Next Generation Optical Fibre: Making Your Broadband Network Go Further

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Introduction

As a recent blockbuster video on YouTube called "A Day of Glass" demonstrates, with the inventive pace of communications technology these days, it is realistic to foresee a world where even the most humble of appliances in our homes and at work, like fridges and desktops, are fully connected and enabled as video and voice interactive devices. It is easy to see that such a world would require an unimaginable amount of bandwidth. The millions of hits that this video has had indicate a real world interest in a future that is so technology and telecoms enabled, and thus offers an explanation for, and a justification for supporting, the incessantly increasing consumer demand for bandwidth in telecoms networks of today.

The global path towards offering high speed broadband via fibre to the home has, at its root, the driver that subscribers want to live in a super-connected world and so want the bandwidth to enable it. Hence the telecoms industry is striving to deliver fibre to the home and 100 G data rates to increase capacity wherever there are bottle necks, such as in the core or the metro-core.

But let us reflect a little bit on the modest technology that is at the heart of this fast evolving communications industry: the optical fibre. It is a little heralded fact that fibre is fantastic, without optical fibre all of this would not be possible: while a single copper pair is capable of carrying six simultaneous phone calls, one single optical fibre, running at a modest 10 Gb/s over 64 channels, can carry over 10 million simultaneous phone calls! Hence it is fair to say that the optical fibre is the fundamental enabler of all modern day telecommunications networks.

But what can the modest optical fibre do to help us enable a future ever more connected world?

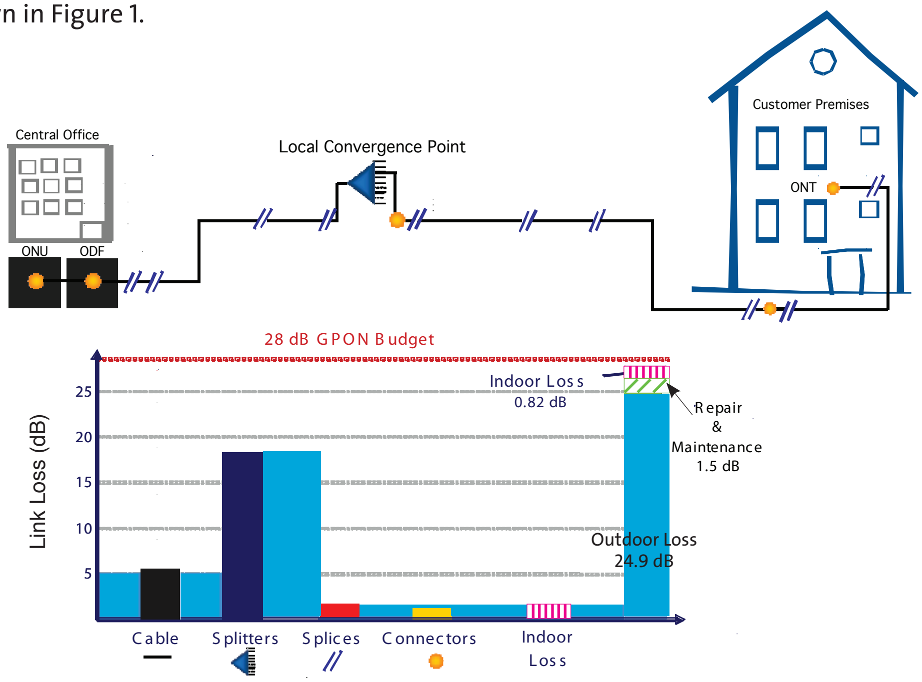
Trends in Broadband Networks: Optical Fibre Design for the Future

The optical fibre is basically a strand of glass 125 µm in diameter that owes its performance to clever material processing and intricate refractive index profiling in the core of the strand. But all fibres are not the same: fibre performance can be altered by modifying the materials, processes, and the refractive index profile. Thus fibre optimisation for different application spaces is possible and although the G.652 standard single-mode fibre is the most common throughout the world there are other fibre types like G.655 non-zero dispersion shifted fibres and laser optimised OM3 and OM4 multimode fibres that have been optimised to deliver cost savings and performance advantages in their respective application spaces.

