Bend-insensitive fibres: a key component of future-proof networks

Prysmian General Cable Draka

Over the last 30 years, fibre optic cabling has evolved to support our new era of hyper connectivity, linking continents, countries, cities, antennas and homes. And that is not set to change.

In 2019, more than 550 million kilometres of optical fibre cables were installed globally, compared with just 200 million kilometres in 2010. This growth is expected to continue with the invention and adoption of new technologies, driving us into a new era of digital demand.

To support the exponential growth of data traffic and adoption of new technologies, it is crucial that we increase the capacity of the world's optical networks. Optical cabling systems need to offer faster, more reliable and cost-effective deployment methods in order to be future-proof, as well as support the complete optical spectrum – from 1260 nm at the beginning of the Original O-band, up to 1625 and 1675 nm at the ends of the Long L-band and Ultralong U-band.

Bend-insensitive single mode fibres (ITU-T G.657.A1 and G.657.A2) are a crucial part of the world's shift towards flexible and reliable connectivity. They are the only fibres capable of securing the whole fibre spectrum, especially at the longer wavelengths (1625 nm and above), by minimising losses linked to macro- and microbends.

These fibres enable the development of extreme fibre count and reduced diameter cabling solutions, so we can meet today's demand for the highest bandwidth capacity in duct installations. Not only will we see benefits through faster and more stable optical networks, installations will become more cost effective, more environmentally friendly, all with lower operational costs as network lifespan increases thanks to higher repair resilience.

What is bend-insensitivity?

There are two types of bend-insensitivity:

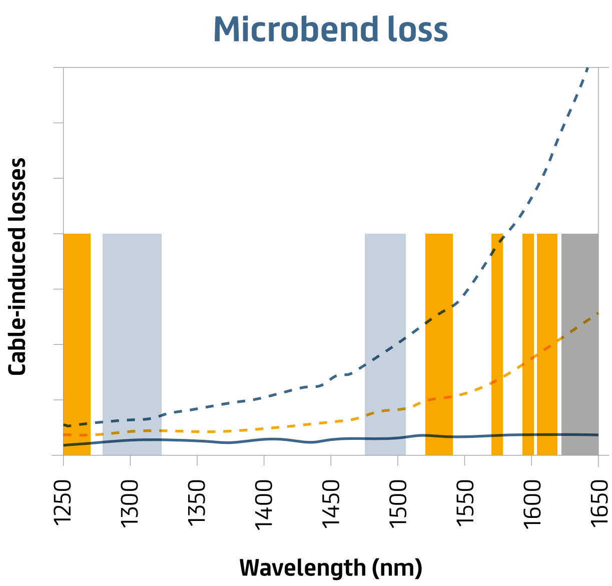
Millimetre-range macrobend-insensitivity

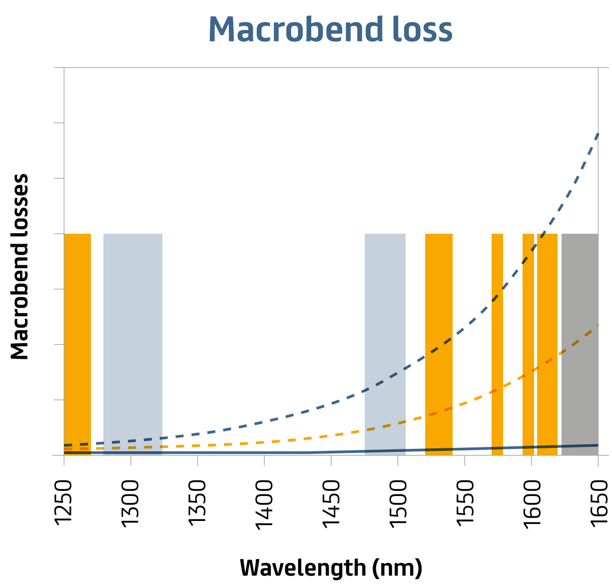
Macrobends are visible to the naked eye, such as fibre cabling which bends around corners, inside splicing closures and within connectivity devices. Macrobending is especially likely to occur within high-density networks, as space is limited to route and accommodate fibres within connectivity devices.

