

Optical Link and Network Characterization

Comprehensive Field Test Solutions for High-Speed Fiber Deployments and Upgrades



The growing demand to upgrade and migrate high-speed DWDM transmission systems to 10, 40, or 100 G requires fully characterizing more and more fiber links. The transmission type and associated bit rates as well as equipment-manufacturer specifications increase the complexity of testing these networks and dictate both the type of tests performed and the measurement limits.

Optical link and network characterization requires a comprehensive collection of point-to-point physical-layer optical tests that measure and determine a given optical fiber's quality and potential transmission capability.

Link Characterization

Link characterization measures fiber performance and interconnection quality, such as splices and connectors.

The suite of tests primarily depends on the user's methods and procedures. Tests can be performed unidirectionally or bidirectionally and can comprise some or all of these measurements for the required test parameters.

| Test Parameters | Measurement Tools |
|-------------------------------------------------|-------------------------------|
| Connector inspection | Video inspection scope |
| Insertion loss (IL) measurements | IL measurement tool |
| Distance measurements (fiber length) | OTDR |
| Connectors/splice measurements | OTDR |
| Reflectance measurements | OTDR |
| Optical return loss (ORL) measurements | ORL measurement tool |
| Polarization mode dispersion (PMD) measurements | PMD analyzer |
| Chromatic dispersion (CD) measurements | CD analyzer |
| Attenuation profile (AP) measurements | Spectral attenuation analyzer |

Network Characterization

Network characterization provides the network's baseline measurements before turning up the transmission system. Measurements are performed through the optical amplifiers, dispersion compensators, and any other inline elements. It offers a limited suite of tests compared to those for link characterization.

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| Polarization mode dispersion (PMD) measurements | PMD analyzer |
| Chromatic dispersion (CD) measurements | CD analyzer |
| Attenuation profile (AP) measurements | Spectral attenuation analyzer |

Link and network characterization measurements are performed during the fiber installation, final commissioning, upgrades, and maintenance. If one or more of these measurements falls outside the defined thresholds (either those from international standards or from the operators/equipment manufacturers), the network will not work properly and cannot be upgraded for higher-bit-rate transmission.



JDSU link characterization solution with T-BERD/MTS-8000 and its suite of fiber test modules

Link Characterization Solution

The Power of One Performing the Work of Many

Technicians need the right tools to carry out complete link characterization. Optimal field solutions like the T-BERD®/MTS-8000 (V2) test platform combine all the necessary test applications into one portable lightweight, battery-operated shock-proof test platform, making it the ideal solution for field-use link characterization.

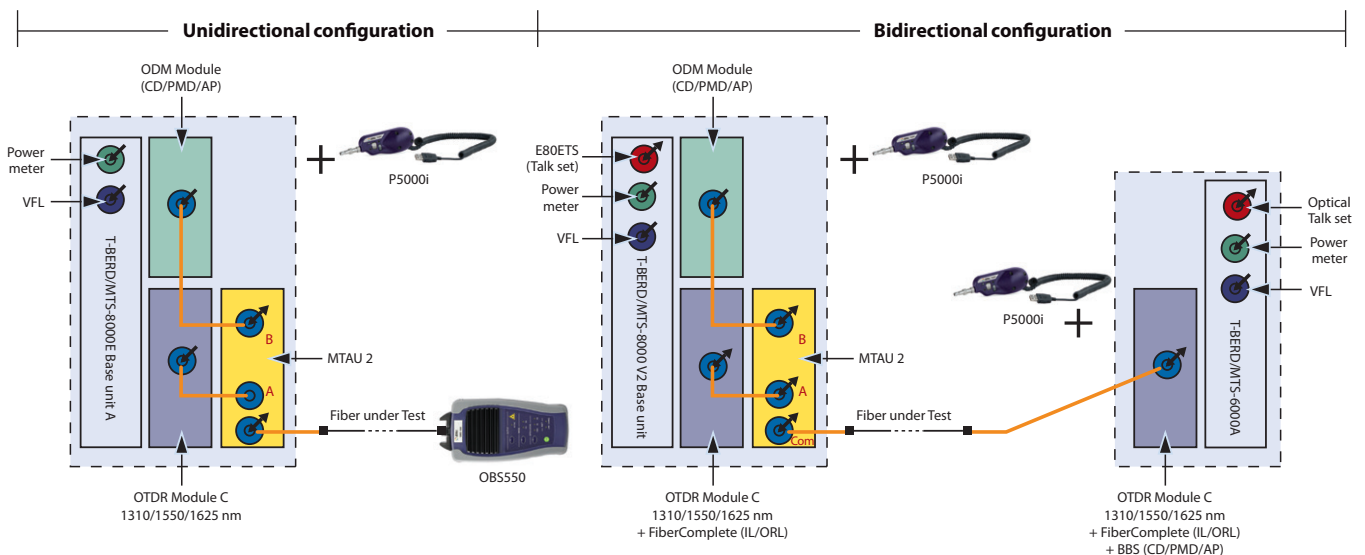
Only the JDSU T-BERD/MTS-8000 includes all of these required tests in one solution.

