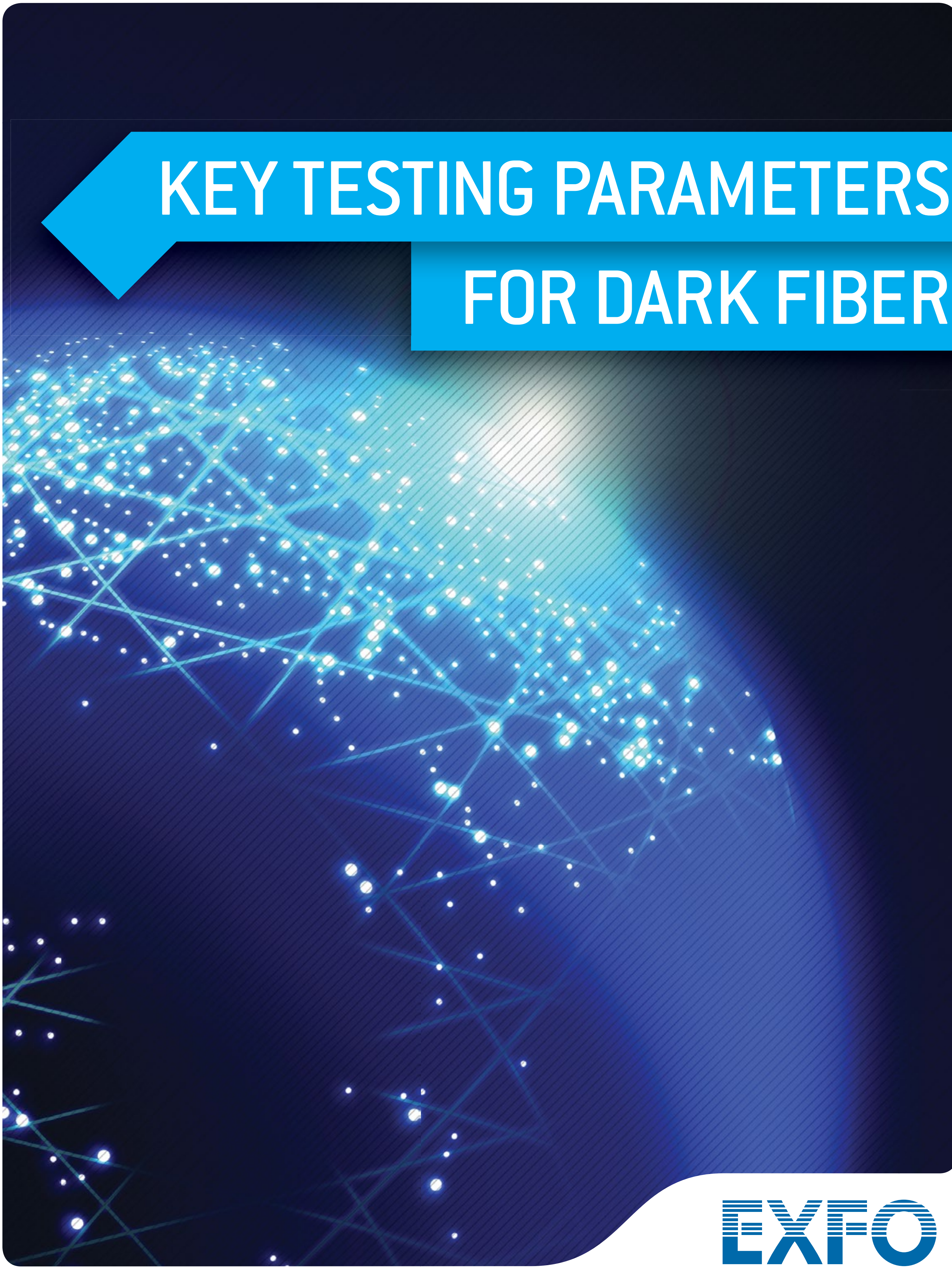
KEY TESTING PARAMETERS FOR DARK FIBER



EXFO

CONTENTS

INTRODUCTION

During the turn-up phase of the dark fiber implementation, it is imperative to have documented results per the required specifications. The purpose of testing an optical fiber cable link following installation or before turn-up is to prove that the fiber link and all of its components meet their specifications, and that the installation has been carried out as per industry-leading practices (for example, splice losses comply with their specification and the cable link is free of damage).

With these elements in mind, we are pleased to offer our guidance, experience and expertise in proper fiber characterization practices. While the ITU-T defines the test required for fiber characterization (ITU T G.650.3 Test methods for installed single-mode optical fiber cable links), a single test can be carried out in many different ways, and with different types of tools.

Recommendation ITU-T G.650.3 specifies that all fibers should be tested in compliance with the following:

Tier 1 – Recommended for all links:

- Connector endface inspection
- Link attenuation
- Splice loss, splice location, fiber uniformity, and length of cable sections and links

Tier 2 – Test methods for verification of service contracts or transmission at particular bit rates:

- Spectral attenuation
- PMD
- CD

In the following pages, EXFO will be reviewing some of the aspects below as they relate to the most relevant tests described above:

- General concept and impact of the phenomenon
- Best testing practices
- How to perform the test

CONNECTOR ENDFACE INSPECTION

INTRODUCTION

Before testing commences, it is imperative to clean and document every fiber connection.

Many studies show that the main cause of network failure is related to connector endface issues. Here are the results of one such study polling network owners and cable installers about the sources of network failures:

