CWDM/DWDM
REFERENCE POSTER

mobile backhaul IMS 3G 4G/LTE FTTx fixed-mobile convergence service assurance IP convergence 100G Ethernet triple-play

EXFO

Az Ön méréstechnikai szakértője:

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CWDM Networks Reference Poster

Standards

CWDM Characteristics

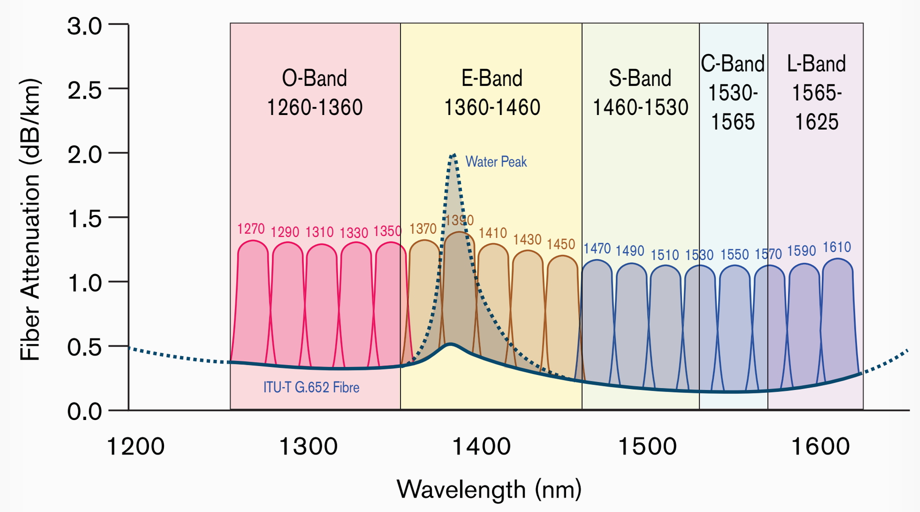
- Affordable alternative for bandwidth increase
- Limited maximum distance
- Can be easily overlaid on existing infrastructure
- Typical transmitter output power : 5 dBm
- Typical signal power at receiver : > -25 dBm

ITU-T G. 694.2—Spectral Grids for WDM Applications: CWDM Wavelength Grid

- 18 wavelengths defined by ITU-T, though usually only 8 or 16 are used
- Transmitter drift tolerance: ±6-7 nm
- Channel spacing: 20 nm

Channel Number	Central Wavelength (nm)
1	1271
2	1291
3	1311
4	1331
5	1351
6	1371
7	1391
8	1411
9	1431
10	1451
11	1471
12	1491
13	1511
14	1531
15	1551
16	1571
17	1591
18	1611

ITU-T G. 652—Characteristics of a Singlemode Fiber and Cable



ITU-T G.695—CWDM Optical Interfaces

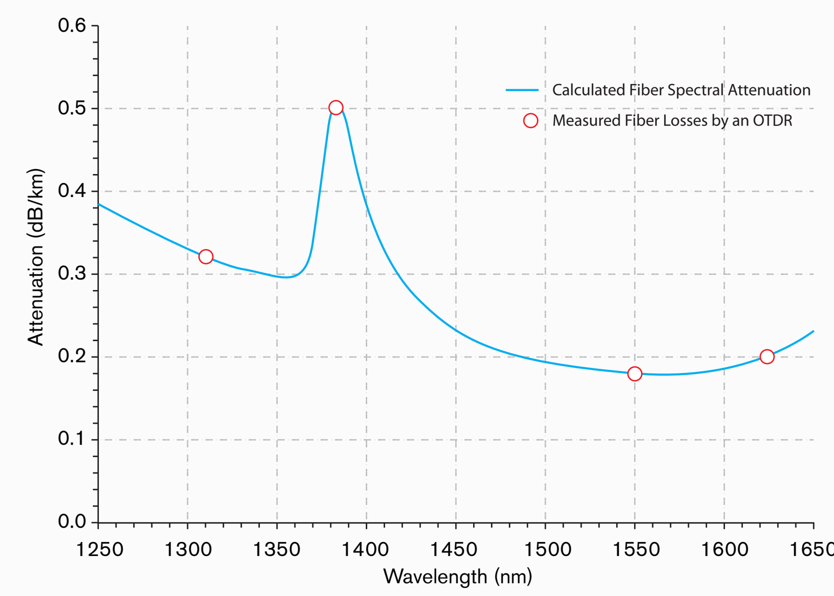
- Provides optical parameter values for physical layer interfaces of CWDM applications with up to 16 channels and up to 10 Gbit/s

CWDM Testing

Test	Test Instrument	Construction/Fiber Qualification	Turn-Up and Provisioning	Maintenance and Troubleshooting
Connector cleanliness according to IEC and IPC standards	Inspection probe with automatic pass/fail analysis software	√	√	√
ORL measurement	ORL testers, OTDR	√		√
Fiber, connector, splice loss	CWDM OTDR	√		√
Channel power and wavelength check	Channel analyzer, CWDM-calibrated power meter		√	√
Wavelength assignment testing	CWDM OTDR, channel analyzer		√	√
Channel wavelength, power drift testing	Channel analyzer, OSA		√	√