But what about fibre optimisation in the world of next generation broadband access networks and fibre to the home? One of the well known limitations of traditional optical fibre is that when subjected to bends of less than 60 mm in diameter significant levels of light leak from the core leading to signal power loss. In addition, optical fibre always exhibits a degree of transmission loss that manifests as a reduction in the signal power level as it travels along the core due to light scattering and photon absorption.

CORNING

To optimise fibre to enable the broadband networks of the future first requires detailed understanding of broadband network architecture and associated trends. Network design is generally driven by the available system power loss budget. For a GPON network the standard budget available is 28 dB. This budget is consumed on its path from the central office to the customer's broadband wall outlet in the home by transmission loss in the cable and the PON splitter, splice and connector loss as shown in Figure 1.



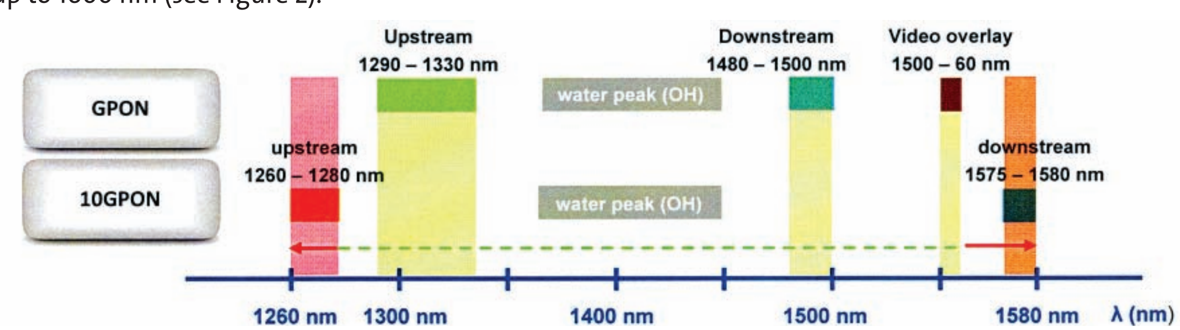
The breakdown of GPON power budget consumption for signal transmission from the central office to the subscriber for a 1:32 split and an access link length of 15 km.

Figure 1

In the outside plant the systems used to deliver broadband to the home are constantly evolving: for example ADSL to VDSL, BPON to GPON, Ethernet to Gigabit Ethernet. In addition, operators face challenges to maximise subscriber coverage while the slow down in subscriber revenue growth induces research into network cost optimisation via concepts such as central office consolidation. The regulators on the other hand are keen to create competitive broadband markets and so Europe has seen a recent proliferation of open access architecture regulation and associated implementation of optical indoor cabling standards.