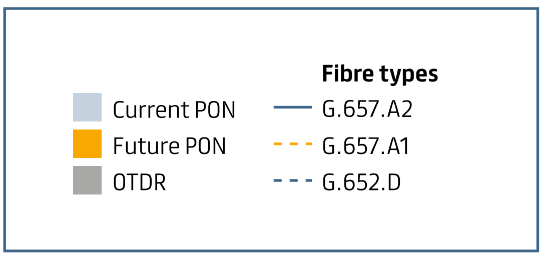
Micrometre-range microbend-insensitivity

Microbends refer to microscopic local effects on a cable – for example, cable material squeezing the fibre. Such bends can occur due to the cable's reduced diameter, or because the cable has been squeezed by external pressure – common over the long lifecycle of a cable.

Microbends can also occur during temperature variations, which can induce material shrinkage, and is especially likely to occur within high-density cables, as fibres can touch due to material shrinkage or other strain. While bend-insensitive fibres were initially developed with macrobend insensitivity in mind, they also outperform all other existing fibre types for microbend-insensitivity.







Bend-insensitive fibres significantly reduce microbend and macrobend losses across the entire wavelength spectrum used by current and future PON.

Fibre coatings

G.657 fibres have been recently developed with 200 µm and 180 µm diameter coatings featuring the same or even better performance than the legacy 250 µm coated G.652.D fibres. This offers the possibility of significantly reducing cable diameters, while achieving high fibre density. These reduced-diameter fibres have opened a gateway to innovation, opening up the potential for many new cable systems to be developed for a variety of network applications.

Moreover, G.657 fibres, whatever the outside diameter (250, 200 or 180 µm), are totally compatible and spliceable to any standard G.652 fibre, a feature that makes them easy to insert into an existing network, hence also perfectly appropriate when replacing or upgrading parts of an existing optical infrastructure.

Optimised performance and full compliance with legacy G.652.D fibres, coupled with enhanced protective coatings make G.657 fibres bend insensitive. The problem of macro- and microbending is virtually erased, securing the integrity of network infrastructure, increasing stability across all bands, and opening up the possibilities for system evolution.

Resilience and future-proofing

Bend-insensitive fibre's resilience gives manufacturers the ability to design cabling solutions which were previously impossible to create, but are now demanded by today's rapidly changing environments.

Supporting the full use of transmission bands, they cover the entire wavelength spectrum: from 1260 nm to 1625 nm for data transmission, and up to 1675 nm for OTDR network monitoring. This is particularly important when future-proofing higher capacity networks, which will likely operate outside of present standard ranges.

Naturally, such cabling solutions are also beneficial for optimising network operators' total cost of ownership (TCO), making networks quicker and easier to install. Plus, they will stay ahead of the competition when it comes to being 'future-fit'.

As fibre networks become more crowded, and space limited, fibre bends are more likely to occur. Preventing power leakage with G.657 fibres therefore becomes crucial for optical systems with limited power budget. Bend resistance allows the use of smaller loop guides upon installation and reduces the bend radius of splice trays. As a result, connectivity devices become smaller, saving even more valuable space. And in dynamic network environments, bend resistance extends the expected network lifetime by improving repair resilience, too. Utilising wavelength division multiplexing (WDM) optics in PON and wireless networks drives the need for bend-insensitive fibres to become part of FTTX and 5G mobile networks.

