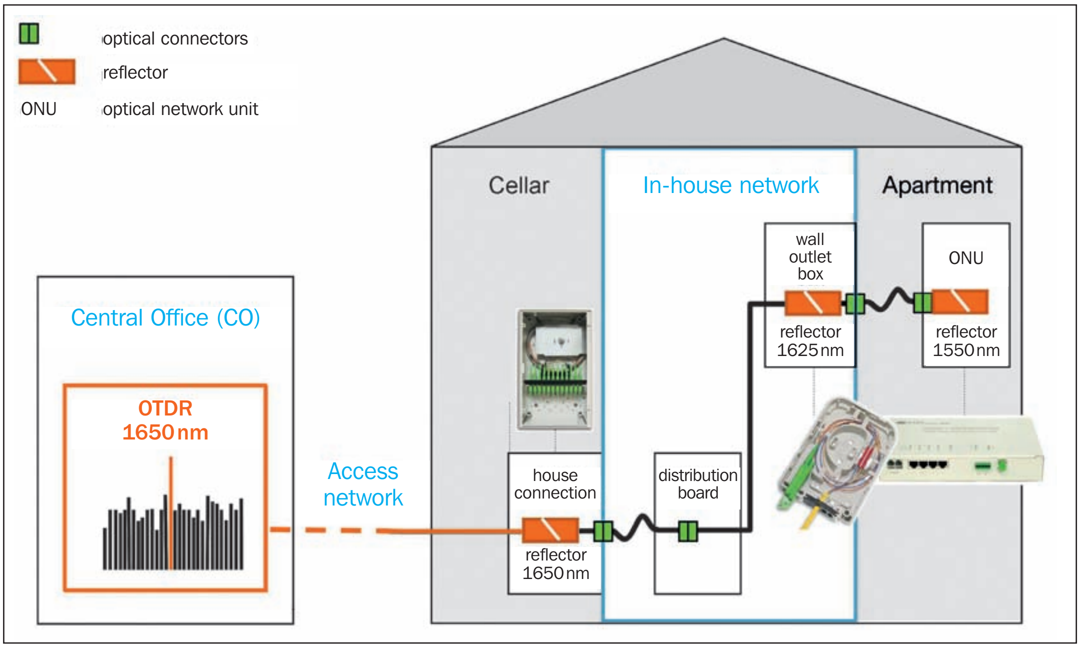


Figure 1
Network infrastructure with wavelength-selective reflectors

Meanwhile the standardization of concepts and products for network monitoring on the basis of reflectors working above the classic telecommunications wavelength range has progressed well. (1,2) Also the number of suppliers of such solutions and products has increased rapidly over the past 12 months.

Although consequently, in connection with the permanently decreasing hardware costs, the additional basic investment in the fiber-optic infrastructure is an increasingly uncritical item in the balance sheet in view of the anticipated lifetime of fiber-optic networks (for the passive infrastructure more than 30 years are assumed), the integration of additional components for monitoring and surveillance is an issue which should not be underestimated.

Resulting from the inevitable task of integrating the reflectors in existing products, in the months following the introduction of the reflectors FOC GmbH has worked on a solution for installing the reflectors in products which are always employed in optical subscriber networks independent of the monitoring or surveillance concept used.

Integration of reflectors

Reflectors are installed at different points in the network infrastructure (Figure 1). (3)

While the design of the reflectors is uncritical, if installed in junction boxes or other inaccessible distribution points (cf. Figure 2), in the subscriber's access area additional factors need to be taken into consideration:

(I) The fibre-optic outlet boxes should be as stylish and small as possible, i. e. the internal space for installing the reflectors is much regulated.

(II) Some network operators favour a solution enabling monitoring beyond the subscriber's outlet box to the terminal equipment. On the other hand it is difficult to convince the terminal equipment manufacturers of integrating reflectors in their terminal equipment (Optical Network Unit, ONU).

(III) The manufacturers try to avoid the expense of integrating additional optical components in the ONU. They do not want to provide anything like an additional support, for example.

Figure 2 Standard reflector form factors

Taking all these factors into consideration the idea was born to integrate the reflector in the connector. In this way the reflector can both be part of the internal pigtail in the outlet box or ONU and be integrated in the patchcord leading to the ONU.

tance. Only since the development of the *lilix* reflectors by FOC there have been cost-efficient reflectors with a high reflectivity available which can be used independent of the network structure.[3]

Figure 3 Integration of wavelength-selective reflectors in optical connectors

Reflector-connector combinations

Well, the idea of integrating reflectors in connectors, pigtails or patchcords is not really new.

Pluggable reflectors implemented using coatings on ferrule surfaces or patchcords with integrated fiber Bragg gratings have long been known on the market (2). However, due to their technological drawbacks they have not met with the required acceptance.