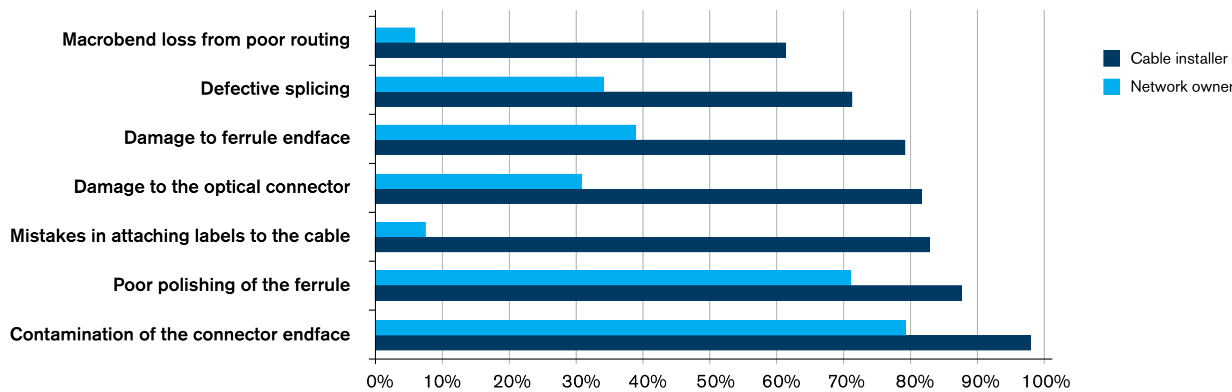


Figure 1: NTT Advanced Technologies

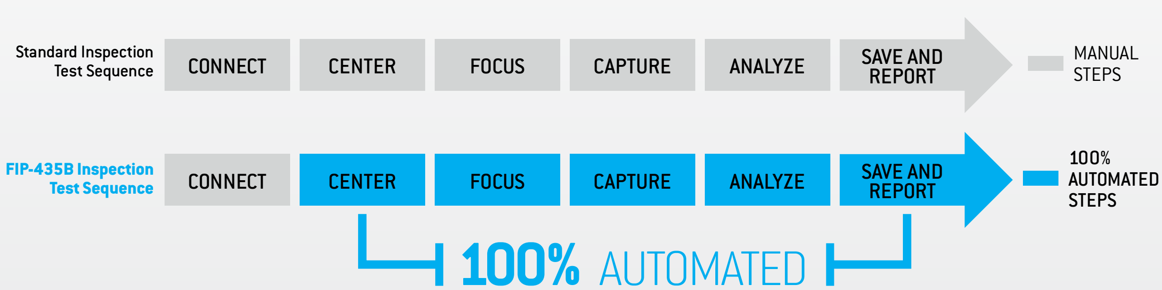
BEST PRACTICES

Fiber inspection and cleaning are critical to every testing aspect mentioned in this document. The effects of endface contamination from dirt, defects, scratches, and other elements will have an increasingly negative impact on your network as data transmission rates increase. Visual inspections are at best subjective, because they are based on technicians' experience, with the end result being that poor endface quality often goes unseen. Therefore, EXFO highly recommends inspection and pass/fail software analysis to eliminate the variability that exists from one technician to another.

The ideal solution for proper inspection is the EXFO FIP-435B fully automated wireless inspection probe with its ConnectorMax2 integrated pass/fail analysis software, which is based on IEC and IPC standards. The reasons for this assertion are outlined on the following pages.

Fiber Inspection Is a One-Step Process

Enabled by its unique, automatic centering and automatic focus-adjustment system, the FIP-435B automates each operation in the test sequence, transforming the critical inspection step into a quick and simple one-step process accessible to technicians of any skill level.



DOING THE TEST

Select the proper connector tip based on the connector style, fiber type, patch cord and/or bulkhead in the patch panel).

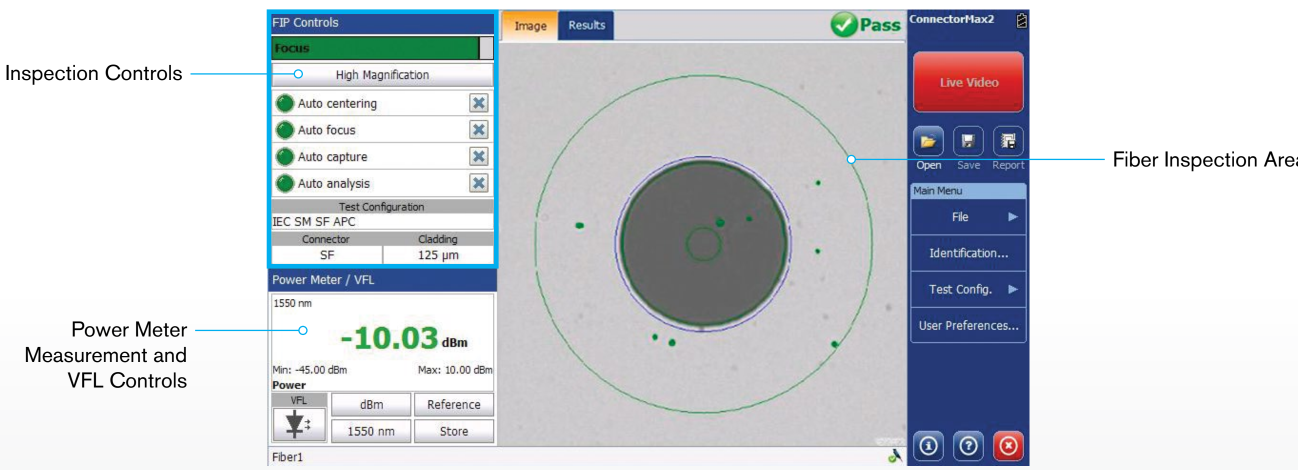
1. **Click the capture button on the probe.**
   Autocentering and autofocusing will begin.

2. **The image will be analyzed automatically.**
   The LED directly on the probe will offer pass/fail analysis knowledge. In the case of a pass, the information is saved and the connector is ready for mating.
   In the case of a fail result, unless the source of failure is permanent damage, cleaning should take place, followed by re-inspection until a pass is obtained.

Pass

Fail

Activity status



Fiber Cleaning Tools

Proper cleaning of fiber-optic connectors requires proper fiber-optic-grade cleaning materials. Materials vary from optical-grade wipes to cassette cleaners. Please refer to your company guidelines for the preferred method of cleaning.

The most common cleaning tools available are outlined below.

SPLICE LOSS AND LOCATION, FIBER UNIFORMITY, LENGTH OF CABLE SECTIONS AND LINKS

INTRODUCTION

For these characteristics, an OTDR-based measurement method is recommended. This is described in IEC 61280-4-2. An OTDR is an instrument able to measure the optical power backscattered along a fiber as a function of distance.