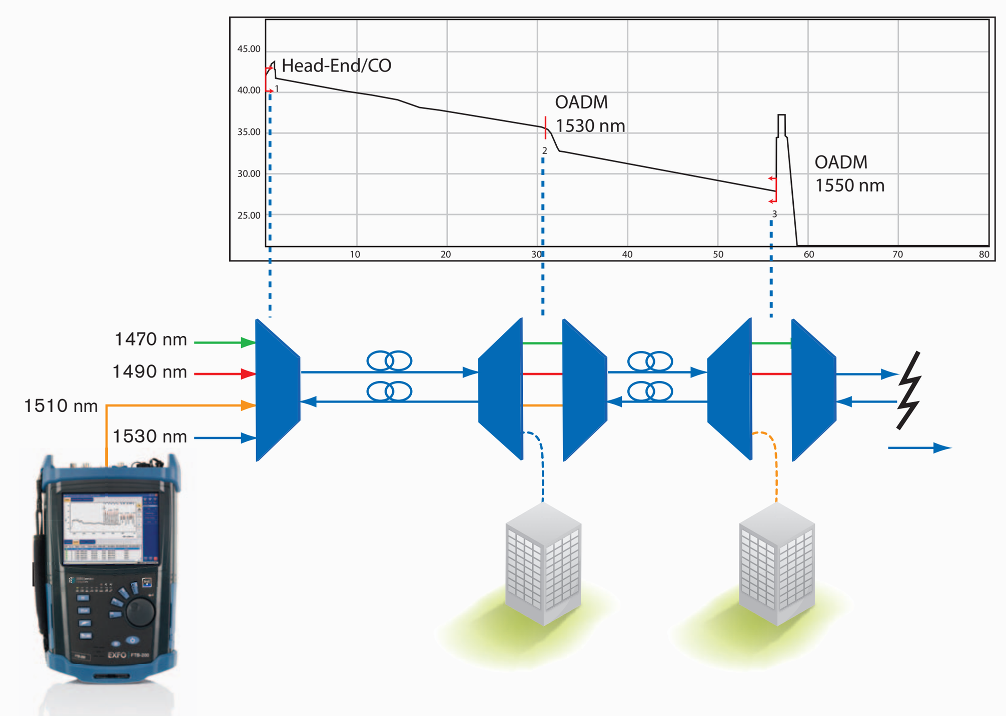
Is Your Network CWDM-Ready?

In most CWDM networks, C-band and L-band are used where attenuation is pretty flat with wavelength. If more than eight wavelengths are required, the S-band must be used where attenuation varies a lot, around the water peak at 1383 nm. Therefore, an appreciation of spectral loss is required. By utilizing an OTDR with four wavelengths including 1383 nm, a simple calculation yields the loss across the whole CWDM range.



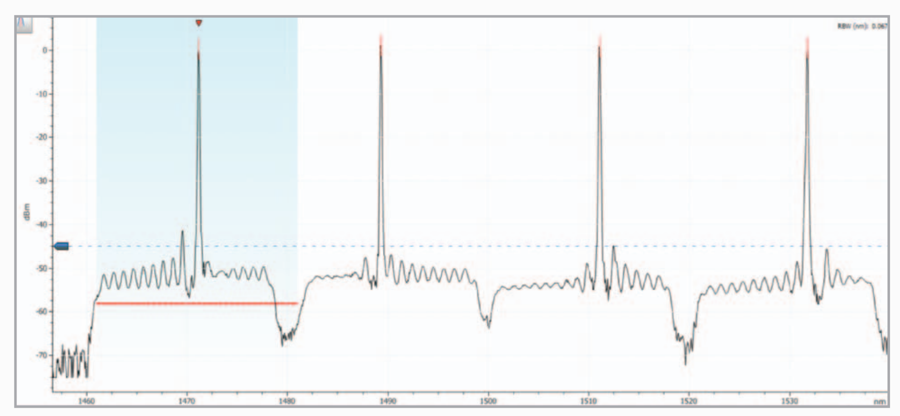
Calculated fiber spectral attenuation from model.

CWDM Testing: CWDM OTDR

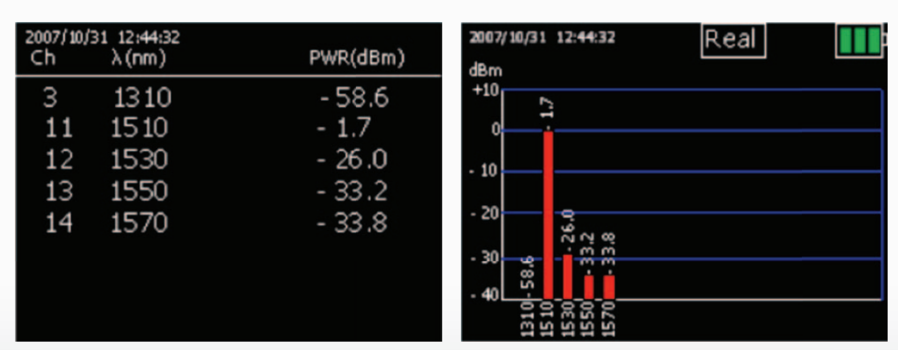


OTDR trace showing the effects of the 1550 nm wavelength going through different OADMs.

CWDM Testing: Spectral Analysis



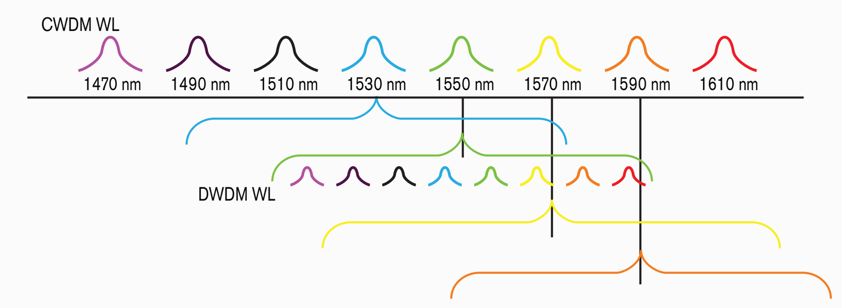
OSA trace of a four-CWDM channels.