Extraordinarily small and flexible

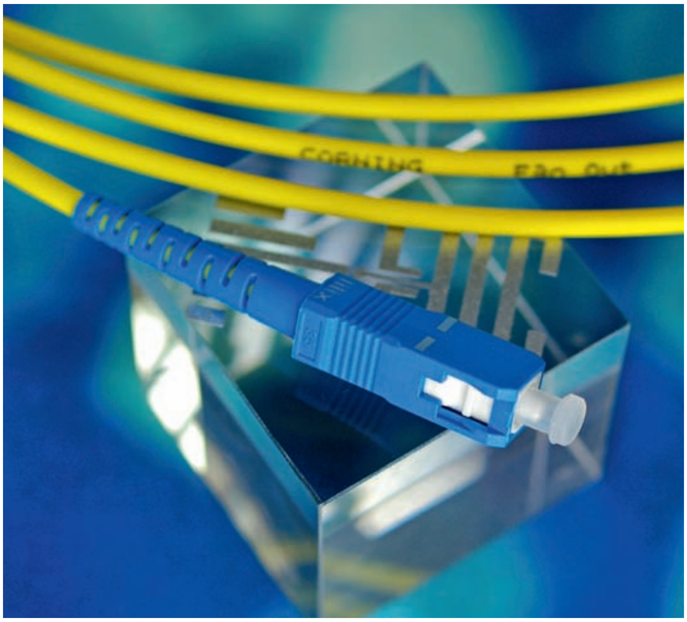


Figure 4 Patchcord with a reflector integrated in the connector

The idea was to miniaturize these high-quality reflectors to such a degree that they could be integrated directly in the connector's ferrule without affecting the basic function of the optical connector or its parameters of use (Figure 3).

In the course of the past three months we have succeeded in developing a technology and a process for integrating the reflectors in the ferrules of all connectors based on round ferrules with an outer diameter of 2.5 mm. Thus, now reflector patchcords can be provided for the majority of the classic LSH (E-2000™), SC, LSA (DIN) and FC connectors available on the market.

Summary

Reflector patchcords allow a completely new flexible integration of the reflectors in existing and future optical networks to be implemented. We hope to be able to present a solution for the next challenge—the integration in Small Form Factor (SFF) connectors such as LC or LX.5—in one of the next issues of our journal.

Axel Thiel, Head of Development Department & Manufacturing FOC

1 Draft ITU-T G.984.5 amendment 1
2 Future IEC 61753-041-02
3 Vitt, M., Thiel, A., Small reflectors, big effect (in German language), NET, Issue 6, 2011, p. 43ff

* E-2000™ is a registered trademark of DIAMOND S.A.

LTE

Complementing or substituting?

Sources: HTC, Apple

Introduction

LTE stands for "Long Term Evolution" and is the broadband successor generation of UMTS. LTE is also called the G4 wireless communication generation. The term of G4 denotes LTE Advanced. Advantages for the user are substantially higher data rates in the order of 50 Mbps and more. Some publications even promise 1 Gbps in the near future. However, like any other wireless technology, Ethernet is a shared medium, too. This means that up to 10,000 subscribers must share this cell capacity. Such data rates cannot be provided by existing wireless communication standards, such as GSM, UMTS and HSPA. The high data rates desired for LTE are achieved by employing new coding and modulation schemes, i. e. the so-called MIMO (Multiple Input, Multiple Output) antenna technology. LTE has been designed as a pure IP network. Voice services are implemented as VoIP. Thus the preconditions for mobile Internet are fulfilled.

Technical background

Frequency ranges: For LTE the following frequency ranges are provided: 800 MHz, 1800 MHz, 2000 MHz and 2600 MHz. The 800 MHz frequency range is also called the "digital dividend". This term was coined because during the changeover of terrestrial TV from analogue to digital this frequency range was unblocked for other applications.

Coding and modulation: In the downlink, i. e. from the base station to the mobile subscriber, OFDMA (Orthogonal Frequency Division Multiple Access) is the modulation scheme used.

Wireless broadband or fixed network substitution

Here the carrier channel is subdivided into individual 15 kHz subcarriers. These subcarriers are then modulated using QPSK (Quadrature Phase Shift Keying) 64 QAM or 16 QAM (Quadrature Amplitude Modulation). In the uplink, i. e. from the mobile subscriber to the base station, SC-FDMA (Single Carrier-Frequency Division Multiple Access) is the modulation scheme used. This coding scheme reduces energy consumption in the mobile terminal.

The above mentioned MIMO antenna technology also contributes to increasing the achievable data rate.

How can we compare LTE with broadband FTTH-based Internet services?

As already mentioned, LTE offers considerably higher data rates than the existing GSM and UMTS networks. So the idea suggested itself to equip the so-called "white spots" in broadband coverage in Germany with LTE technology. This was also the aim of the German regulatory agency and/or the German federal government. In this way they wanted to realize their ambitious projects for implementing broadband coverage in the country. Due to its favourable propagation characteristics the 800 MHz range is well suited for large-scale wireless coverage.

The fact that the frequencies had to be purchased by auction by the network operators, thus injecting about €4 billion into the state's finances, was seen as a pleasant side-effect. It was the frequency range of around 800 MHz (LTE800), which—as the "digital dividend"—brought the majority of the auction proceeds.

The terms of use for the 800 MHz range stipulate the preferential development of the so-called white spots. This means that the areas where previously only ISDN or a maximum of 1 Mbps were available now can be offered 50 Mbps or more. All is needed is to set up some radio towers in those areas or expand the existing wireless installations—and the demanded coverage is available at once. There is no need to engage in seemingly difficult installation work, as was necessary with the FTTH expansion, for example.