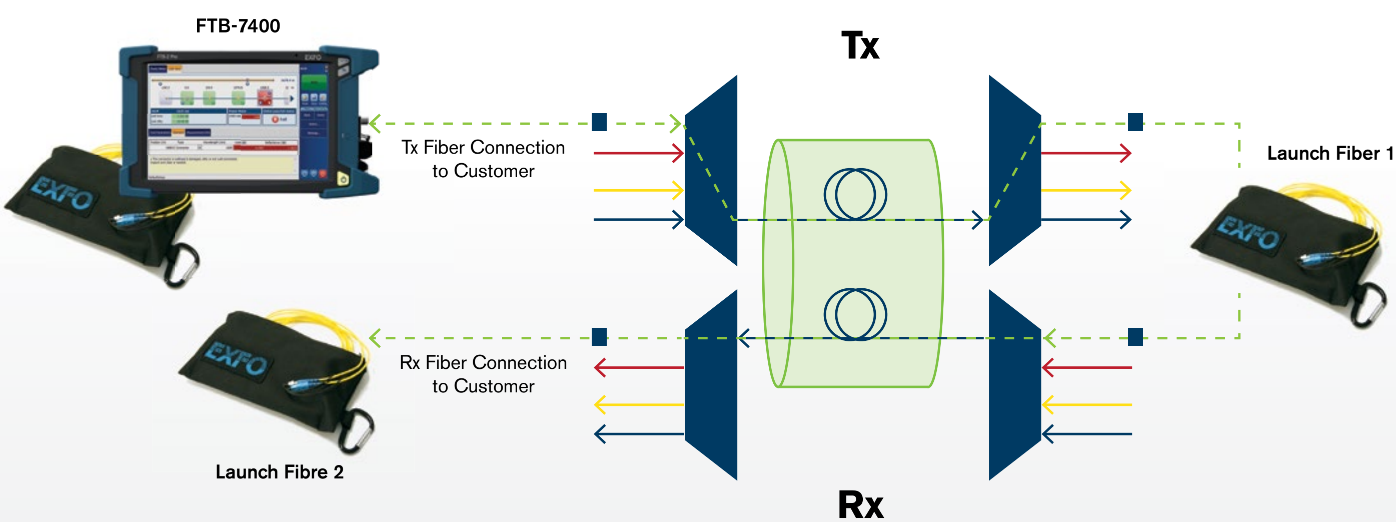
Detailed analysis of these OTDR traces then allows for accurate measurement of total link attenuation, total link optical return loss, and full breakdown of component losses along the link, including fiber section attenuation, splice losses, connector insertion and return loss. In addition, excessive mismatches between fibers in different cable sections along the route can be identified along with any problems, such as bends on the fiber.

BEST PRACTICES

Normally, for commissioning or accepting a dark fiber section, OTDR (or more recently, iOLM*) testing is carried out in both directions on every fiber using at least two wavelengths. These wavelengths should be representative of the wavelengths at which the fiber may operate.

For CWDM systems, because they use optical filters (different wavelengths), it is very important to ensure that the right wavelength from the customer is patched into the right port on the CWDM muxes and demuxes.

To effectively test the circuit and ensure that both the Tx and Rx are patched correctly, it is necessary to use an iOLM with CWDM wavelengths. The iOLM can be used to measure the specific CWDM wavelengths testing through the network cable to the drop site (cell site), provided that the mux/demux are optically designed. Furthermore, the fiber can then be looped with an additional launch fiber onto the return fiber to the customer. This means that both the TX and Rx links can be tested in one measurement.

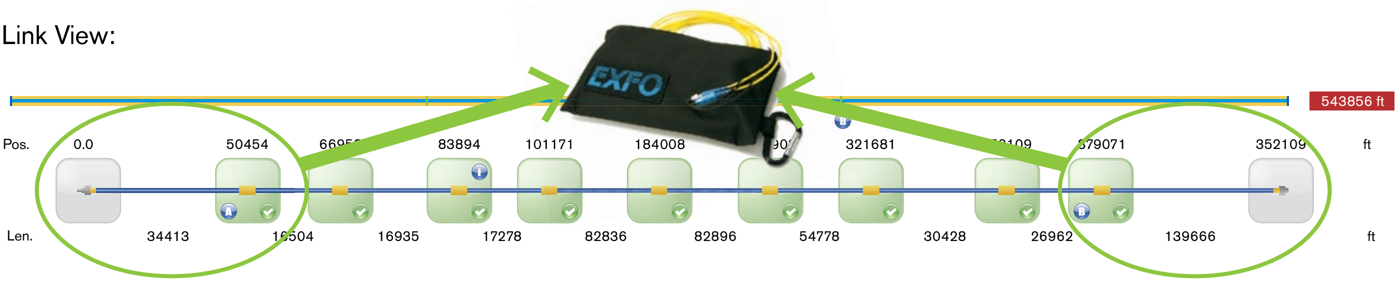


* Intelligent Optical Link Mapper

iOLM, an Evolution of the OTDR

The intelligent Optical Link Mapper (iOLM) performs several consecutive OTDR-like measurements at different wavelengths, in addition to measurements at different power and pulse widths to ensure that there is no compromise on range and resolution—and therefore, greater accuracy. All of these traces are compared, analyzed and integrated for a complete, extremely accurate and repeatable link mapping. The iOLM application is the best method capable of providing full assurance and consistency of the test results.

Link View:

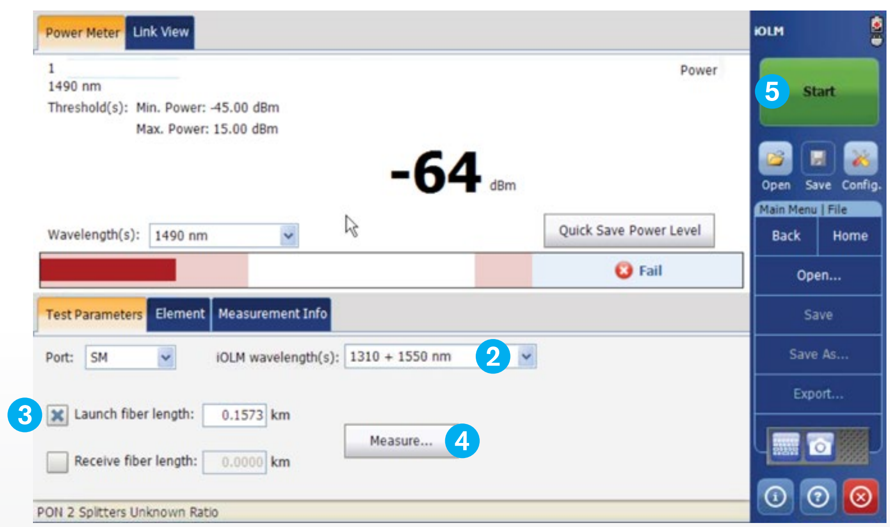


DOING THE TEST

Unlike a traditional OTDR, the iOLM requires only a short launch fiber (50 meters or less) to benefit from all the advantages of this reflecting method, regardless of the link length and loss. It is recommended that a receive fiber be used at the end connector. This method gives a true and accurate end-to-end characterization.

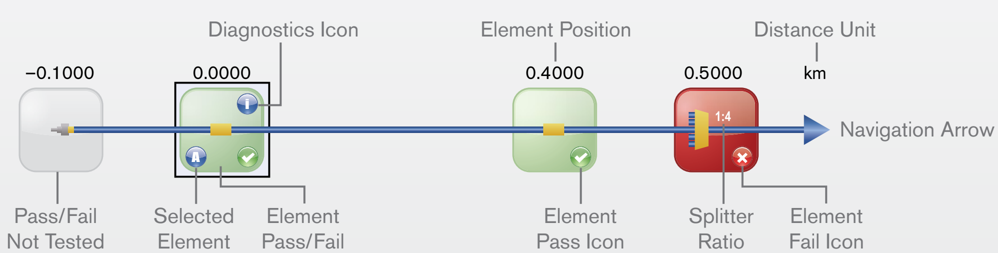
iOLM Test Parameter Setup

1. Inspect and clean as necessary, and then ensure that the fiber connector is connected to the proper port of the iOLM module.
2. Select the iOLM wavelengths for the acquisition.
3. Specify if a launch fiber is connected between the test unit and the link under test.
4. Press measure to calibrate the launch and/or receive the fiber length.
5. Press Start.