Channel power for each CWDM wavelength measured with a channel analyzer.

Future of CWDM Networks

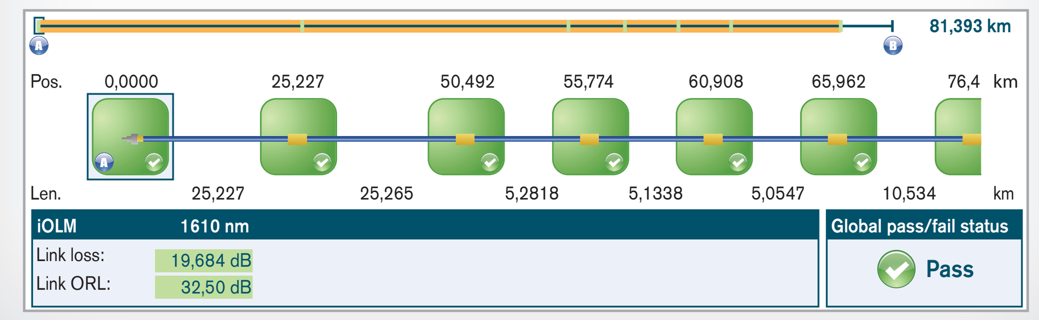
Future of CWDM Networks: Hybrid Networks or DWDM over CWDM



- Increase network capacity by replacing a CWDM card by a DWDM card
- Single CWDM channel now supports 8 or 16 wavelengths
- No amplification = no noise = no need to measure optical signal-to-noise ratio (OSNR)
- Spectral testing: channel analyzers won't work. Basic optical spectrum analyzers (OSAs) without OSNR capabilities can analyze both CWDM and unamplified DWDM wavelengths without the extra cost of full OSAs. Basic OSAs provide the best fit for the technician to test DWDM over CWDM.

CWDM Testing with iOLM

Using a multipulse approach to ensure maximum accuracy, the iOLM enables any technician to test individual CWDM channels at the touch of one button.

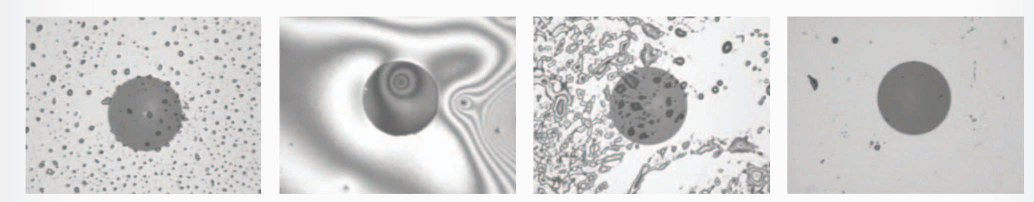


Fiber Connector Inspection

'AN OUNCE OF PREVENTION IS WORTH A POUND OF CURE'
Properly inspecting a fiber-optic cable can prevent a slew of problems, saving you time, money and pains.

Connectors are key components that interconnect all network elements. This is why maintaining them is essential to ensuring that the equipment will operate at maximum performance and catastrophic network failures will be avoided.

Common Connector Issues



Dust/dirt residue *Wet residue* *Oily residue* *Dirty/damaged connector*

Connector Inspection and Maintenance Solutions

Connector Cleaning Supplies
- Dry cleaning supplies
- Wet cleaning supplies
- Cleaning kits

Fiber Inspection Probe and Display
- Inspects male and female connectors
- Very secure, no direct eye exposure to laser radiations

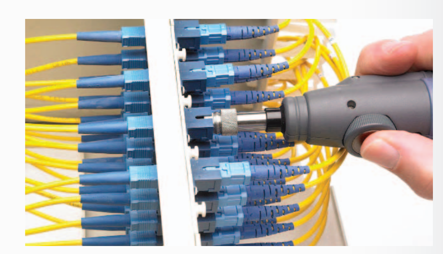
Fiber Inspection Probe on FTB Platform
- Uses the platform screen; no need for additional display
- Stores images for future reference
- Performs automated image analysis (when paired with analysis software)

Connector Endface Analysis Software
- Delivers clear-cut pass/fail verdict
- Guarantees a uniform level of acceptance (IEC and IPC standards-compliant)

Where to Inspect/Clean

The following items should always be on your inspection/cleaning list:

- Patch panel (e.g., splitter cabinet)
- Test jumpers
- Cable connectors



Patch panel inspection.