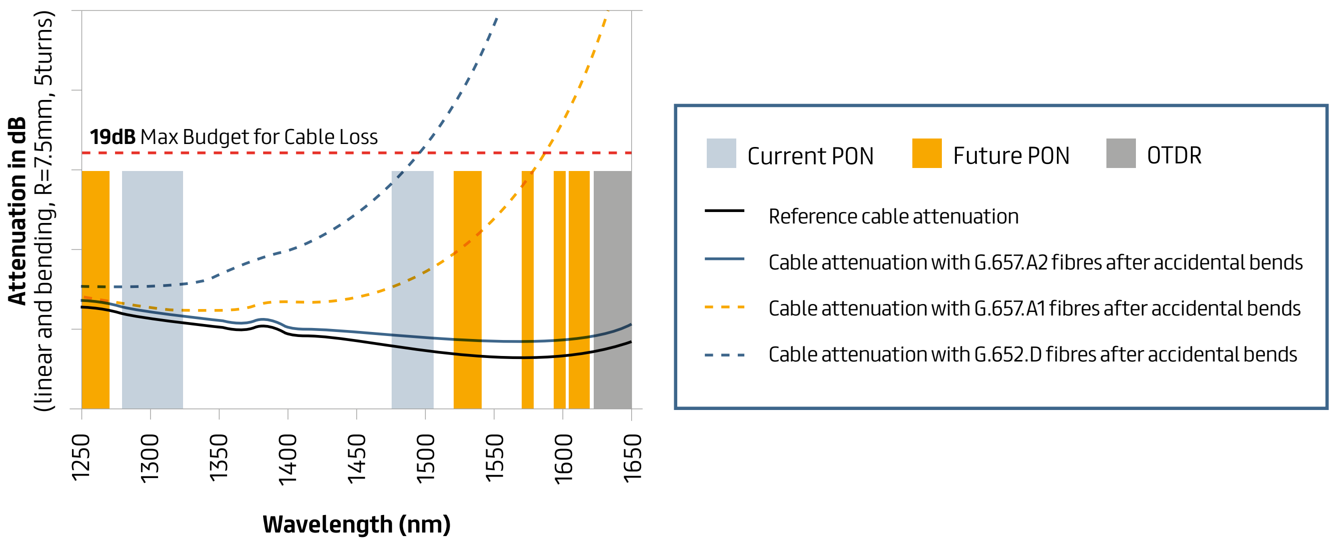
Fibre optic networks are a long-term investment and the solutions used to build them must be considered carefully. G.657 cabling systems' broad-spectrum transmission, small diameter and 'pay-as-you-grow' potential is what makes them the ideal, future-fit solution. With their preservation of system power budgets – even when installed by less-practiced technicians – the use of cable solutions with bend-insensitive fibres is an opportunity for significant OPEX savings.

Smaller connectivity devices

Optimised Total Cost of Ownership

Pay-as-you-grow

OPEX savings thanks to easy installation and superior robustness



The above graphic demonstrates the attenuations which occur in an 18 km link over time, beginning on day one of access network deployment, and after accidental bends occur during the life-time of the network.

The link consists of only one 1:8 splitter (9 dB loss) and 18 km of cable. Insertion loss of splices, patchcords and connectors, as well as safety margins are not included. Considering a PON system with 28 dB link budget, the cable's maximum allocated budget loss is 19 dB.

The **solid black line** in the diagram represents the attenuation of the 18 km span at day one of the deployment. The attenuation of the cable is below 8 dB from 1250-1650 nm.

As more access points are added to the system, it's likely that accidental bends may occur. The diagram demonstrates cable attenuation when just five 7.5 mm radius accidental bends occur over the 18 km span.

The **dotted blue line** represents a cable with G.652.D fibres. It will experience a significant increase of attenuation and the total loss of the link exceeds the 19 dB budget allocated to the cable for wavelengths longer than 1490 nm.

The **dotted orange line** is a cable with G.657.A1 and passes the allocated budget for wavelengths longer than 1580 nm.

The **solid blue line** shows the attenuation of the cable with G.657.A2 fibres is well below the 19 dB budget allocated to the link throughout the 1250-1650 nm wavelength range. Therefore, the network with this cable can help operators to reduce repairs and future-proof the network.