Understanding the Link Composition, Results and Diagnostics

The link composition is described below:



The detailed iOLM analysis of the total span or fiber link allows for accurate measurement in a single, simple linear view. Measurements also provide pass/fail analysis to meet the provider's criteria:

- Total span distance
- Section and distance attenuation
- Total link loss (attenuation)
- Optical return loss (ORL): The ratio of the forward optical power to the reflected optical power
- Splice loss: Loss of optical power at a (fusion) splice point
- Connector loss: The loss of light at a mated pair of connectors
- Connector reflection: The percent of power reflected back from a mated pair of connectors
- Excessive mismatches between fibers in different cable sections

Connector loss, macrobends and splice loss that are out of the design specifications will give clear failures with diagnostics and pointers on how to resolve the problem.

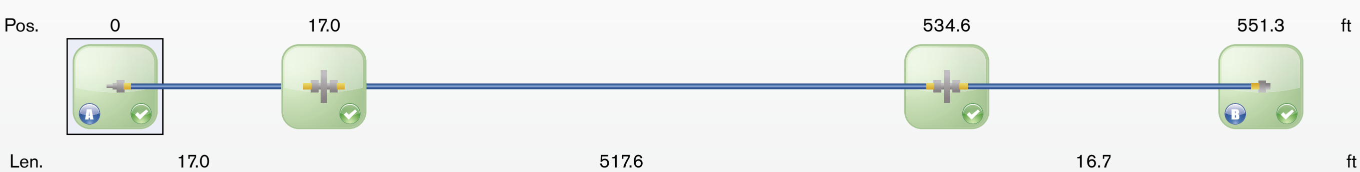
Once the test is completed, you can refer to the result sections for information about the fault potentially present on the fiber. The table below lists a few of the faults that could lead to system failure.

Type of Fault Diagnostics that Solve the Issue

Type of Fault	Diagnostic	Solving the Issue
Bad connector	The connector or bulkhead is damaged, dirty or not well connected.	Inspect and clean as needed.
Macrobend	Excessive fiber bend.	Inspect the fiber in this area for excessive bending. Use of a VFL could help identify the exact location of the macrobend.
Bad splice	Excessive loss of a non-reflective fault.	Inspect the splice at this location, and respliced if needed. Use of a VFL could help identify the exact location of a bad splice.

Bidirectional iOLM Testing—Why Is It Recommended?

Bidirectional iOLM testing and results can be analyzed directly from the EXFO platform. This method will improve the confidence level for splices, connectors and differing types of fibers connected together in the network paths by averaging both directions to provide the optimum accuracy.



Results

Identification | Summary | Thresholds | Elements Table

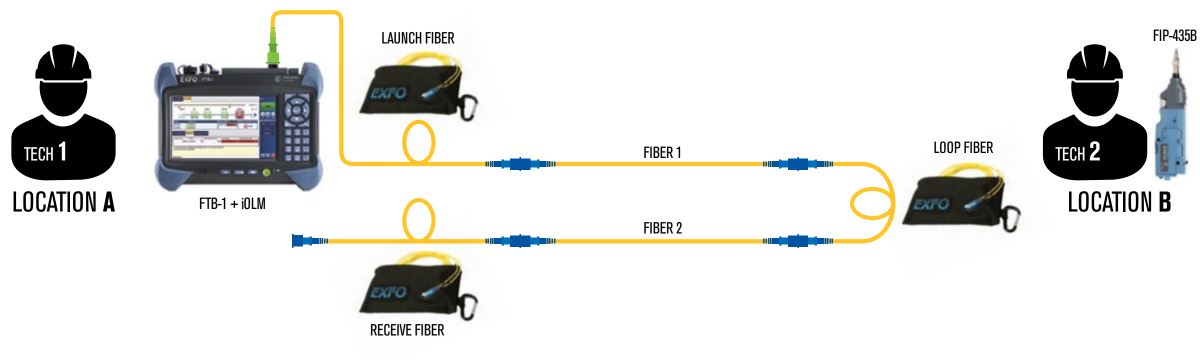
Identifiers	Dir.	P/F	Wavelength (nm)	Position (ft) Loss, Refl. (dB)	Element 1 0.0 ft 1/1	Element 2 17.0 ft 1/1	Element 3 534.6 ft 1/1	Element 4 551.3 ft 1/1
1	Bidir	✗		Type:				
				Position:	0.0	17.0	534.6	551.3
			1310	Loss:	0.296	0.446	0.052	0.392
				Reflectance:	-54.6	-53.1	-54.3	-54.3
			1550	Loss:	0.283	0.416	0.149	0.366
				Reflectance:	-55.7	-54.3	-55.3	-55.4

SAVE 50% OF YOUR TESTING TIME WITH THE LOOPBACK TEST METHOD

Double your test efficiency by characterizing two fibers at once using the iOLM's loopback mode (iLOOP).

Loopback Test Methodology

- Loops two fibers together at one end to test both fibers at once from the other end
- Software application is able to distinguish between the fibers during reporting
- Very useful in construction when fibers are deployed in pairs
- Particularly efficient in short- to medium-range fiber deployments, and in any applications using Tx/Rx fiber (e.g., in data centers)
- Makes it possible to test both upstream and downstream links from a single port—ideal for fiber to the antenna (FTTA) and distributed-antenna-system (DAS) applications



Key Benefits of Using Loopback Testing

- 50% less testing time, because you characterize two fibers in one OTDR acquisition
- Single-ended test: only one OTDR unit is required at one end of the link
- Performing loopback testing with two technicians only requires minimal expertise from the second technician, who simply needs to properly inspect the fiber connector with an inspection probe, clean it if required, and then install the loop fiber
- Distinct results for each fiber tested in loop (both OTDR and iOLM)
- Intuitive link view (iOLM) or traditional graphical view (OTDR) for easy identification of the loop section

iOLM'S LOOPBACK TESTING MODE (iLOOP)

iLOOP

The iLOOP feature is an intelligent application that relies on the single-ended loopback measurement method to characterize two fibers at once using the iOLM.

Once the measurement is completed, iLOOP

- Splits the merged results into two individual links
- Applies pass/fail assessments to generate a report for each single fiber
- Generates individual iOLM, OTDR (.sor) files and PDF reports automatically for all your fibers
- Eliminates the need for post-processing, enabling you to close your job immediately and directly from the field, and move to the next fiber pair faster

DISPERSION—PMD/CD

INTRODUCTION

Polarization mode dispersion (PMD) and chromatic dispersion (CD) are two effects created by dispersion that cannot be overlooked during the commissioning or troubleshooting phase of any network path.