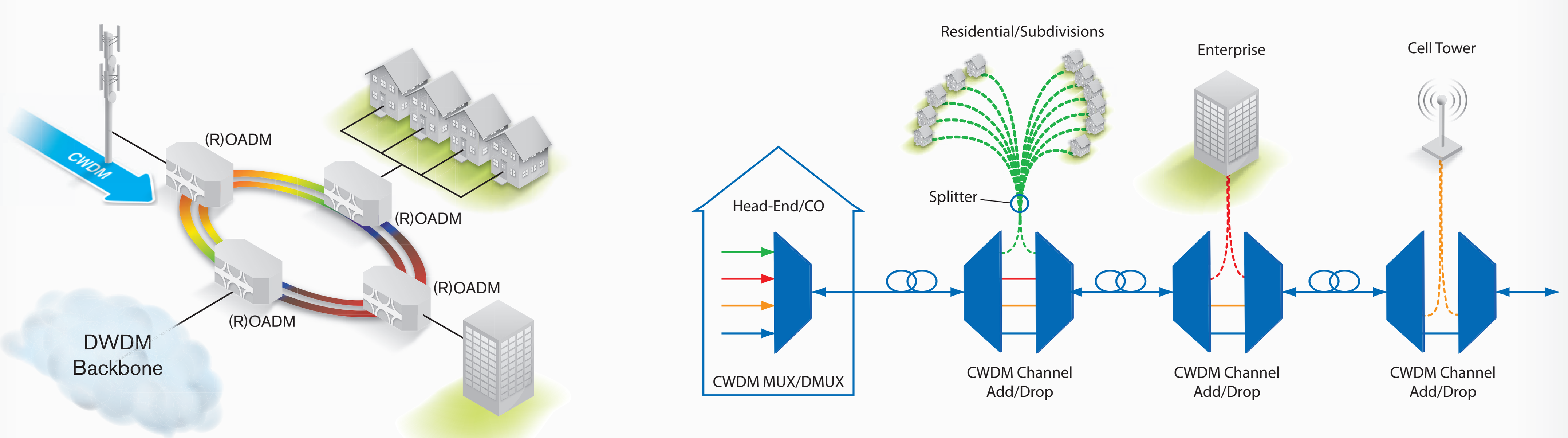
When to Clean

The very first step is connector inspection. This applies to all testing phases—construction, activation and maintenance. **Connectors should be cleaned only if the inspection reveals that they are dirty.**

How to Clean a Single Fiber Connector with a Dry-Cleaning Method

Scan and watch the video (EXFO.com/Connector2)

Topologies



Each customer (enterprise or tower) receives a wavelength via an add/drop multiplexer (OADM).

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DWDM Networks Reference Poster

Standards

DWDM Characteristics

- Best approach to maximize fiber capacity
- Extensively used in metro, long-haul and ultra-long-haul networks

ITU-T G. 694.1—Spectral Grids for WDM Applications: DWDM Frequency Grid

- Defines specific wavelengths (frequencies) allowed for 12.5 GHz, 25 GHz, 50 GHz and 100 GHz channel spacing

Channel Spacing (GHz)	Allowed Channel Frequencies (THz)
12.5	193.1 + n*0.0125
25	193.1 + n*0.025
50	193.1 + n*0.05
100	193.1 + n*0.1

(n is a positive or negative integer including zero)

$$\text{Wavelength (nm)} = \frac{2.9979 \times 10^8}{\text{Frequency (GHz)}}$$

Channel Spacing Conversion					
GHz	200	100	50	25	12.5
nm	1.6	0.8	0.4	0.2	0.1

DWDM Testing

ITU-T G.650.3—Test Methods for Installed Singlemode Optical Fiber Cable Links

- Detailed tests should be carried out on a singlemode fiber for proper operation

Recommended Tests	Test Instrument
Connector endface inspection	Inspection probe
Link attenuation	OTDR
Splice loss, splice location, fiber uniformity and cable length	OTDR
Polarization mode dispersion	PMD tester
Chromatic dispersion	CD tester
Optical return loss	ORL tester

Common Failures in DWDM Networks

Impairment	Frequency	Test Instrument
Attenuation	High	OTDR, OLTS, probes, OSA
Optical channel power changes due to gain variations	High	OSA
Frequency (or wavelength) deviation from normal	High	OSA
Polarization mode dispersion	Medium	PMD tester, distributed PMD tester
Four-wave mixing	Medium	OSA
Amplified spontaneous emission noise from optical amplifier	Medium	OSA
Chromatic dispersion, CD slope	Medium	CD tester
Reflection	Medium	OLTS, OTDR, probe
Laser noise	Medium	OSA
Interchannel crosstalk	Medium	OSA
Interferometric crosstalk	Medium	OSA

High = 10 events per year
Medium = 1 event per year

EXFO recommendation

Source: Recommendation ITU-T G. 697. Optical Monitoring for DWDM Systems, Table 1–Optical Impairments.

DWDM Dispersion Testing

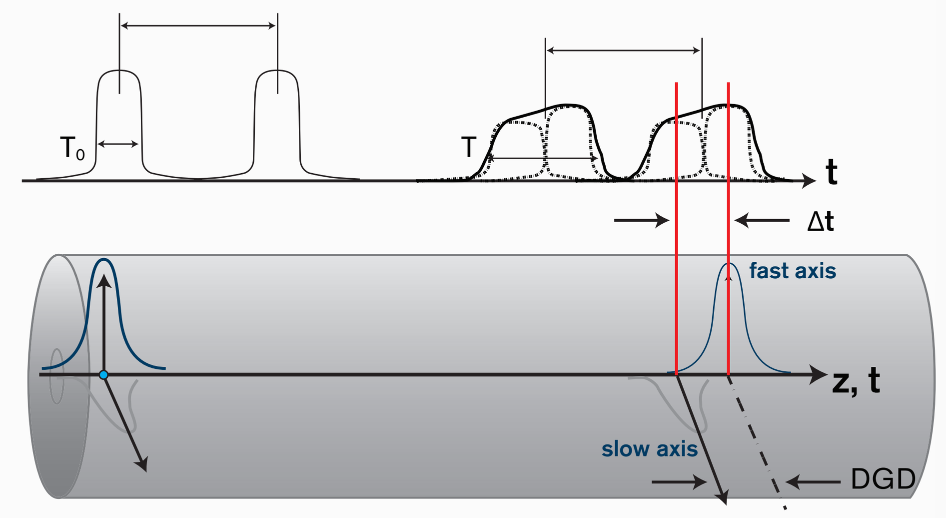
- Dispersion is an important phenomenon that must be tested in DWDM networks to avoid bit errors. The longer the light path, the more dispersion there is.
- EXFO recommends dispersion testing for fiber span longer than 20 km.