- Performs OTDR+IL/ORL+CD+PMD+AP in the same test sequence
- Most compact link characterization solution available
- Integrated connector inspection with digital video-inspection scope
- Communicate during testing: Use the built-in talk-set option on dark fiber to talk and transfer data.

Reduce Handling Time and Risk for Errors: The One-Connect Solution

JDSU innovatively incorporates a multi-test access module (MTAU) with application modules and automated test sequences to completely automate the test process for more comprehensive link characterization. This strategy lets technicians test faster and easier with increased productivity and consistency, job to job and technician to technician.

- The MTAU interconnects all test modules to the fiber under test.
- Connect only one fiber per end to run the complete test suite.
- Reduces handling time and risk for error.
- Total test time: Less than 4 minutes per fiber for IL/OTDR, PMD, CD, and AP.



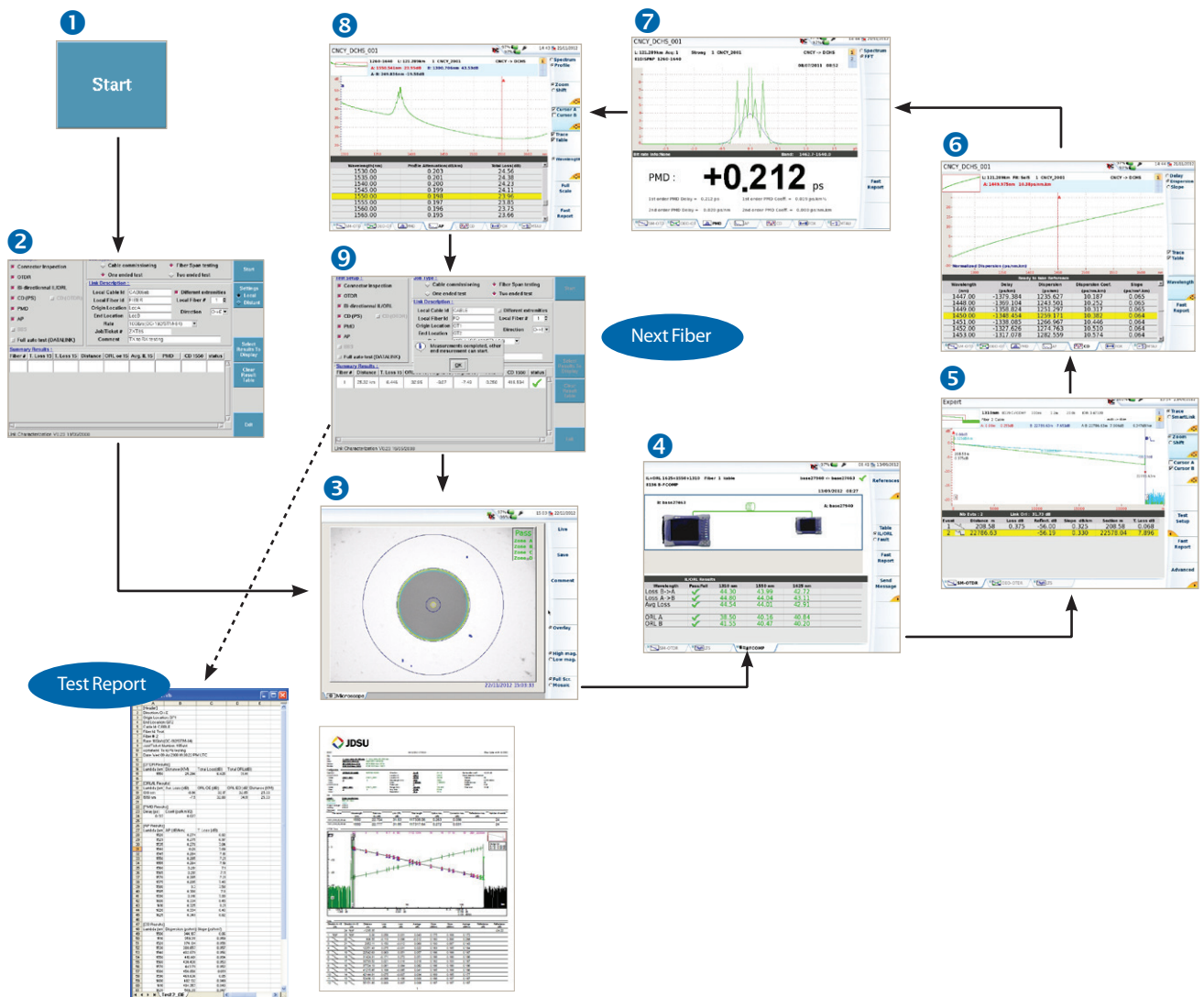
The innovative JDSU multi-test access unit connection schematic showing the relevant link characterization test functions