PMD is caused primarily by fiber defects, imperfections, and external stresses. These external stresses may be natural (earthquakes, storms), or artificial (digging, vehicle-induced vibration). As such, PMD can vary quite fast, and is not wavelength-dependent. When testing for PMD, a safety margin is often required. PMD cannot be compensated for in the optical domain. Some advanced technologies, such as those used in 100 Gbit/s coherent transmission, partly help to mask the impact of PMD.

CD is caused by normal light dispersion in a medium such as glass, where some wavelengths travel faster than others. CD is a given value for a given fiber, and as such, once known can be quite easily compensated for.

CD and PMD issues become very important at 10G, because higher amplitude-modulated data rates can handle less CD and PMD. In addition, CD and PMD scale with distance, so longer links are more prone to dispersion issues.

BEST PRACTICES

Several PMD and CD test methods exist; however, the single-ended solution is the most cost-effective in a dark fiber implementation in short-haul and metro networks:

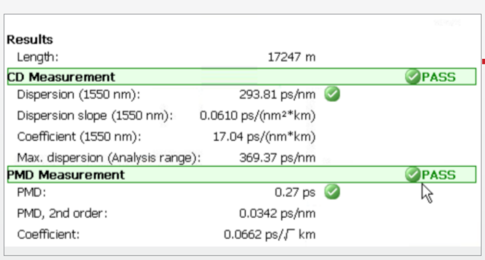
- Single-ended: Based on OTDR-like technology, these offer the benefit of much faster and simpler characterization procedures, because a single technician can carry out these two complex measurements without waiting for a second technician to go from one site to another. These are ideal and recommended test approaches for CWDM-based networks, because they are typically less than 150 km, and do not contain amplifiers.

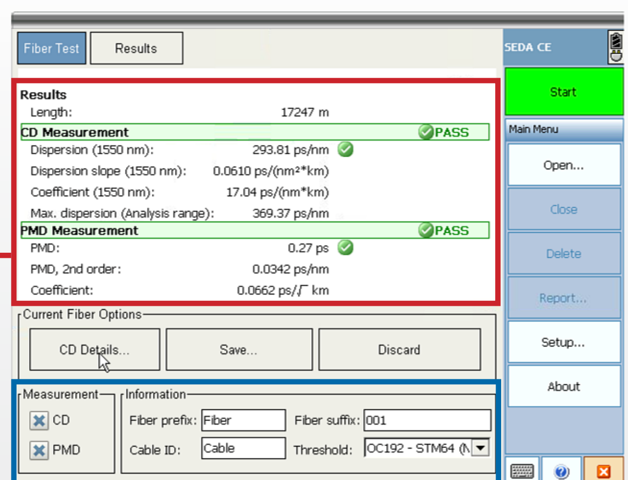
The single-ended approach can have both testing capabilities (CD and PMD) within the same unit, tested at the same time, and without the need to re-configure, or to disconnect test equipment. In the process, these units also measure fiber length, which can serve the following purposes:

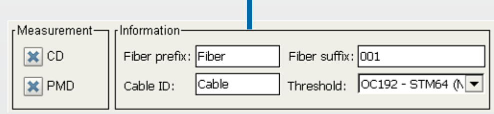
- Validate the fiber length found by the iOLM
- Automatic calculation of CD and PMD coefficient, which is the amount of dispersion per kilometer, and often an indication of fiber quality and type.

DOING THE TEST

Performing the test is extremely simple using the FTB-5700 Single-Ended Dispersion Analyzer, which comprises both testing capabilities (CD and PMD) within the same unit.







Data Rate	CD Tolerance	PMD Tolerance [1]
2.5 Gbit/s	18 468 ps/nm	37.5 ps
10 Gbit/s	1193 ps/nm	9.3 ps

1 Assuming an outage probability of 0.001%.

WDM AWARE™
POL-MUX TECHNOLOGY

INTRODUCTION

A system validation test is commonly performed during commissioning using an optical spectrum analyzer (OSA).

BEST PRACTICES

High-quality OSAs are known for the ability to discriminate extremely close wavelengths (as seen in DWDM systems), and very accurately measure noise and optical signal-to-noise ratio (OSNR). Both attributes are not required in CWDM systems, due to the fact that wavelength spacing is wide and these networks are nonamplified, meaning there is limited noise input. In DWDM systems, recommended measurements are channel power, channel wavelength, OSNR and channel flatness. This latter concept refers to the power difference between the most powerful channel and the weakest channel. It should be minimized so that amplifiers offer the best possible performance. Regarding OSNR measurements, it is imperative to use the right OSNR method to obtain a valid result. Depending on the data rate (10G, 100G, etc) and the presence or not of ROADMs, the right OSNR measurement method will be chosen among the IEC, in-band and Pol-Mux methods.

Although it is essential to validate that the proper wavelength spacing is dropped at the proper point, this cannot be done with an OTDR, because the system is now active. This cannot be carried out with a power meter either, because it cannot discriminate which wavelengths are present, or whether there is more than one wavelength.

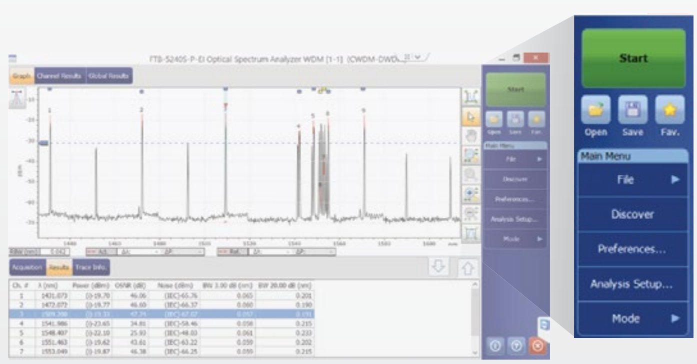
The tool recommended for this job is either an optical channel analyzer (OCA), or a channel checker.

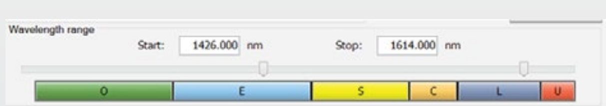
Channel Checker: These basic instruments have a series of filters that can analyze power at predetermined wavelengths. While these may be good on a particular network, they will not adapt to different networks or configurations, and more importantly, to network evolutions. The output of such a device is a bar graph representing the power at nominal wavelengths. These instruments typically work on only one WDM technology, i.e., CWDM or DWDM, but not both.