Chromatic Dispersion (CD)

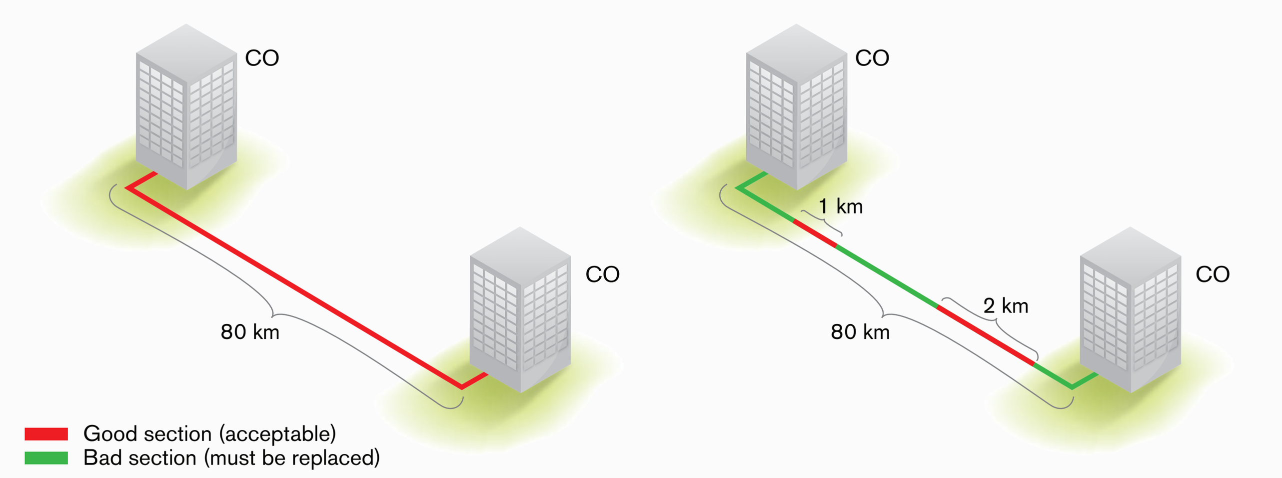
Chromatic dispersion is a pulse broadening that occurs when different wavelengths of an optical pulse travel at different velocities in a fiber due to the variation of the fiber index of refraction with wavelength.

Polarization Mode Dispersion (PMD)

PMD is a pulse broadening that occurs when different polarization modes (fast axis and slow axis) travel at different velocities due to fiber geometric imperfections or environmental constraints (heat, mechanical stress on the fiber like bends, etc.). PMD leads to differential group delay (DGD).

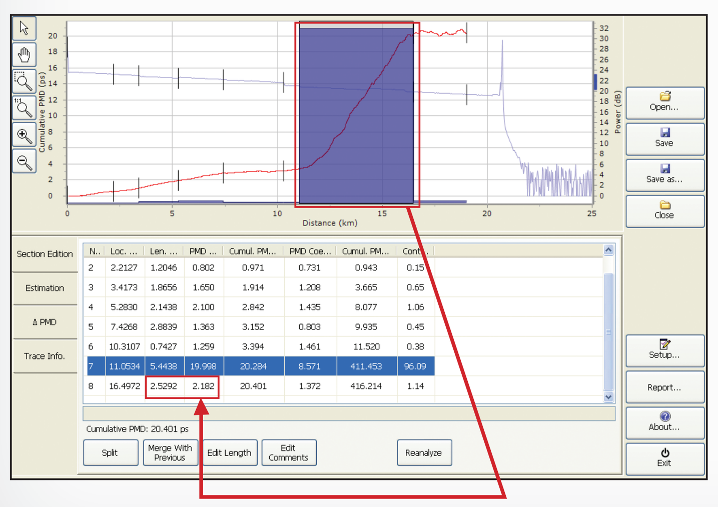


How to Handle High PMD



Traditional PMD measurement techniques provide a total link PMD value but do not locate which spans are causing the link to fail the test.

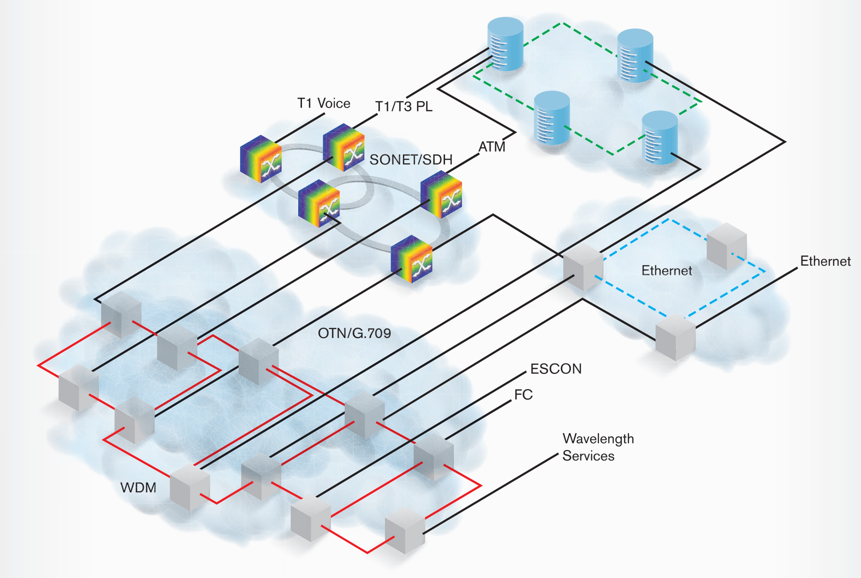
Distributed PMD analysis breaks down the measurement results, effectively pinpointing the high-contributing sections of the link.