This, at least, is the theory. But what does the practice look like?

The LTE bandwidth of up to 50 Mbps and more can only be achieved under almost ideal conditions. Since, in general, several subscribers have to share the existing wireless cells, this is also called a shared medium. However, in order to be able to cost-efficiently cover a certain geographic area, the wireless cells will have to be as large as possible. In a bigger distance to the LTE base station, due to the worse signal-noise ratio (SNR), the transmission rate will be reduced.

We have to assume that, in the near future, the medium transmission rate will be in the range of ADSL technology (i. e. 2-6 Mbps). Deutsche Telekom indicates a transmission rate of up to 3 Mbps in their LTE tariffs. This is a realistic value. For the areas, which so far had to be content with ISDN or a maximum of 1 Mbps, this surely is a gain in bandwidth. However, bandwidth demand is permanently increasing. Already today, a transmission bandwidth of up to 3 Mbps is not sufficient for many existing services and applications. Even if the expansion of LTE can offer up to 50 Mbps and more in many areas, this technology will always be short of the demand.

Consequently, the alternative can only be a consistent expansion of the fibre-optic infrastructure up to the subscriber. This is the only technology which allows the bandwidth demand for the next decades to be satisfied.

"LTE—complementing or substituting?"

It is undisputed that there is an increasing demand for mobile Internet services. This demand is mainly driven by smart phones and tablet computers such as I-Phone and I-Pad. The existing wireless communication systems will not be able to fully satisfy this demand in future any longer.

In this context LTE is to be considered as complementing.

However, is LTE really substituting a fibre-optic fixed network? Here we can only repeat that only an adequate fibre-optic infrastructure can satisfy the future bandwidth demand.

Another important point is the existing tariff structure of the LTE suppliers. The rates depend on the agreed download volume.

Usually download volumes of a maximum of 10 GB are stipulated. With today's applications this limit is achieved fast, in particular, if several family members share one LTE connection.

If the volume agreed in the tariff is exceeded, the download rate is reduced down to some 100 kbps. Consequently, the users are back to a level of a bit more than ISDN. Here, a certain conflict can be seen with the promised bandwidths of 50 Mbps and more. What benefit does this bandwidth provide to the user, if he/she will not be able to use it any longer after a short time (after reaching the maximum volumes of the agreed tariff)?

It is doubtful, that this tariff policy will change in the short run, since the LTE providers first have to earn the money they spent on obtaining the frequencies and on the expansion of the LTE infrastructure.

Another aspect which needs to be taken into consideration is the aversion of large parts of the population to the so-called electric smog. Because of the increasing expansion of wireless applications in their own home and in their immediate surroundings more and more people feel some discomfort, even if so far it has not been possible to establish a provable connection between high-frequency radiation and serious diseases such as cancer. Nevertheless the medium exposure to high-frequency radiation should be reduced to the necessary minimum. LTE makes no contribution to this aim.

According to our observations, we can also see a certain division of markets. There is an increasing demand for mobile Internet applications. This demand is partly much oriented towards juvenile users. Here LTE is an alternative to existing wireless communication networks.

On the other hand, the demand for high-quality home entertainment applications such as HDTV, 3D, but also Triple Play, is increasing. Here the bandwidth demand is permanently rising, in particular in the upload direction. Also with a view to future applications, this demand can only be satisfied with an FTTH infrastructure.

Michael Riecke, Sales FOC

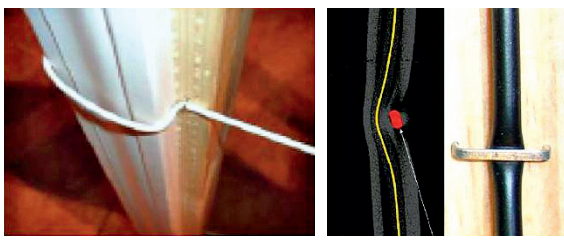
Conditions of use and compatibility of bend-optimized fibres according to ITU-T G.657

Today standard singlemode fibres are installed and used at least as frequently as copper-based transmission media. The future requirements for optical fibres will increasingly have their origin in the home environment.

The increasing bandwidth demand also in the residential environment will make it necessary in the future to substitute copper-based transmission media such as telephone and TV cabling. The only alternative is the large-scale use of fibre-optic cables also in single family units (SFU) and multi-dwelling units (MDU).

This task is underestimated by many even today, since in Germany we only have little project experience in this field. So far also the network equipment providers have not contributed much to solving this problem, except with the already established structured cabling systems for business and office buildings.

Based on the historic development of the country, in residential buildings we find two media for transmitting and providing information and communication and for using electronic media.



Figures 1, 2 Future requirements for mechanic and optical parameters of optical fibres installed at the subscriber (source: Corning)

On the one hand this is the telephone line, and on the other hand—but exclusively in the urban areas—the coaxial cable of a TV cable network operator.

The latter offers the additional advantage that it can make essentially more resources available in the form of bandwidth compared with the twisted pair telephone line.