Next Generation Fibre for Broadband Networks: Outside Plant Cabling

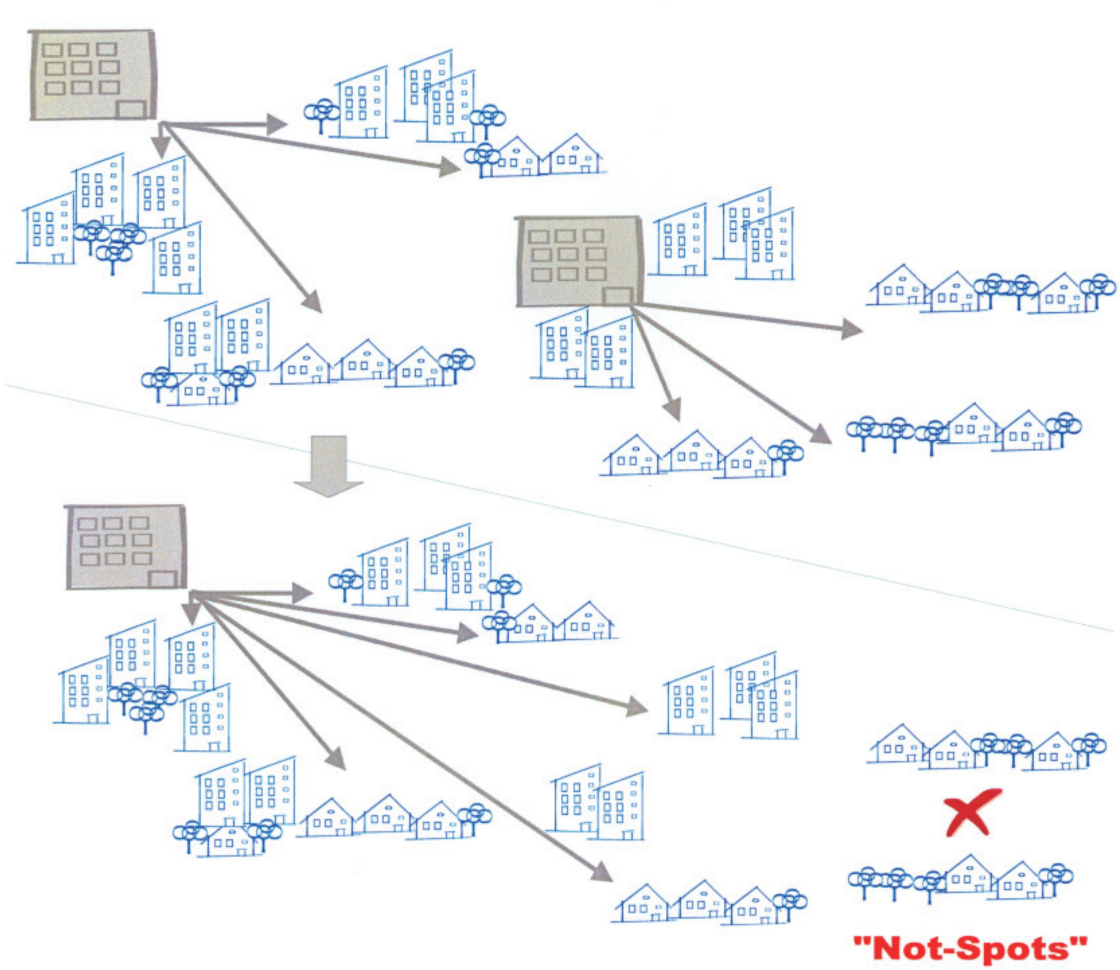
The aforementioned trends in broadband networks put pressure on the fibre and system solutions. In the outside plant, classical GPON/EPON and BPON systems use wavelengths from 1290 nm to 1330 nm for upstream transmission, 1480 nm to 1500 nm for the downstream with 1550 nm being reserved for analogue video broadcast. As we move towards next generation PON systems and in particular 10 G-EPON, operators will need to use an even broader spectrum of the fibre from 1260 nm up to 1600 nm (see Figure 2).



Optical spectrum usage is being broadened by the evolution to new PON technologies.