Automated Fiber Characterization Test Sequence

Combined with the MTAU module, this innovative and powerful solution gives technicians a superior tool for performing their job efficiently and consistently because of its

- automated one-button testing
- step-by-step fiber characterization process
- online and instant report generation
- advanced characterization features for complex testing situations
- proven ability in any test scenario and for any technician's skill level.

It automatically saves all test results in one directory, eliminating the need for technician intervention, and it generates a summary of results at the end of each test sequence for quick PASS/FAIL analysis. In addition to graphic results in industry-standard formats, it also generates a text file which includes all test results (loss, ORL, CD, PMD, and AP) in a pre-defined tabular format.



Automated step-by-step fiber characterization test process and summary report generation

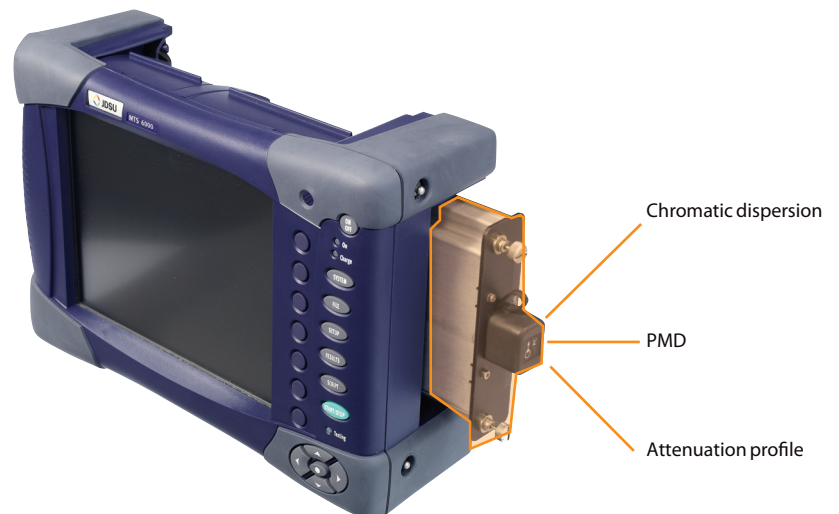
Network Characterization Solution

Characterizing a Fiber Network with In-Line Optical Network Elements

Characterizing a complete fiber network requires using measurement methods that allow testing through active network elements such as amplifiers and dispersion compensators.

The JDSU T-BERD/MTS-8000 or T-BERD/MTS-6000A uses both the high-performance Optical Dispersion Measurement (ODM) module and broadband source to validate baseline optical network performance before turning up the transmission network.

- Performs CD, PMD, and AP tests with active network elements in-line
 - measures through amplifiers
 - qualifies and validates the dispersion compensating fibers in place
- Measures end-to-end CD to validate implementation of the correct amount of compensation
- Measures end-to-end PMD to verify that performance, including active network elements, remain within maximum PMD operational limits
- AP testing confirms proper optical amplifier allocation and verifies overall loss characteristics over the entire network operating wavelength range.