But very soon these transmission media will not be able any longer to satisfy our information, communication and entertainment needs. Consequently we will have to make the change-over to fibre-optic cables.

This task is relatively simple to fulfil for residential buildings which are in the process of being built. However, buildings which are already occupied and fitted with copper lines are problematic. Here we are confronted with a substantial lack of space. This is because a substitution of the transmission medium does not necessarily mean that it is possible to simply replace the "old" line with the "new" one. There a quite a lot of reasons for this.

Two of the reasons are that the media are owned by different persons/companies and that an additional fire load is produced when an additional cable is pulled in. In this context the legal requirements for residential buildings must be observed.

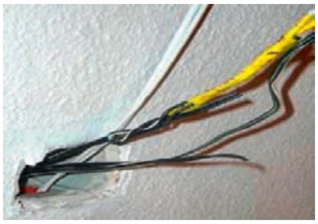


Figure 3
Existing copper lines are used as a "pull-in aid" for fibre-optic cables

In order to mitigate the problem of the space requirement at least a bit, the cabling industry has developed a special optical fibre and specified it in international standards. I speak of a bend-optimized fibre which is used in the form of a micro-cable and which does not only reduce the size of the house cabling from the basement to the apartment, but also allows the cable to be laid under similar conditions like a copper cable. These include the routing of the cable in 90° corners of rooms and in hard-to-access raceways on the individual storeys. But also the joint routing in so-called media collecting systems together with low-voltage cables brings up the problem of microbendings through crossing cables.

The standard singlemode fibre G.652 D, as known today, cannot be used to overcome this challenge. Over the past three years this has led to the development and standardization of the bend-optimized G.657 fibre. Here two specific types are known, which are also increasingly used.

Ready for large-scale use

The actual advantage of this bend-optimized fibre is that no increased loss occurs, neither at very small bending radii of up to 5 mm even at the bigger wavelengths of 1625 nm (see table).

Some manufacturers have already begun to perfect these fibre types and achieve still better values in the attenuation behaviour of the fiber. One example is the leading fibre manufacturer Corning (see table).

Another important aspect—and decisive for the use of this fibre type—is its downward compatibility with installed fibre types, in particular with the G.652D standard singlemode fibre. Over the past years this fibre has been installed in newly installed optical access networks and frequently terminates in basements of residential buildings, mostly as a Fibre-to-the-Building (FTTB) solution. If this system is later expanded to a Fibre-to-the-Home (FTTH) solution, the bend-optimized fibre has to guarantee full optical and mechanical compatibility. The splicing process for connecting both fibre types presents no problem any longer, since the manufacturers of splicing units have responded by supplying adequate software updates.

But bend-optimized fibres will play a significant role in the future, not only in the FTTB/FTTH environment. Moreover, all other historically grown cable management systems require a space-saving routing due to the increasing packing density and the filling level. Here, too, this new type of fibre offers ideal preconditions.

Parameter	ITU-T G.657 Table A	ITU-T G.657 Table B
Main aim	Maintenance of downward compatibility	Maximizing of bending properties
Compliance with ITU-T G.652.D	required	not required
1 turn × 7.5 mm radius at 1550 nm	not specified	0.5 dB
1 turn × 7.5 mm radius at 1625 nm	not specified	1.0 dB
1 turn × 10 mm radius at 1550 nm	0.75 dB	0.1 dB
1 turn × 10 mm radius at 1625 nm	1.5 dB	0.2 dB
10 turns × 15 mm radius at 1550 nm	0.25 dB	0.03 dB
10 turns × 15 mm radius at 1625 nm	1.0 dB	0.1 dB

Table 1 Summary of specifications relating to the bending properties according to ITU-T G.657, Tables A and B (Source: ITU-T)