Optical Channel Analyzer: A scanning type of channel ckecker is much more of an entry-level OSA, as it will scan the entire wavelength range and produce a detailed power vs. wavelength chart, at the exact wavelength present in the network, regardless of the network configuration. This allows for much more flexibility and visibility into potential issues. In addition, it works with all types of networks: DWDM, CWDM and even DWDM over CWDM.

DOING THE TEST

For brownfield systems which contain a mix of 10G and 100G channels, new impairments such as interchannel crosstalk and nonlinear effects emerge. It makes sense to prevent errors (BER) stemming from these impairments by testing your network with EXFO's WDM Investigator, which, in addition to an analysis of interchannel crosstalk and nonlinear effects, provides a PMD assessment on live signals. Despite the fact that most OSAs are complex tools, EXFO's OSA makes simple work of OSA tests thanks to its Discovery function.

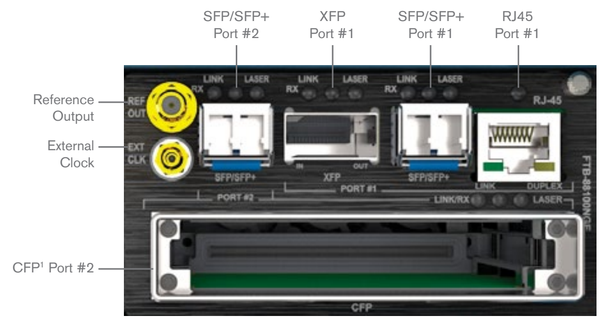




INTRODUCTION

As the complexity in today's high- speed networks increases, with rates from 10M all the way up to 100G and using multiple technologies, technicians and operators are now looking for a single test solution that can provide the wide range of testing capabilities for qualifying the integrity of data transmission over multiple protocol layers.

EXFO's 10M-to-100G Power Blazer solutions offer advanced unframed and framed Ethernet and OTN testing for carrier labs, field tests and deployment testing.



BEST PRACTICES

There are multiple tasks that will need to be performed to qualify the network link. We will look at the key testing points from the interface all the way to the service tests.

CFP/CFP2 Validation

Unlike the single wavelength transceiver that was used for legacy 2.5G and 10G, each CFP parallel optical channel must be monitored for transmitted and received power levels. Although the overall power across all channels (4 or 10) might be within the acceptable range, this may be the result of averaging a channel with very low power. This can impact the transmission and performance on the optical channel and high-power channel, which in turn may damage the optical receiver at the other end. Figure 2 illustrates a quick CFP/CFP2 power validation.

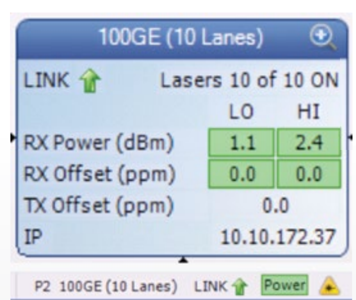


Figure 2. Quick CFP/CFP2 Power Validation.

In the same line as the CFP/CFP2 Validation EXFO also offer a CFP Health Test applications Figure 3 support pre-define Ethernet tests; one or multiple test can be selected at once, optimizing and reducing the test time.

CFP Health Check

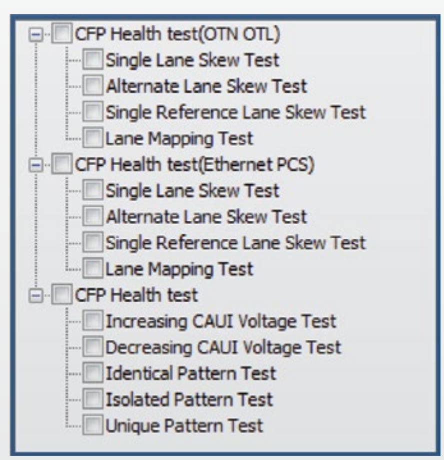


Figure 3. CFP Health Test Menu

In some cases, a per-lane view can be required to identify any suspicious lanes that may eventually cause bit errors. Lane 9 in Figure 4 below is slightly out of range.

Physical Interface

Optical Lane	Laser	TX Power (dBm)	Wavelength (nm)	RX Power (dBm)	Min RX Power (dBm)	Max RX Power (dBm)
0	ON	2.05	0.00	-7.55	-8.51	-7.54
1	ON	1.66	0.00	-7.11	-8.06	-7.11
2	ON	2.25	0.00	-6.28	-7.23	-6.28
3	ON	1.94	0.00	-6.61	-7.61	-6.60
4	ON	2.03	0.00	-6.97	-7.98	-6.96
5	ON	2.32	0.00	-6.98	-8.09	-6.94
6	ON	2.31	0.00	-6.89	-7.96	-6.89
7	ON	2.03	0.00	-6.81	-7.73	-6.81
8	ON	2.04	0.00	-6.88	-7.96	-6.88
9	ON	1.64	0.00	-8.00	-8.80	-7.98

Laser ON/OFF | Laser OFF at Start-Up | Power Range (dBm) -8.1 To 5.2

Figure 4. Per-lane Power and Frequency Measurement.

BER Test: Use of Different Test Patterns

Once our physical layer test is completed, the next step will be to ensure that any transmitted bits can be sent through the network and received correctly. This can be done through an unframed or framed BER test using pseudo-random traffic. It's also key to perform these tests at the protocol layer, where the Ethernet or OTN frame can be transmitted, get to the far end and back through a loopback without any errors.

As displayed in Figure 5, the EtherBert test will require a loopback mechanism at the far-end. As the main purpose of this loopback device is to resend the traffic, it is crucial that the device features some intelligence and not just be used as a hardware loopback. The reason? Some tests may require loopbacks of specific Ethernet layer. This functionality is called a Smart Loopback (SLB).

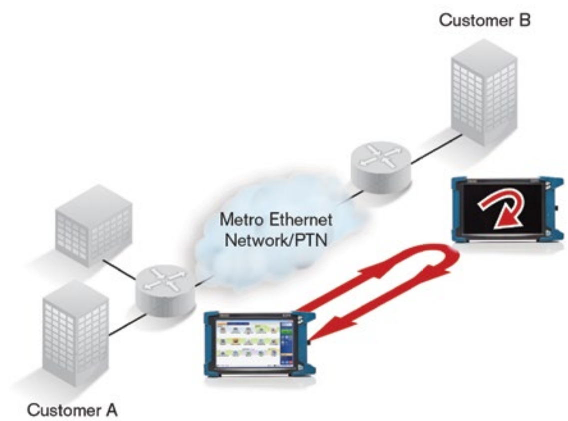


Figure 5. Typical 100G Network Test.

Testing Multiple Types of Services

As the BERT test is based more on pseudo-random traffic, the reality is that live traffic is based more on different types of services. As a result, the need arises for more multiservice tests where the user can simulate multiple streams with predefined data, voice and video traffic profiles or user configurable profiles.