Support PON Evolution and Full Optical Spectrum

High-capacity networks expanded beyond standard wavelength ranges

Improved repair resilience

Prevents bend-induced power leakage and failures

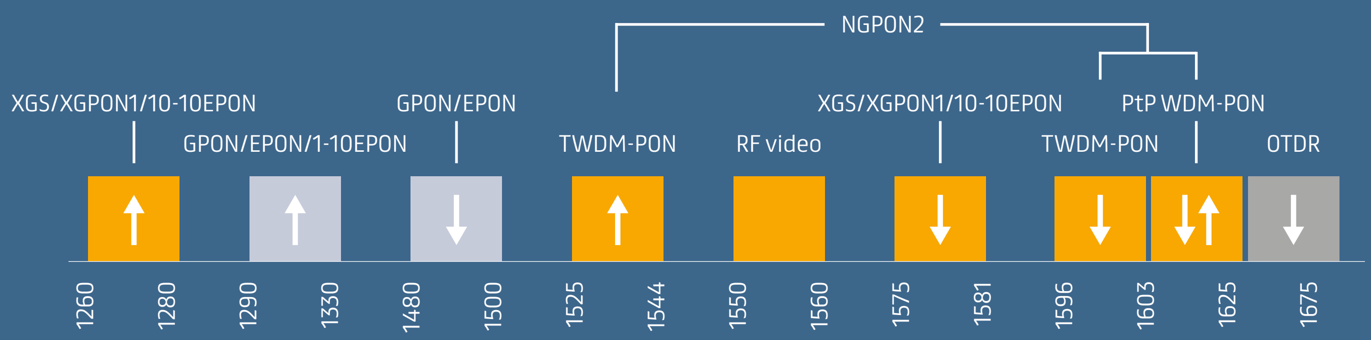
Access network system evolution

Advanced broadband wireless and FTTX networks are considered essential infrastructure to support economic growth. Deployments of FTTX and mobile networks have consumed more than hundreds of millions of fibre km per year to support the bandwidth demand of end users.

Having deployed 1 Gigabit PONs (EPON and GPON), operators moved to a higher speed of 10 Gigabits in 2015: 10 Gigabit EPON (10G-EPON) and 10 Gigabit (symmetrical) PON, or XG(S)-PON. XG(S)-PON already used a broader spectrum than GPON, up to 1580 nm for downstream. These evolutions are expected to represent the largest market during the next decade.

Next generation PON2, delivering 10 Gigabits per wavelength up to 1625 nm on a single fibre, was also standardised by ITU-T and it is expected to see significant market adoption in the coming years. The ITU and IEEE Standardisation bodies are now considering even higher speeds of 25 Gigabits and 50 Gigabits with high-speed PON (HS-PON) and WDM PON for 5G wireless fronthaul, where 20 channels resulting in an aggregate capacity of 500 Gigabits could be useful.

The increasing wavelength requirements of Passive Optical Networks



Recently, operators have deployed WDM systems for mobile fronthaul. Both coarse WDM (CWDM) and dense WDM (DWDM) systems are being offered by equipment vendors. The adoption of WDM fronthaul puts extra constraints on the optical network, as more wavelengths are activated.

As 5G grows and more antennas are deployed, WDM optics will also be required to manage system congestion. The long lifecycle of access infrastructure requires PON systems to be backwards compatible, with new, longer-wavelength windows needing to be activated. OTDR testing and monitoring signals will then be pushed up into the 1650 nm range, where cable constraints become critical.

Conclusion

There's one unique answer to securing the network evolution our future systems will need: building networks with bend-insensitive cabling systems from the very beginning, securing the full optical spectrum and offering the possibility of achieving high fibre density. Operators who choose these fibres, and in particular, G.657.A2, will achieve the most potential from their deployed networks.

Ready to power the world of tomorrow, today?

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