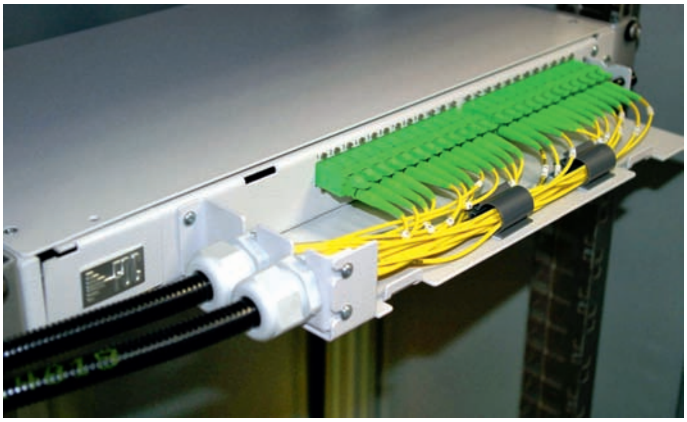


Figure 4 OKE (splice box) with optimized cable management

Table 2

		ITU G652A	ITU G652D	ITU G657A	ITU G657B	Corning Clearcurve™ fibre
Bending properties (loss – dB for 1 turn at 1550 nm)	Maximum bending radius*	30 mm	30 mm	10 mm	7.5 mm	5 mm
	10.0 mm radius	n.v.	n.v.	0,75	0,1	n.v.
	7.5 mm radius	n.v.	n.v.	n.v.	0,5	n.v.
	5.0 mm radius	n.v.	n.v.	n.v.	n.v.	0.1
Attenuation at 1310 nm		✓	✓	✓	✓	✓+
Attenuation at 1383 nm			✓	✓		✓+
Attenuation at 1550 nm		✓	✓	✓	✓	✓+
Attenuation at 1625 nm		✓	✓	✓	✓	✓+
Dispersion		✓	✓	✓	✓	✓+
PMD			✓	✓		✓+
Geometries		✓	✓	✓+	✓+	✓++
Comprehensive environment specifications		✓	✓	✓	✓	✓+
Downward compatible with G.652D			✓	✓		✓
Compatible with tried and tested processing techniques		✓	✓	✓		✓
Suited for manufacturing techniques in series production		✓	✓	✓		✓

* Maximum acceptable radius: Radius at which the loss is ≤0.1dB for 1 turn   Source: Corning

Table 3

	G.652.D	G.655.A	G.655.B	G.657.A1	G.657.A2	G.657.B1	G.657.B2
G.652.D	+++	++	++	+++	+	–	–
G.655.A	++	+++	++	n.n.	n.n.	n.n.	n.n.
G.655.B	++	++	+++	n.n.	n.n.	n.n.	n.n.
G.657.A1	+++	n.n.	n.n.	+++	++	?	?
G.657.A2	+	n.n.	n.n.	++	+++	?	?
G.657.B1	–	n.n.	n.n.	?	?	+++	?
G.657.B2	–	n.n.	n.n.	?	?	?	+++

+++ Compliance with Grade A limits, can be spliced (≤0.05 dB)
++ Compliance with Grade B limits, can be spliced (≤0.1 dB)
+ Compliance with Grade B limits, increased splice loss (>0.1 dB)
– Combination does not work
n.n. not necessary, different target market
? Not clear, weak data basis

Conclusion

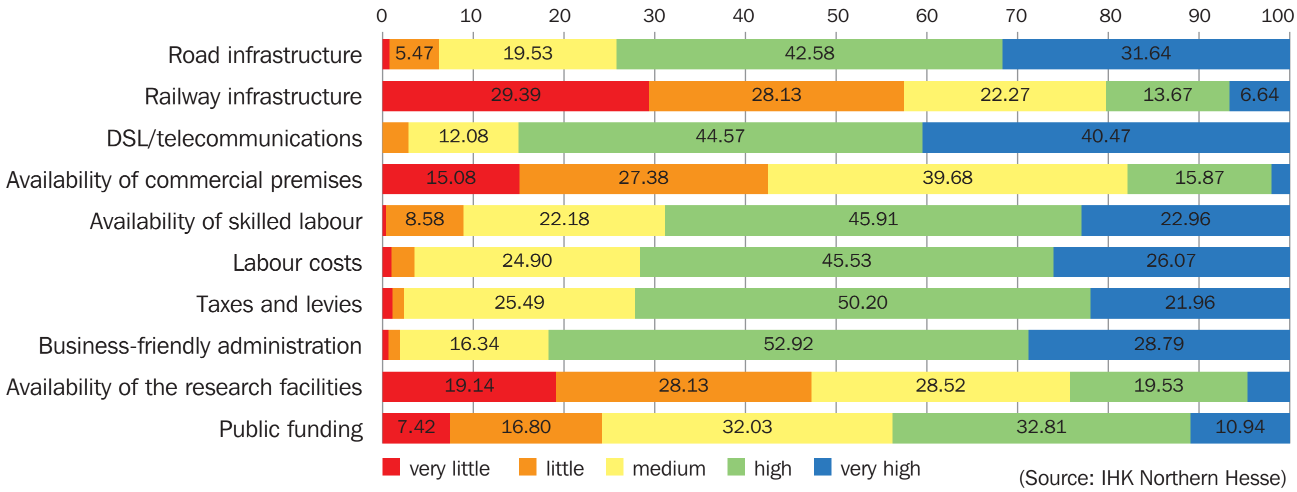
With the bend-optimized fibres the foundation has been laid for the network equipment providers to consider and develop solutions in the form of structured cabling systems for existing buildings which are already occupied. Another problem is an installation performed by the owner/tenant within the apartment. We will need intelligent solutions.

Also for these reasons FOC has decided to exclusively rely on the G.657 A fibre type for the connectorization of patchcords and the manufacture of pigtails, and to offer this fibre type at the same price as before. We will implement this process from 01 October 2011.

Tilo Kühnel, Sales FOC

Self-help for broadband access

The venerable university town of Marburg in Northern Hesse, Germany, is solving its broadband problems now on its own: A future-proof communications infrastructure is vital for this scientific centre. A study prepared by the Chamber of Industry and Commerce (IHK) last year under the title of "Location factors in Northern Hesse and Marburg" (see Figure) showed that the companies consider DSL and telecommunications to be the most important location factor, much more important than road access.