Figure 2

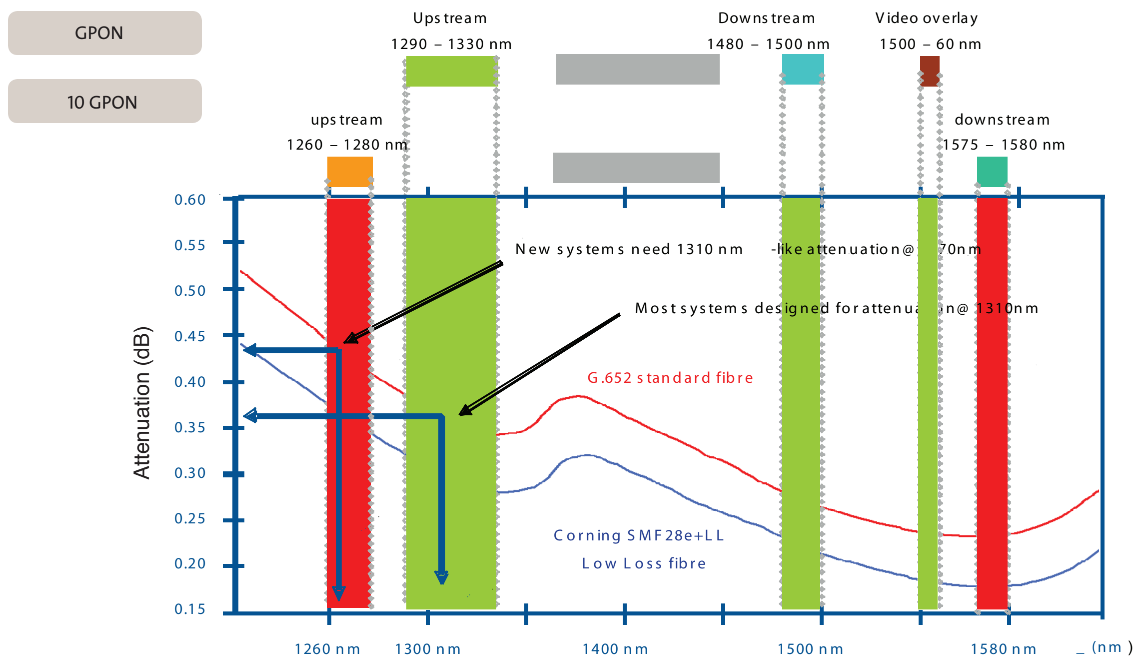
The trend towards central office consolidation coupled with, often government driven, initiatives to serve not just the cities with fast broadband services but rural communities also, is resulting in much longer link lengths in the access network than originally conceived (see Figure 3) and potential for increased areas of no coverage ("not-spots").



Central office consolidation will extend access link lengths and if new technology is not introduced to compensate could result in reduced subscriber coverage.

Figure 3

These longer link lengths put pressure on cable transmission losses which must be minimised in order to bring adequate signal levels to the customer to achieve connection. Standards for extended reach systems (e.g. Class C GPON) with higher power loss budgets have been developed but even these have their limitations in total reach and require incremental capital spend on advanced electronics. Here advances in optical fibre can help. A new wave of innovation in optical fibre at Corning Optical Fiber has delivered a portfolio of new lower loss standard single-mode G.652 fibres. One of these fibres, Corning® SMF-28e+® LL features industry leading low attenuation while being G.652.D compliant and fully backwards compatible with the ubiquitously deployed G.652.D fibres in access networks. This new low loss fibre delivers industry leading low attenuation across the newly required broad spectrum of wavelengths from 1270 nm to 1580 nm as shown in Figure 4.



Low loss fibre reduces fibre attenuation levels at 1270 nm nearer to accepted 1310 nm attenuation levels on legacy fibres enabling migration to NG GPON with minimal compromise on network link design.

Figure 4

Corning® SMF-28e+® LL fibre represents the next generation of fibres and in all broadband access networks, be it VDSL, PON or Point to Point (P2P), can enable the following:

- Up to 20% increase in access network coverage area[1] with the obvious knock on benefits of being able to connect more customers
- Ease of transition to central office consolidation: lower attenuation fibre naturally enables longer access network link lengths, such as are required to achieve consolidation.
- Additional network margin to facilitate network updates like upgrades to higher data rates or the trend towards pre-connectorised solutions, with minimal compromise on original network design and feeder cable lengths.

In effect this next generation low loss fibre effectively enables your broadband to go further and reach out and connect more customers.