JDSU network characterization solution with T-BERD/MTS-6000A and ODM module

Link and Network Characterization Test Summary

Even with a complete fiber characterization testing suite that includes all the aforementioned measurements, test scenarios can vary from one operator to another, depending on the link or network qualification required or the methods and procedures in place.

| | Connector Inspection | IL/ORL | OTDR | CD | PMD | AP | Multi-Test Access Switch |
|--------------------------------------------------------------------------------|----------------------|--------|------|----|-----|----|--------------------------|
| Installing New Fiber Links (10 G+) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Planning/Upgrading an Existing Fiber Plant (10 G+) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Maintaining Fiber Networks | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Characterizing Terrestrial Networks (Test through amplifiers, CD compensators) | ✓ | | | ✓ | ✓ | ✓ | |
| Characterizing Submarine Networks (Test through amplifiers, CD compensators) | ✓ | | | ✓ | ✓ | ✓ | |
| Characterizing Aerial Links | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

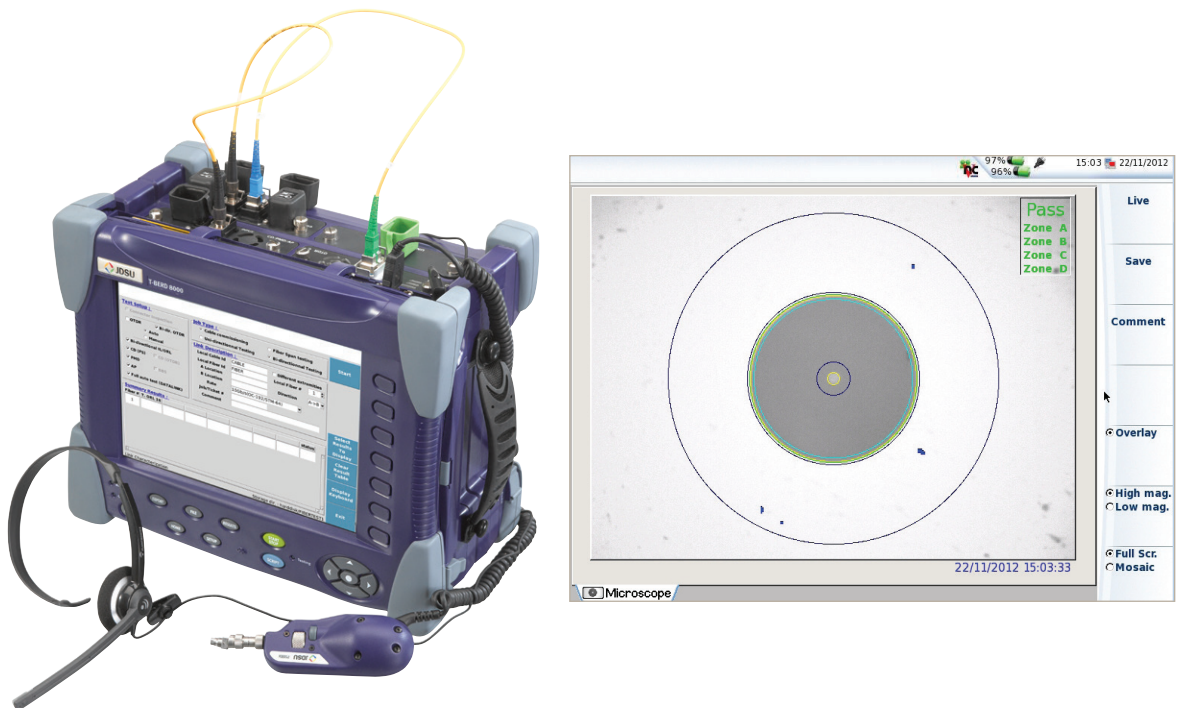
Table 2. Link and network characterization test summary

Connector Inspection

The most frequent type of network failure occurs when conducting link characterization measurements and is caused by handling the actual fiber connections. All connectors must be properly and proactively inspected and cleaned before they are connected. Connectors are the only elements that can be easily disconnected and, therefore, can become contaminated with dirt or debris upon reconnection, which causes more than 80 percent of the optical link/system failures.

Technicians can use the JDSU T-BERD/MTS test platforms to inspect the connector surface using a video inspection scope that plugs in and operates through a USB interface. An on-screen digital high-resolution image display lets technicians perform PASS/FAIL analysis as needed.