(Source: IHK Northern Hesse)

And since this positive location factor is sustainably imaginable only through the expansion of a fibre-optic network—an active expansion was not planned for the foreseeable future by the telecommunications companies of Telekom, Vodafone and Unitymedia active in Marburg—the town helped itself and engaged their own utility companies. Consequently, they expanded continuously their large-scale fibre-optic network over the past years. All commercial areas, such as Cappel, Wehrda and the Behring company, were developed. The economic location was strengthened, companies retained and new companies attracted to Marburg.

Compared with this optimized situation the partly decade-old copper networks of Deutsche Telekom in the centre of the town and in the residential areas fell more and more behind. Although in the city core area up to 50,000 kbps were possible via VDSL in selected spots, in most areas of the university town the offer was clearly under 10,000 kbps, frequently a maximum of 3,000 kbps.

Some parts of the town almost had no broadband access, at all.

Clearly worse was the situation in the urban districts on the outskirts of the town: Some were completely without broadband access, most had to content themselves with bandwidths of about 1,000 kbps. As a first step the Marburg utility companies have provided a basic wireless DSL coverage (up to 3,000 kbps) in all outer districts and laid empty conduits during running road improvement works or other civil engineering projects.

Now in the urban district of Bauerbach the connection of the households via FTTH is in preparation as a pilot project. Since ANGA 2010 CFS GmbH has been using the "FTTx-Plan" tool, which is the result of the work of a research consortium including the Fraunhofer Heinrich-Hertz Institute for telecommunications and Atesio GmbH, Berlin.

FTTx-Plan as a tool for the pilot project in the urban district of Bauerbach

The central goal of the FTTx-Plan planning tool is to simplify the strategic decision process of city utility companies, communities, authorities and special-purpose associations for the construction and expansion of their own FTTx networks.
This tool takes the interests of the customers into consideration, in particular with a view to the calculation of costs and of profit/loss performed by the NGA network designers of CFS GmbH, Berlin.

Also in Marburg this calculation was based on a short-term, objective, model-based analysis which included the specific marginal conditions on site.

The concept of the tool reduced any uncertainties in the evaluation of architectural and technological alternatives through systematic techno-economically optimized planning, which was based on efficient mathematic optimization procedures and supported a realistic cost forecast. Technological dead ends were identified early in the design process; different planning approaches were compared.

The construction of the fibre-optic broadband network in Bauerbach was quite labour-intensive; updating the specific geo-data on site alone entailed much personal effort. In order to achieve a positive business development for the Marburg utility companies, the techno-economic dependence between the overall costs and the technical potential of the available system technologies had to be taken into consideration. Initially the fibre level was planned on a P2P basis. Two fibres and one additional fibre were routed to the approx. 720 households. However, the decision on the final technology was not yet taken.

During this process the Marburg utility companies developed a deep understanding of the technology trends for fibre-optic network infrastructures and of the possibilities of the specific optimization procedures and their corresponding implementation in computer-based methods and tools: This is an essential advantage provided by FTTx-Plan for the conceptual design of future FTTx networks.

Christoph Pauselius, CFS GmbH, Berlin

Fibre-optic city networks for triple-play products

Fibre-optic technology is the future of fixed network telecommunication. This statement is based on the permanently increasing bandwidth demand of the fixed network users. Internet TV, video download, online gaming, cloud computing and home automation on the basis of smart grids are applications which are used today and tomorrow and which need more than 50 Mbps transmission bandwidth.

Moreover, competition in the fixed network segment is not any longer between double-play service providers (telephone and Internet), but increasingly between triple-play service providers offering TV and video entertainment services in addition to telephone and internet products. Consequently, for gaining new end customers, the classic fixed network providers are today in direct competition with CATV providers, which have expanded their product portfolio with telephony and Internet. But in the feeder network and in the local loop this market development requires the use of technologies and media offering high transmission bandwidths.

The DSL technologies used so far (VDSL, ADSL 2+) are increasingly approaching their physical limits and can rarely provide bandwidths of more than 25 Mbps. Transmission rates beyond 100 Mbps up to 1 Gbps can only be achieved on the basis of a fibre-optic infrastructure. The resulting consequence is the construction of fibre-optic transmission and access networks in order to fulfil the requirements of the multimedia-based fixed network market. In this context fibre-optic infrastructures for connecting buildings (FTTB) but also for connecting households (FTTH) have to be established. It is estimated that an investment volume of € 50 to € 60 billion is required for a complete upgrade of the German households to optical fibres. It is improbable that one single investor or one single company will be able to implement such a project. Thus there will inevitably be many individual initiatives resulting in a patch rug in Germany. Consequently, the cooperation of different partners for the creation of such fibre-optic infrastructures will play a special role in future.

In this context, typical partners are regional and communal utility companies already professionally constructing and operating networks for providing electricity, gas, heat and water. Such utility companies are all capable of installing and operating fibre-optic infrastructures and of offering all infrastructural services in their geographic business areas from a single source. Two business models have emerged for marketing such fibre-optic infrastructures:

1. Sale of passive fibre-optic infrastructures (cables)
2. Sale of IP-based transmission services in the form of bitstream access (lit cable)

The Bitstream Access model is often also called Open Access model, because the operator of these infrastructures offers the bitstream access services to all interested market actors without any discrimination. With this business model the respective operator does not only need to plan, construct and operate the corresponding passive fibre-optic networks, but also to implement the operation of the respective transmission systems and the generation and marketing of the bitstream access products.