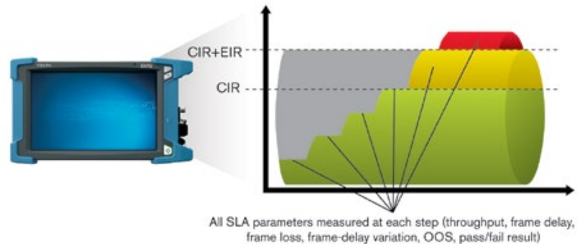
With Ethernet continuing to evolve as the transport technology of choice, network operators have shifted their focus from purely moving data to providing entertainment and new applications in the interconnected world. Ethernet-based services, such as mobile backhaul, business and wholesale services, need to carry a variety of applications, namely voice, video, e-mail, online trading and others.

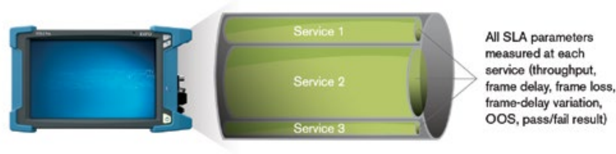
RFC 2544 Tests

- In order to ensure that an Ethernet network is capable of supporting a variety of services (including VoIP, video, etc.), the RFC2544 test suite supports seven pre-defined frame sizes (64, 128, 256, 512, 1024, 1280 and 1518 bytes) to simulate various traffic conditions. Small frame sizes increase the number of frames transmitted, thereby stressing the network device, because it must switch a large number of frames.

Y.1564 for Ethernet Services Testing

- ITU-T Y.1564, or EtherSAM, is the only standard test methodology that allows for the complete validation of Ethernet service-level agreements (SLAs) in a single, significantly faster test, and with the highest level of accuracy.

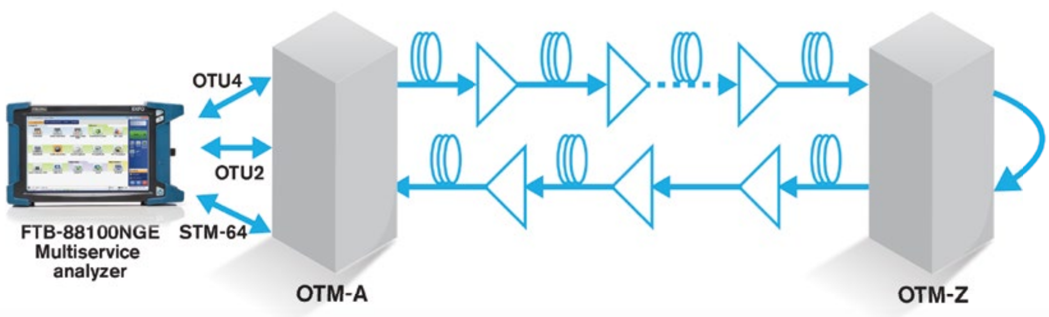




OTN Performance Testing: Long-term Bit Error Test

The most significant content of OTN performance testing is the test of long-term bit error rate (BER). BER has become the most fundamental item of transport network testing. BER tests are conducted by placing pseudo-random bit sequence (PRBS) in the OTN frame and measuring the ratio of number of incorrect bits transmitted through the network over the total number of sent bits.

The typical performance test in OTN projects is 24h error-free test. This bit error test can be carried out with OTU4 interface or by configuring the service as low rate (e.g. STM-64 or OC-192). Here is a typical test configuration:



DOING THE TEST

a) Connect the test configuration as per the above diagram; all OTU4 services should be concatenated respectively; the services are then activated normally.

b) Ensure that the traffic can be sent and received, error free; start the long-term BER test.

c) Record the test results after 24h.

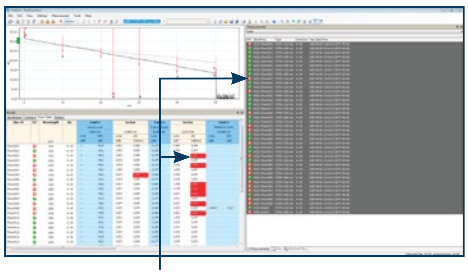
CONCLUSION

In summary, as 100G networks become more complex, operators require testing capabilities that are similar to the tests required for the lower rates, such as 1GE and 10GE. EXFO's FTB-88100NGE offers advanced Ethernet and OTN testing from 10M all the way to 100G. The solution can provide high-speed connectivity testing and wide-ranging features to qualify the state of the fiber plant. It can also assess the integrity of data transmission over short, long and ultra-long-haul networks.

POST-FIBER CHARACTERIZATION

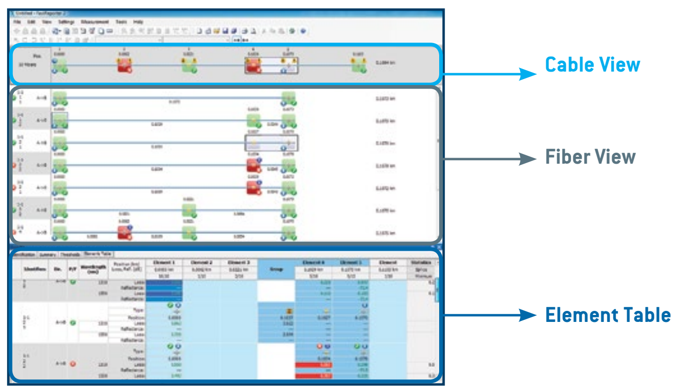
CREATING AND VIEWING THE TEST RESULTS IN FASTREPORTER 2

Long-term documents are imperative for turnover specifications, fiber network-plant verifications and future troubleshooting. The EXFO FastReporter 2 reporting tool performs batch reporting, generates and saves cable reports, and uploads test data into a larger database.



Failed events/fibers vs. set thresholds

Use two monitors, one for the data, one for the graphic.



The following statements explain why documentation of test results is so important:

1. It gives you a network topology in addition to visibility, and is very helpful in the case of new builds and constructions.
2. It ensures that the system is always performing at its best.
3. It improves mean time to repair (MTTR) by providing a reference trace to which current conditions can be compared.
4. It offers great reporting capability, thereby enabling you to compare results from various regions. It also provides dynamic and intelligent reports for process improvement initiatives.
5. It compares fibers within a cable, or pairs within a bundle for qualification, thereby managing allocation for specific fibers that meet higher bandwidth demands.