Next Generation Fibre for Broadband Networks: Indoor Cabling

It is not immediately self-evident, but the proliferation of indoor cabling standards to support competitive broadband markets via open access architecture has a striking impact on indoor optical fibre cabling performance requirements. Open access architecture requires that the broadband network architecture is configured so as to ensure that competitive service providers are not (within reason) precluded from delivering a broadband connection to a customer due to their lack of proximity to that customer or a difference in broadband transmission technology. As shown in Figure 5, all broadband links irrespective of system technology deployed will have a maximum power loss budget. If however, Provider 1, whose Point of Presence (PoP) or central office is closest to the customer, is responsible for deploying the in-building cabling, in the absence of regulation could, by installing indoor cabling with high signal power loss, due to the fixed power loss budget available, prevent Providers 2 and 3 from delivering a connection to the customer due to the additional distance that they

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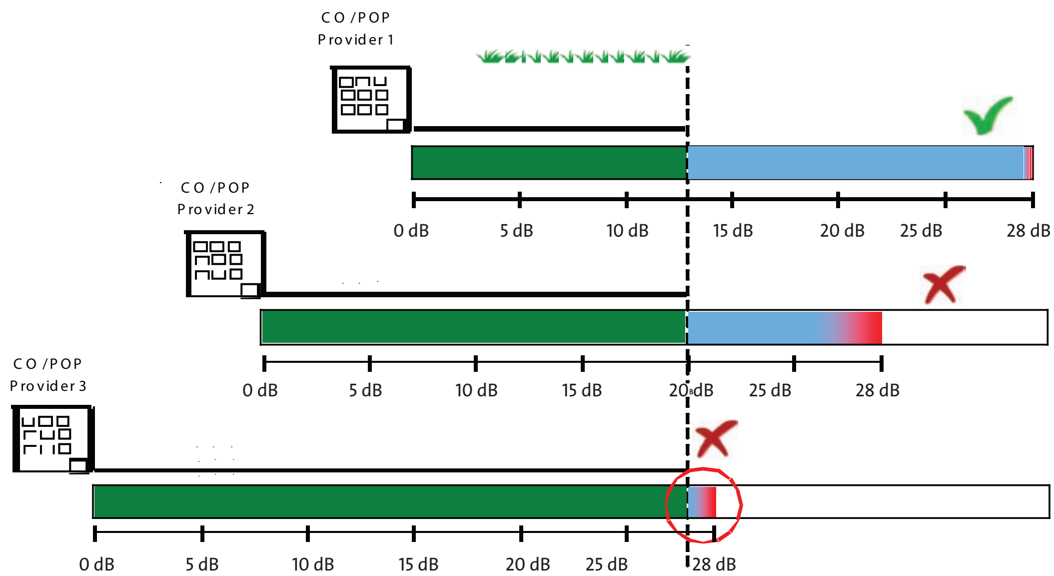
[1] Comparing SMF-28e+ LL with an attenuation of 0.32 dB/km at 1310 nm, to a typical fibre with an attenuation of 0.35 dB/km results in extension of the maximum reach of a typical VDSL feeder cable from 10 km to circa 11 km, or extension of an FTTH feeder link from 19 km to almost 21 km. This increase in feeder cable length increases the area that a central office can cover by almost 20%.

have to cover (with associated additional power loss) to reach the customer. If however, Provider 1 is required by open access regulation and associated indoor cabling standards to minimise signal power loss in the indoor cabling, then there should be sufficient power loss budget remaining to enable Providers 2 and 3 to reach the customer. To date open access architecture initiatives in Europe have resulted in such indoor cabling standards being put in place in Germany (max 1.2 dB loss indoor), France (1.5 – 2 dB loss indoor) and Switzerland (0.9 dB max).