The vitronet Group from Essen, Germany, has been engaged in the planning, construction and operation of fibre-optic networks for different customers for ten years already. In addition to pure outside cable plants and networks, such as for the Unity Media CATV operator, we also have successfully constructed a number of communal fibre-optic subscriber networks over the past years. These customers include the Danish electric utility company of Dong (Copenhagen city network), Hansenet/Telefonica Deutschland (Hamburg city network), Net Cologne (Cologne, Aix-la-Chapelle), the Schwerte and Munich utility companies. Together with the utility companies of Essen and Bochum we founded independent fibre-optic network societies (essen.net, Glasfaser Bochum), for which vitronet does not only supply the required technical services but also is a co-partner.

Since the last year, in both cities FTTH city networks have been built, which in Essen will connect about 80% and in Bochum about 60% of the addressable potential (inhabitants, households, buildings. For both projects an overall time for completion of five to six years is expected.

In the planning and construction of the passive fibre-optic networks vitronet relies on a point-to-point architecture where each apartment in the development area will receive its own fibre. The house connections are implemented using micro-cables containing 12 or 24 fibres. In addition to the fibres for each apartment and the corresponding spare fibres, for each house there will be a fibre for energy-related services as well as TV coverage via an analogue RF overlay signal.

The longitudinal routes in the streets to be developed will be fitted with micro-pipe bundles each containing 24 micro-pipes. All in all, 80 buildings will be routed via a micro-pipe bundle to a raceway supplying a total of 160 buildings. The raceways will be connected via backbone cable routes with so-called Regio POPs (Points of Presence), where about 3,000 to 3,500 homes are wired to an optical distribution rack (ODR) with fibre-optic patch panels.

In these Regio PoPs the systems of the active transmission equipment will be installed and operated, too. In addition, vitronet manages the operation its own FTTH networks in Essen and Bochum. Access equipment is based on a multi-service access node offering an interface both for connecting passive optical networks (PON) and point-to-point Ethernet (active Ethernet). From today's perspective the bitstream access products will be marketed in both city networks from 1st quarter 2012.

On the basis of our long years of experience in planning, building and operating fibre-optic networks and on our experience in the marketing of bitstream access services in our own networks,

vitronet offers comprehensive and integrated services in these fields also for third-party network operators. A major target group are the above mentioned utility companies, of which about 100 are already considering the development of a new fibre-optic business and/or have already begun implementing it.

In the future the two companies CFS, a subsidiary of FOC and vitronet will bundle their experience in the field of network technology for communal and regional utility companies and jointly address this important target group. This partnership is aimed creating complete system and infrastructure solutions for energy-related serv-ices and FTTH for the utility companies. With its ten years of experience in the conceptual design and implementation of communal fibre-optic access networks as well as outside cable plants vitronet supports CFS in the planning, construction and service of fibre-optic (FO) networks Within the framework of such customer projects FOC will provide its products and components (optical fusion couplers, splitting modules, connectors, patchcords, pigtails, cable racks and terminations). This portfolio is complemented by an optical monitoring system for permanently monitoring fibre-optic networks and increasing the availability of the network services.

Thus the customers will receive comprehensive all-in-one solutions from a single source: passive FO components, customized fibre-optic network solutions and active transmission systems for future-oriented communication networks and planning.

About vitronet

The vitronet Group from Essen is a market-leading full-service provider of turnkey fibre-optic infrastructure solutions. The whole value-added chain from network design, via construction and installation to operation and marketing of network capacities is covered. This applies both to passive fibre-optic network infrastructures and to the active transmission technologies for generating data transmission services.

Moreover vitronet is operating its own fibre-optic networks and maintains and services more than 15,000 km of fibre-optic cables for major customers. The shareholders of vitronet are the Ventizz Capitel Partners financial investor, the RWE Deutschland AG energy supply company and Harald Ross as the company founder. Currently the company has 135 employees. In 2010 vitronet recorded a turnover of € 20 million. Its customer base includes well-known energy supply companies, city utility companies, public administrations, CATV network operators and telecommunications carriers. Since 2010 vitronet has shareholdings in network operator societies such as essen.net GmbH and Glasfaser Bochum GmbH & Co. KG. Bestmile GmbH & Co. KG, which is jointly operated with the Bochum city utility company, markets network capacities in the form of bitstream access products.

Further information is available at: www.vitronet.de

Rüdiger Kramer, Managing Direktor vitronet Projekte GmbH

BEL2: *Berlin technical fair was a complete success*

Under the slogan of "Let's take a quantum leap!" the Bel2 fair opened on the premises of the WISTA science and technology park in Berlin-Adlershof, Germany, on 08 June 2011. The two-day fair and conference event attracted more than 50 exhibitors and 400 visitors to engage in a joint dialogue on the topic of broadband and telecommunications.

On both days the fair was accompanied by a series of lectures which was much appreciated by the many visitors. Well-known lecturers from business, politics and associations presented and discussed their views on the issue of broadband expansion in Germany. In the opinion of many participants the general consent was that Germany still had a great potential in this field which needed to be leveraged.