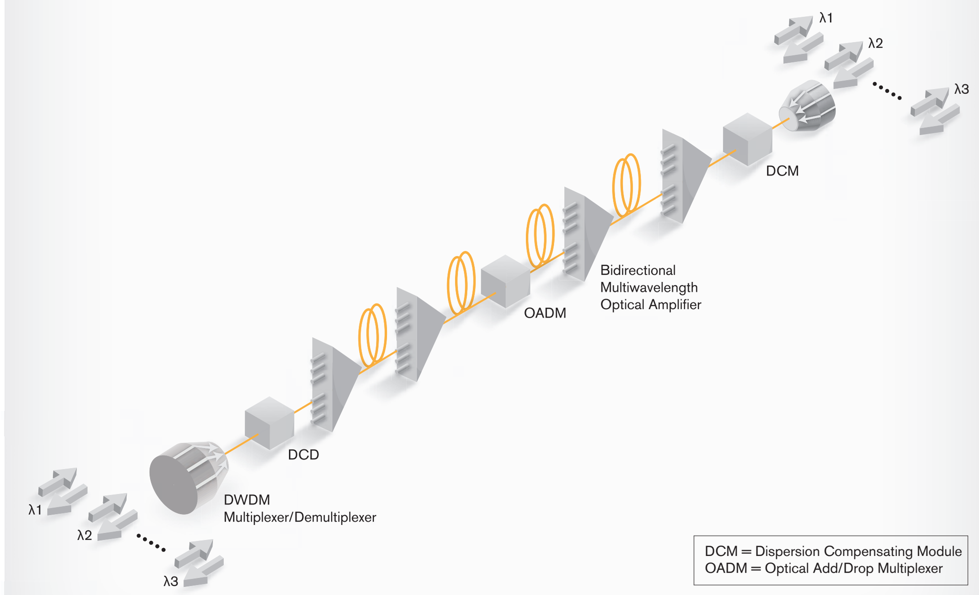
High-contributing PMD section.

- Locates the fiber sections that are the main contributors of the total PMD of a link
- Enables to isolate and repair only the worst PMD sections of the fiber cable and allows the cost-effective upgrade of a fiber network