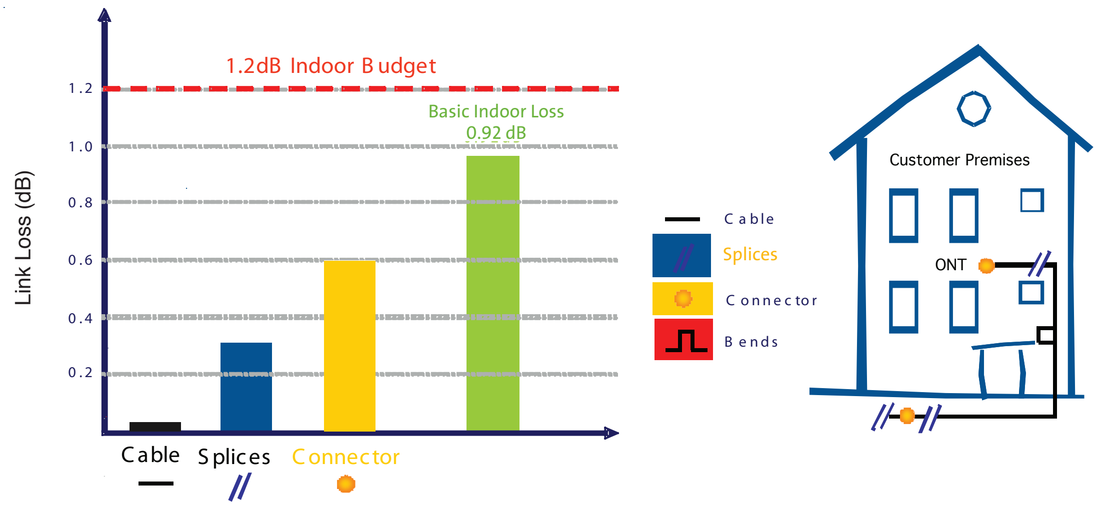


Poor indoor cabling can lead to excessive consumption of power budget within the building, precluding competitive providers, located more distance from that building from offering service to the subscriber. Indoor cabling power loss must be controlled and minimized to ensure competitive open access to subscribers.

Figure 5

It is worth noting that such tight control of indoor power loss is also beneficial for carriers operating outside of open access architecture regulation. For such carriers, tight control over indoor power loss frees up additional power loss budget for the complete link from central office (PoP) to the subscriber that can be used to provide technology robustness to their network: with extra power loss budget being available to facilitate perhaps a future upgrade to higher data rates or central office consolidation where the operators average link lengths will naturally increase.

But what does all this mean for the fibre? If we consider a 1.2 dB indoor cabling power budget, we can see from Figure 6 that this budget is readily consumed by a basic installation involving 50 m of cable, three splices and two connectors (maximum values considered). But when fibre cables enter a building, the cables begin to be installed in a new way. This new cable environment requires that the cables are smaller to be aesthetically pleasing and also need to be routed in very tight spaces. As a consequence installation of indoor cabling naturally involves a number of tight bends. Tight bends in traditional optical fibre introduce significant signal power loss. But indoor cabling standards and a desire to minimise indoor cabling loss leave little head room for bend loss. Hence we need a fibre that is insensitive to bend.



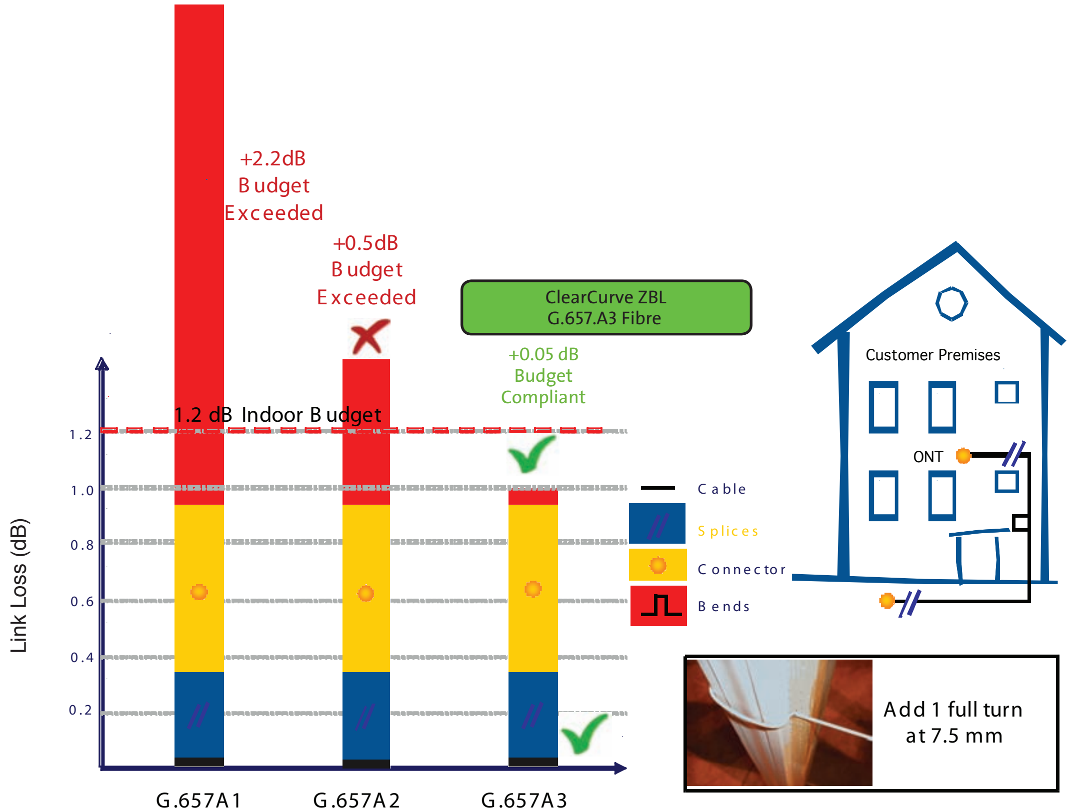
New indoor power budgets are readily consumed by a basic installation involving 50 m of cable, three splices and two connectors. Little headroom is available for signal loss due to bends.