Till today Germany plays only a minor role in the expansion of FTTx compared with other countries. In the forefront are the Asian countries, which according to the FTTH Council Europe have more than 45 million FTTx connections (Europe: 3.9 million). Within Europe countries like Sweden, Lithuania or Norway take the lead in terms of the number of FTTx connections.

FOC participated in the fair together with its sister company CFS at a joint stand with the Heinrich-Hertz-Institute. The highlight of our appearance at the fair was the presentation of the *lilix* reflector made by FOC enabling network operators to implement permanent FTTx network monitoring. FOC underlined the advantages provided by this component with a view to a possible increase in customer satisfaction as well to the potential savings in operational costs.

CFS, as a sister company of FOC, presented its service portfolio for the development of fibre-optic networks. The CFS portfolio ranges from the design to the installation of the networks and allows network operators to receive turnkey infrastructure solutions.

Dr. Michael Siebert, who organised the event, was very satisfied with the fair: "We are very pleased about the big interest in the BEL2 fair, which has become firmly established in Berlin."

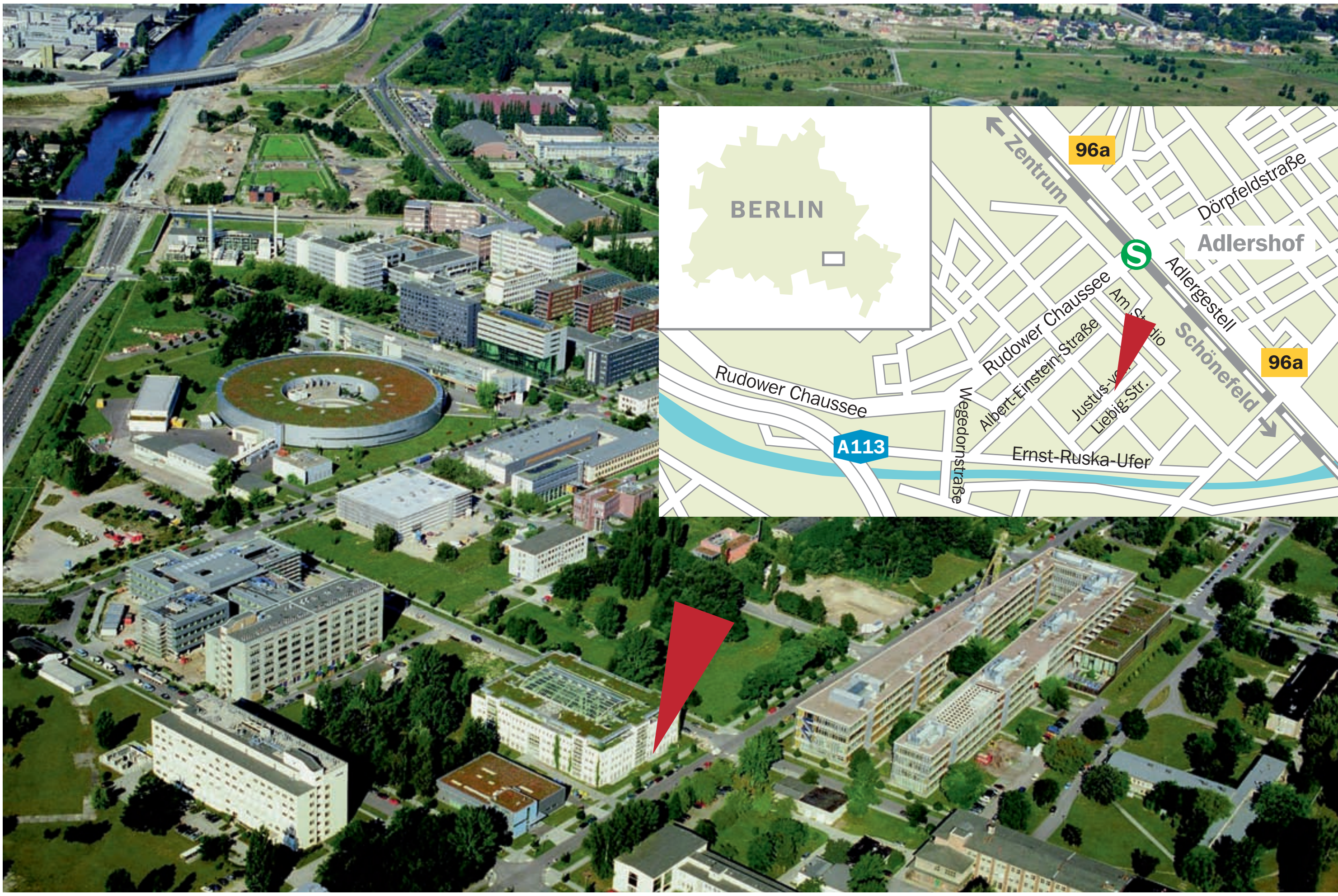
The next BEL fair will be held on 5 and 6 June 2012 (further information at www.bel2.net).

Stefan Nier, Sales Director FOC

Fibre-optic technology remains relevant for the future – also in the next year

FOC fibre optical components GmbH

In the Berlin-Adlershof Technology Park.



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