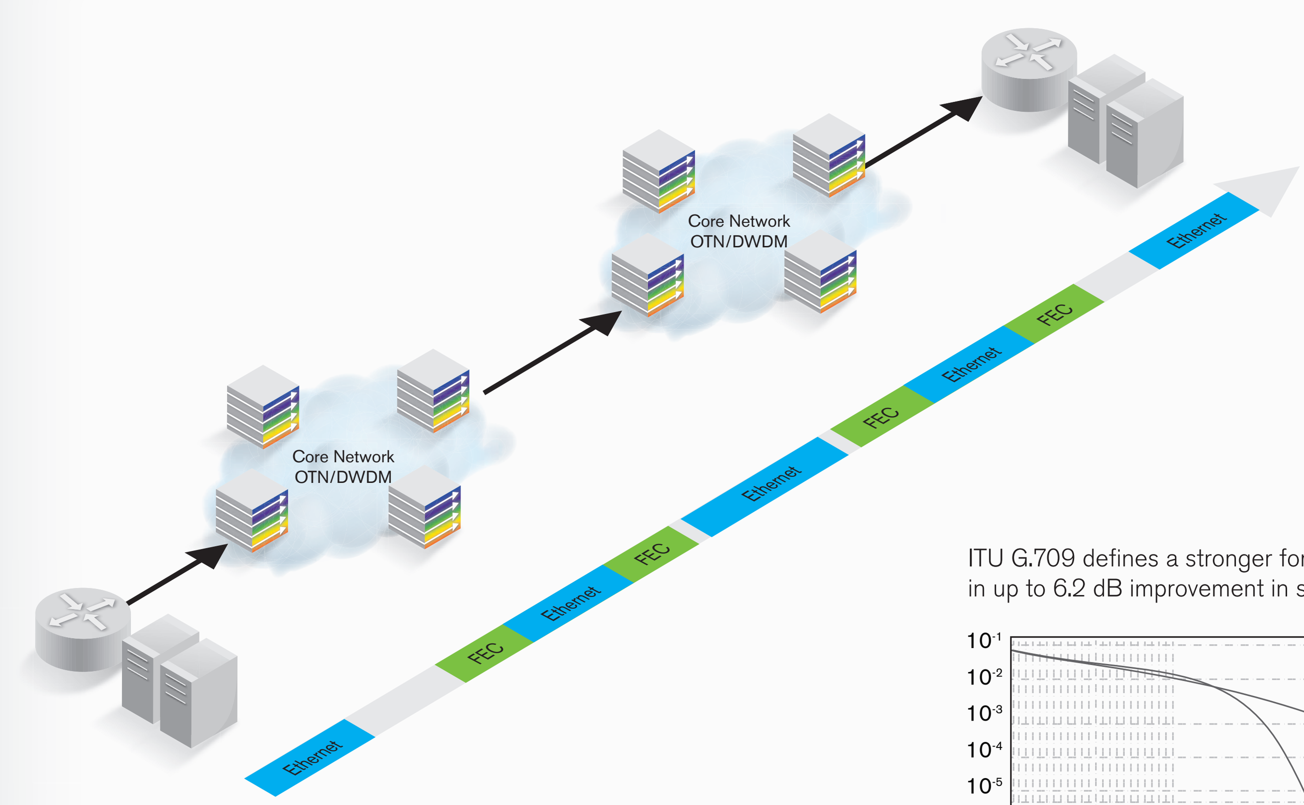
Network Topology



Building Blocks/Components of a WDM Network

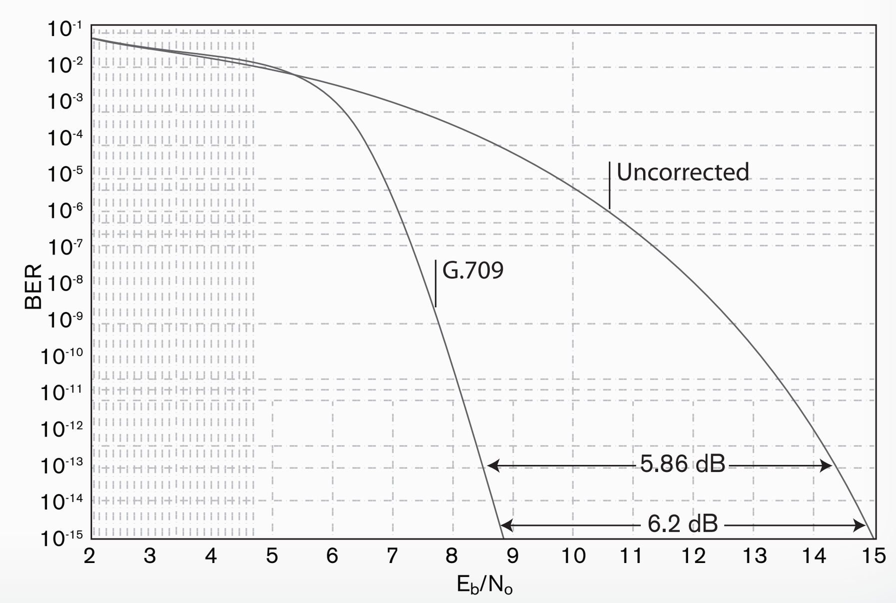


Optical Transport Network (OTN)



- OAM&P
- Transparency
- FEC
- Integrated Solution
- Scalable Up to 100G

ITU G.709 defines a stronger forward error correction for OTN, which can result in up to 6.2 dB improvement in signal-to-noise ratio (SNR).

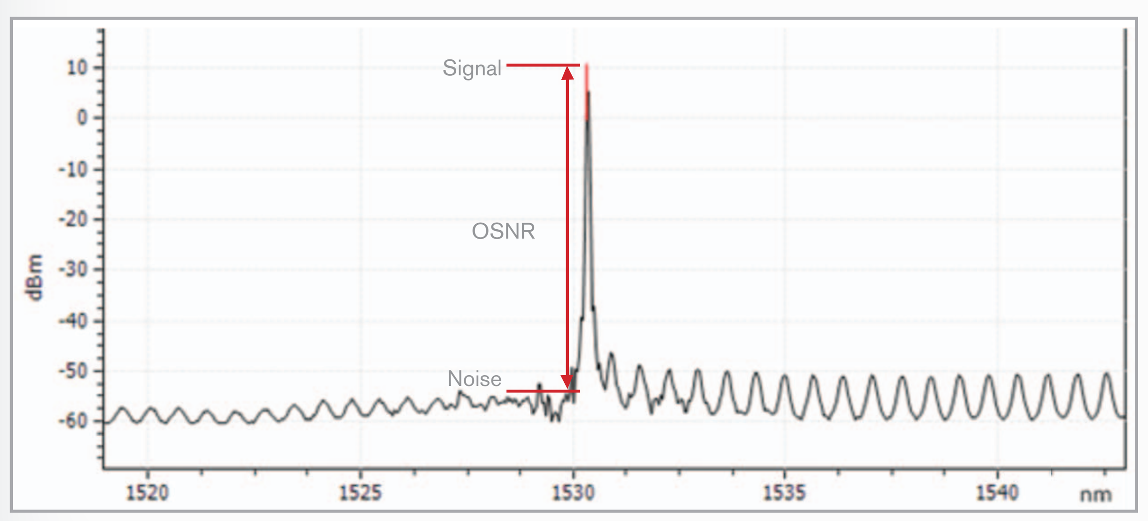


BER vs E_b/N_o

DWDM Spectral Testing

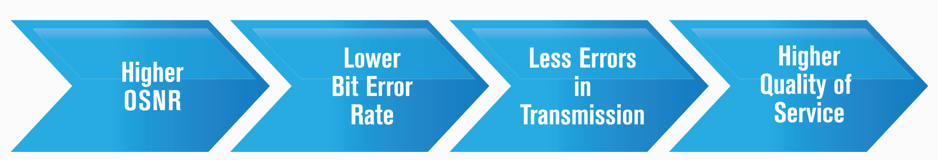
- Spectral testing with an optical spectrum analyzer (OSA) is key to identifying many common types of failures in DWDM networks, as shown in the following table:

