

## FIBER CHARACTERIZATION

### What is fiber characterization?

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“Fiber characterization” is performing a comprehensive suite of tests that determine all of the key performance attributes of installed fiber infrastructure.

The March 2008 version of G.650.3, that was substantially re-written by Richard Ednay of OTT, includes this definition of fiber characterization:

“A comprehensive suite of measurements that is carried out on a fiber optic cable link to determine the key performance attributes of that link which may affect current or future applications that operate over that link. Fiber characterization also allows the quality of the fiber optic cable link to be assessed, including the identification of the type and grade of fiber installed.” Full fiber characterization includes:

- Connector end face inspection
- Insertion loss measurements
- Return loss measurements
- OTDR testing
- Chromatic dispersion testing
- Polarization mode dispersion testing
- Spectral attenuation

#### Results and analysis

The results of the characterization need to be documented and an important and valuable part of the process is the analysis and interpretation of the results.

This analysis should include an assessment of the infrastructure quality and its ability to support particular systems.

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### Why is fiber characterization necessary?

#### Higher data rates

As telecoms networks have to carry more and more traffic to meet the demands of the Internet and other 'Bandwidth Bandit' applications, then the data rates are getting higher and higher. 10Gb/s systems are being widely deployed and people are once again starting to talk seriously about 40Gb/s channels. The next development of Ethernet will include 100 Gb/s. At these very high data rates then many aspects of the fiber infrastructure become critical including chromatic dispersion and PMD (Polarization Mode Dispersion). Also the power budgets become much tighter so loss measurements are more critical.

#### Broader wavelength ranges

In addition to high data rates per channel, there is also a proliferation of multi-channel systems using DWDM technology - and as more channels are required and the data rates increase then the total grange of wavelengths being used also increases. CWDM (Coarse Wavelength Division Multiplexing) is also being deployed extensively in metro networks - this uses a very wide spread of wavelengths (ITU 6.694.2 mentions 1271 to 1611 but notes that these end points are illustrative only).

Therefore the fiber might need to be characterized to assess its performance at wavelengths other than those it was originally intended for and tested against. For example OTDR testing at 1625nm to verify satisfactory operation at wavelengths beyond 1550nm.

#### Application support

Once the fiber infrastructure has been characterized then the performance attributes of particular links can be compared with the transmission requirements of any application standard to assess whether or not the link will support the application.

#### System selection or specification

The fiber characterization may also provide essential information that is needed for selecting or specifying the transmission equipment that will operate over the links.

There are now many choices to be made about different technology options for high performance telecoms systems. These different technologies can have quite different tolerance to various infrastructure impairments - knowing how good, or how bad, the infrastructure is can influence the choice of technology to be deployed.

#### Component quality checks

The presence of any defective components or problem areas in the infrastructure can be highlighted and recommendations made for any remedial work that needs to be carried out.

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### When is fiber characterization needed?

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#### Dark fiber deals

The demand for fiber characterization services is increasing in many territories due to the increasing complexity of the competitive telecoms markets. In the UK for example, there are many fiber networks operated by different companies. However there are very few new networks being built due to the very high cost of construction and the lack of money in the telecoms industry! This means that as new customers are signed up then often fairly complex dark fiber deals are being done sometimes with several different providers, to stitch together a new fiber route whilst installing the minimum amount of new fiber.

This fiber route then needs to be characterized.

#### Network upgrades

Since there are few new cables going in, then network operators need to upgrade their existing infrastructure to operate at higher data rates and/or using DWDM or CWDM systems over extended wavelength ranges.

It is likely that older fibers were never tested for Chromatic dispersion or PMD. At 40Gb/s data rates it may be necessary to know the chromatic dispersion precisely so that it can be compensated for with sufficient precision. Following ITU Recommendations, an upgrade from 10Gb/s to 40Gb/s means that the CD compensation has to be 16 times more precise!

PMD was unlikely to be a limiting factor on the performance of 2.5Gb/s systems, but can become critical at 10Gb/s and at 40Gb/s it is likely to be a problem on many older fibers.

#### Mergers and acquisitions

2005 onward saw a revival of merger and acquisition activity in the UK telecoms marketplace. Two major cable TV companies: Virgin and Telewest merged and are now Virgin Media; Cable & Wireless bought Energis; BskyB bought Easynet.