In addition, FastReporter 2 offers specialized analysis for:

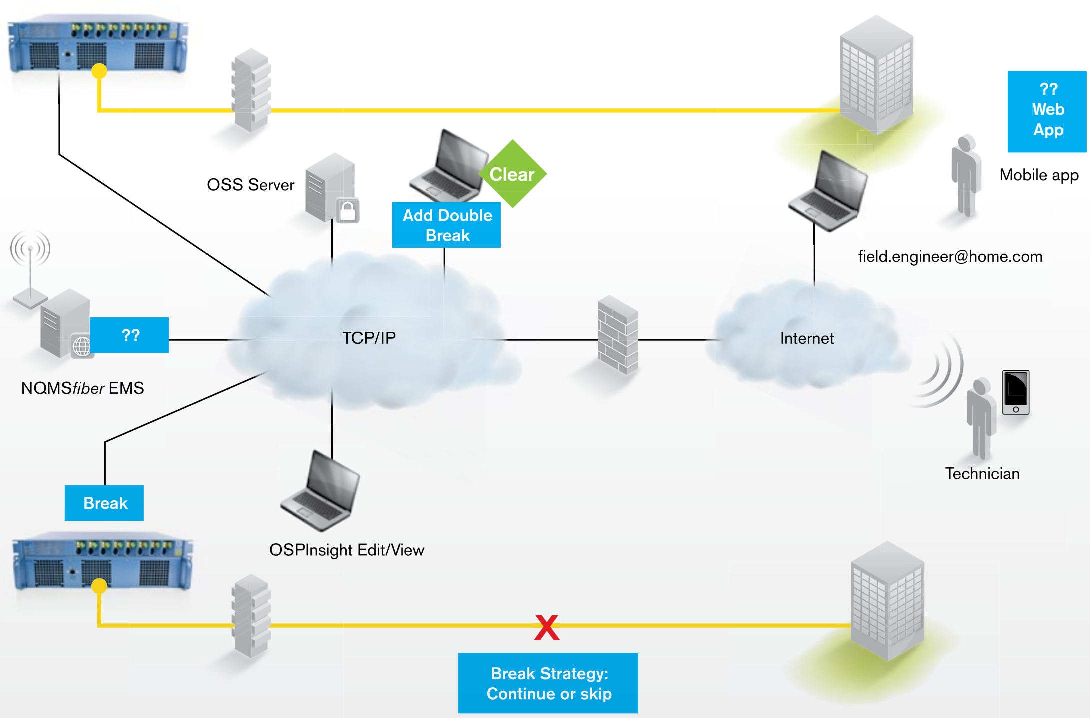
- Performing OTDR bidirectional batch analysis
- Detecting duplicated measurements
- Easily identifying the results in the case of failing network requirements
- Obtaining combined results from multiple wavelengths in multiple directions and consulting them in a single, easy-to-read iOLM-style format thanks to the iOLM bidirectional feature (patent pending)
- iOLM cable, fiber and element views that enable faster analysis and diagnostics
- Applying new configurations (in batch) to ConnectorMax2 results
- CD and PMD results

NETWORK QUALITY MONITORING SYSTEMS (NQMS)

INTRODUCTION

Managing your cable and fiber network is a full-time concern. Running remote test units (RTUs) deployed at key locations across the network, EXFO's NQMS*fiber* Network Quality Monitoring System is the ideal monitoring solution. Featuring sophisticated functions such as alarm management and reporting, trouble-ticket handling and complete network-status schematic viewing, the NQMS*fiber* enables you to integrate all of your network operation and maintenance activities into your existing network management systems. NQMS*fiber* also provides network documentation based on geographical information system (GIS) technology for mapping of the as-built and fault-on-map feature.

- 24/7 monitoring with remote test units ensures that you know the integrity of the network at all times with real-time testing and surveillance of the network.
- Fully scalable: EXFO's Fiber Guardian Stand-Alone Remote OTDR Unit is the perfect entry point to start monitoring at your own pace. Plus, it allows you to migrate seamlessly to a complete monitoring solution whenever you are ready, and without the need to change test units.
- Proactive maintenance: Allows for deeper characterization of fiber routes. Builds up trending data for future analysis and historical tracking.
- Reduced operational costs and improved MTTR thanks to optimized fault detection and location, allowing for prioritized dispatch of correct repair teams. SLA management and improved network documentation.
- Scheduled reporting allows reports to be e-mailed to individuals or groups at specified times. The flexible NQMS*fiber* Report Tool covers many aspects, including alarms, alarm management, MTTR, dedicated SLA management reports, and even system hardware efficiency.
- Optical performance tracking and management by region, or even by customer.



In addition to the capabilities indicated above, see below for a complete list of the test and measurement modules available for EXFO's modular platforms.

PLATFORMS

OPTICAL TEST MODULES	FTB-1	FTB-2	FTB-200	FTB-500
FTB-700G Series Optical, Ethernet and Multiservice	•			
FTB-720 LAN/WAN Access OTDR	•			
FTB-730 PON FTTx/MDU OTDR	•			
FTB-7000 Compatible OTDRs (B-C-D-E Series)		• ▲	•	•
FTB-3930 MultiTest Module		• ▲	•	•
FTB-5230S/-OCA OSA and Optical Channel Analyzer		• ▲	•	•
FTB-5240S Optical Spectrum Analyzer		• ▲	•	•
FTB-5240BP Optical Spectrum Analyzer				•
FTB-5500B PMD Analyzer				•
FTB-5600 Distributed PMD Analyzer				•
FTB-5700 Single-Ended Dispersion Analyzer		• ▲	•	•
FTB-5800 Chromatic Dispersion Analyzer				
FTB-9100 Optical Switch				•
Intelligent Optical Link Mapper (iOLM)	•	• ▲	•	

TRANSPORT AND DATACOM MODULES	FTB-1	FTB-2	FTB-200	FTB-500
FTB-700G Series Optical, Ethernet and Multiservice	•			
FTB-860 NetBlazer Ethernet Tester	•			
FTB-860G NetBlazer Ethernet Tester	•			
FTB-860GL NetBlazer Ethernet Tester	•			
FTB-870 NetBlazer Multiservice Tester	•			
FTB-880 NetBlazer Multiservice Tester	•			
FTB-8130NGE Power Blazer Multiservice Test Module			•	•
FTB-8510B Packet Blazer Ethernet Test Module			•	•
FTB-8510G Packet Blazer 10 Gigabit Ethernet Test Module			•	•
FTB-8525/8535 Packet Blazer Fiber Channel and Ethernet Test Modules			•	•
FTB-85100G Packet Blazer 100G/40G Ethernet Test Module				•
FTB-8805 Power Blazer DSn/PDH and SONET/SDH Electrical Test Module		• ▲		•
FTB-8830NGE Power Blazer Multiservice Test Module		• ▲		•
FTB-88100NGE/88100G Power Blazer Multiservice Test Modules		▲		•

▲ = FTB-2 Pro

COPPER, DSL AND MULTIPLAY TEST MODULES	FTB-1	FTB-2	FTB-200	FTB-500
FTB-610 Wideband Copper Test Module	•			
FTB-635 Wideband Copper and DSL Test Module	•			

NOTES

NOTES

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