Definition of Optical Signal-to-Noise Ratio (OSNR)

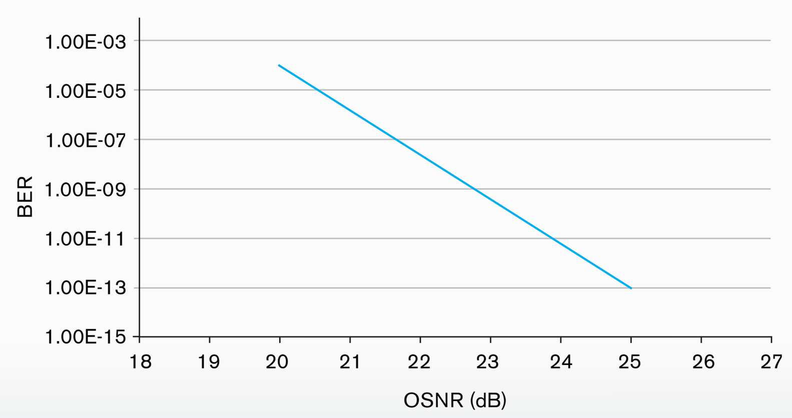


The simplest case for an OSNR measurement is a single channel, as there is no interference coming from adjacent channels.

Importance of OSNR

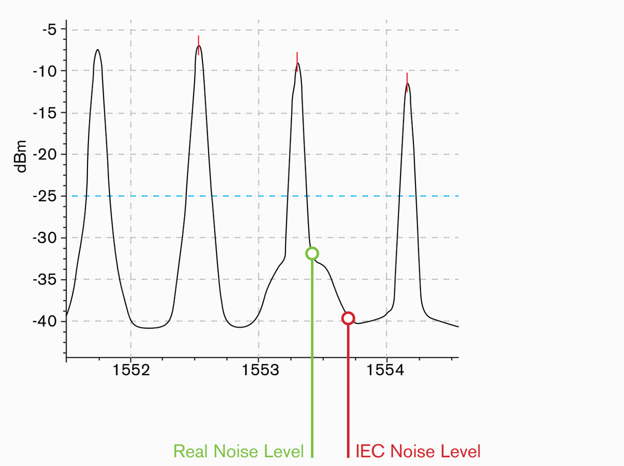


OSNR vs. BER Typical Relationship



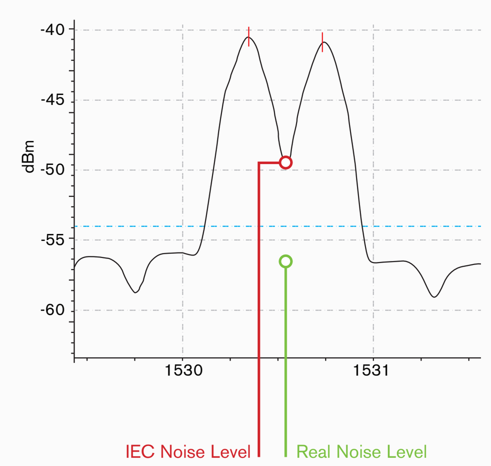
IEC Method and (R)OADMs

- IEC method fails for signals that went through (R)OADMs
- It leads to an underestimation of the noise level



IEC Method and 40G Signals

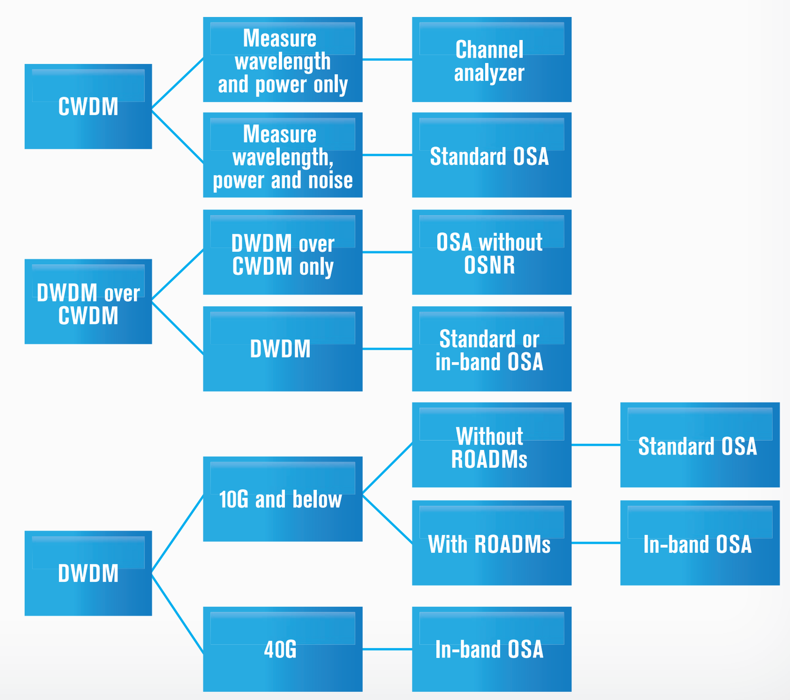
- IEC method fails for 40G signals
- It leads to an overestimation of the noise level



The Solution: In-Band OSNR

- In-band OSNR method is required to measure 40G signals or signals that went through (R)OADMs
- It consists in measuring the noise level inside the signal band, not out-of-band

Spectral Analysis Product Selection Guide



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