Figure 6

Recognising this, the optical fibre industry responded with the G.657 standard of fibres. Within that standard there are three classifications of performance, G.657.A1, G.657.A2 and G.657.A3[2]/B3. The question is which G.657 fibre is most suitable? Within any indoor cabling installation it is a fair assumption that at least four tight 90° degree bends will occur (at circa 7.5 mm in radius and equivalent to one full 360° turn). If we compare the bend loss performance of G.657.A1, G.657.A2 and G.657.A3 fibres we can see from Figure 7 that it is only G.657.A3 that effectively gives us near zero bend loss and so ensures that we maintain very low indoor cabling loss to achieve compliance with the indoor cabling standards and provide technology robustness for the network.

G.657.A3/B3 fibres, like Corning® ClearCurve® ZBL fibre, with their near zero bend loss performance are true bend insensitive fibres and are yet another example of how innovation can take the already fantastic optical fibre and make it even better. Use of G.657.A3/B3 fibres not only enable compliance with indoor cabling standards but have other just as significant network reliability and subscriber revenue protection benefits. Bringing optical fibre cabling indoors brings with it a heightened risk of public intervention, such that the introduction of accidental bends during the cable lifetime becomes likely. For all fibres other than G.657.A3/B3 fibre such bends will probably lead to excessive signal power loss resulting in disconnection of the customer. Repair of customer disconnections drives higher Opex and reduces customer satisfaction. The latter increases customer churn and can result in a significant reduction in subscriber revenues. Only G.657.A3/B3 fibre, like Corning® ClearCurve® ZBL fibre, with its innovative bend insensitive design can provide the maximum protection of customer connection satisfaction to reduce Opex and protect subscriber revenues while also fulfilling the effectively zero bend loss requirements of open access architecture driven indoor cabling standards. In this sense the innovation of bend insensitive optical fibre also enables your broadband network to go further and deliver more for your business.

[2] G.657.A3 is a proposed new standard classification that requires G.657.B3 bend performance and compliance with the G.652.D standard.



Only G.657.A3/B3, the truly bend insensitive fibres, can effectively gives us near zero bend loss and so ensure that we maintain very low indoor cabling loss to achieve compliance with the indoor cabling standards.

Figure 7

Conclusion

If we reflect again on the direction our world is going in terms of connectivity, there seems no end to the bandwidth requirements. Hence it is comforting to know that the technology that opened the door to this highly connected world in the first place, the optical fibre, keeps on delivering new advances like low loss Corning® SMF-28e+® LL fibre and bend insensitive Corning® ClearCurve® ZBL fibre to make your broadband go further and deliver with each step another step closer to that exciting future of a super-connected world.

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