Due diligence studies by purchasers of networks may require an independent audit of the quality and value of the assets being purchased.

#### New networks

Although there are few new networks being installed in mature telecoms markets such as Europe, there are many territories where new networks are still being deployed. There's lots of activity in China & other Far East countries as well as development programs in Africa, Asia, and elsewhere.

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### How is fiber characterization done?

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Comprehensive fiber characterization is a complex subject that requires detailed knowledge of many aspects of fiber optics and considerable skill and judgment in defining test programs carry out the tests, validating the data, analyzing and interpreting the results to provide comprehensive, authoritative documentation that is often used as a basis for making very expensive decisions.

Due to this complexity OTT have developed the special "Certified Fiber Characterization Engineer" course so that delegates can learn how to characterize fibers with confidence, with the full back up and support of OTT and Richard Ednay, the UK's Principal Expert on fiber testing (BSI GEL86/1,2 & 3, acts, IEC SC86C WGI, ITU-T SCI 5, SC86C & ISO/IEC JTC Acta 19 WG3 liaison).

The course includes a formal assessment that provides successful candidates with the "Certified Fiber Characterization Engineer" (CFCE) status.

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### Standards

#### ITU-T

The international telecommunication union - Telecoms division makes recommendations on all aspects of international telecoms systems including fiber optics.

The G.650.1 & 2 standards cover the testing of fiber and cable in a factory environment.

In June 2007, an initial version of G.650.3 was published that was meant to cover testing of installed links. Unfortunately this version of the recommendation was very poorly written. Richard Ednay of OTT then joined ITU in order to re-write this Recommendation and the revised version was published in March 2008.

This second edition includes, for the first time anywhere in the standards, a definition of fiber characterization as given in the introduction to this module.

This Recommendation calls up the relevant IEC measurement standards for installed links detailed below.

All ITU-T published, in-force, Recommendations are now available for free download from their website at [www.itu.int](http://www.itu.int)

#### IEC

The International Electro-technical Commission sets standards for products and defines test methods. The Technical Committee 86 deal with fiber optics. Under this there are three Sub Committees:

SC86A deals with fibers and cables

SC86B deals with fiber optic interconnecting devices and passive components (connectors etc.)

SC86C deals with fiber optic systems and active devices (installed links, amplifiers etc.)

The 61 280-4-x series covers tests on installed cabling links, including attenuation, return loss and PMD.

61 280-4-2 covers attenuation testing of singlemode links. Richard Ednay of OTT has been appointed as project leader to substantially re-write this standard to produce an initial draft in October 2008. This will also include return loss measurements that were originally destined to (40 into a separate 61 280-4-3 standard.

61280-4-4 covers PMD test methods for installed links and the Technical Report 61282-9 provides further guidance on PMD test methods.

IEC 61 300-3-35 is a new standard for fiber optic connector end face inspection, due for publication in 2008.

The IEC website is at [www.iec.ch](http://www.iec.ch)

There is a joint ISO/IEC Technical Committee 1 that deals generally with IT systems, Subcommittee 25 deals with "interconnection of information technology equipment" and undercoast there is a working group three that deals with "customer premises cabling". Richard Ednay acts as liaison between this group and IEC SC86C.

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#### National/regional

Nowadays there is good harmonization of national, regional and standards international standards, so generally the relevant national standards bodies (such as the British Standards Institution in the UK, ANSI in the US etc.) and regional standards bodies (such as CENELEC in Europe) adopt the international standards and just add their own prefix to the standard to indicate that it has been 'rubber stamped' by them - egg. BS EN 60825 (laser safety).

#### Trade bodies

In America the Telecoms Industry Association (TIA) and the Electrical Industry Association (EIA) have been active in developing and setting standards - and in the UK the Fibreoptic Industry Association (FIA) has developed some guidance notes. Often these bodies now feed their work into the international standards work.

#### OTT

Having written the ITU-T G.650.3 Recommendation on fiber characterization then OTT is setting the standard for competence in performing fiber characterization with the "Certified Fiber Characterization Engineer" course and qualification scheme.