- Video inspection probe for bulkhead and patch-cord connectors
- Alternate between 200x and 400x magnification
- Auto-center for consistent views of connector end-faces
- Image capture button to take snapshots of connectors without losing focus
- PASS/FAIL analysis as per IEC standard
- Compare up to three images on one screen



JDSU T-BERD/MTS-8000 platform and video scope combination

Conventional Testing

Insertion and Optical Return Loss

Measuring IL is a fundamental and crucial test to perform, because each system transmitter/receiver combination has a minimum power threshold. Exceeding this limit will distort signals (bit errors) or cause receipt failures.

The link's ORL represents the portion of light reflected back to its laser source. It is the ratio between power transmitted and received at the fiber's origin. Reflected light can be caused by such diverse physical phenomena as connector reflections, Rayleigh backscattering, and diffusion. Optical networks are designed to work within certain maximum ORL limits, so it is important for overall ORL values to remain within network specifications.

Optical Time Domain Reflectometry

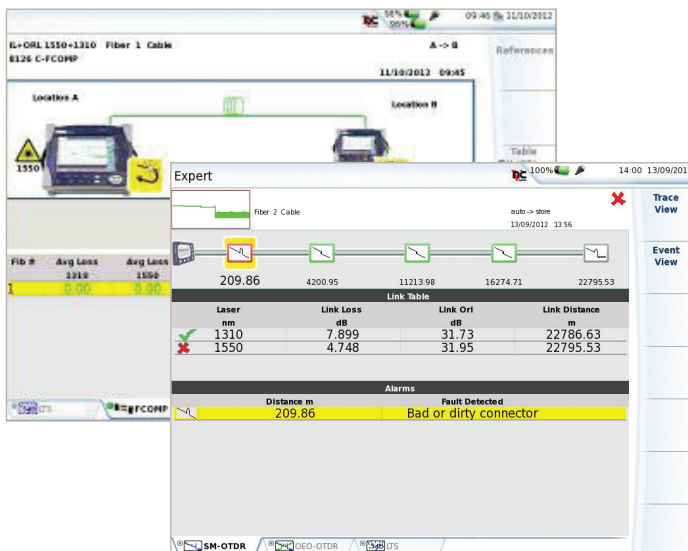
Fiber links are made of sections of fiber-optic cables, which are connected using splices (fusion or mechanical) and connectors. Each section or event must be characterized, called "event characterization," and consists of measuring the section's attenuation, event loss, associated reflectance, and the related distances.

The OTDR is the only instrument that measures splice, connector loss, and reflectance. It obtains the fiber's "signature" with distance and loss/reflectance information for each event along the link.

FiberComplete™ EVO Module with the E81xxx-FCOMP Series

The FiberComplete EVO Module combines a high-precision loss test set, an optical return loss meter, and an OTDR with only one access point and one test sequence into a single module solution for all conventional testing requirements. It can be configured to test in almost any testing combination. FiberComplete comes in two measurement ranges (B- and C-series modules) that let users select the most effective solution for their needs.

It combines large storage with automatic functions, such as auto-lambda and auto-store, to test high-fiber-count cables.



- Single-slot plug-in module measures bidirectional insertion loss, return loss, fiber length, and OTDR
- Test at 1310, 1550, and 1625 nm telecom wavelengths
- One-button automated testing
 - 1-Continuity check
 - 2-Uni or bidirectional IL
 - 3-Uni or bidirectional ORL
 - 4-Length
 - 5-Uni or bidirectional OTDR
 - 6-PASS/FAIL analysis
 - 7-Store IL and ORL test results in both test units

OTDR Module Range with the E8100 EVO Series for Metro, Long-Haul, and Ultra-Long-Haul Networks (B, C, and D Modules)

The E8100 EVO series offers unprecedented levels of speed, processing power, resolution, and dynamic range. Extremely short dead zones down to 0.5 m can be used to pinpoint faults close to cable junctions or splice points. An outstanding dynamic range in excess of 50 dB enables testing even the longest fiber spans. Also, users can characterize fiber with the highest precision possible.

- Short haul to ultra-long haul
- 2, 3, 4 wavelengths per module (1310/1383/1490/1550/1625 nm)
- Multimode, single-mode modules
- Very short dead zones (down to 0.5 m event dead zone and 2 m attenuation dead zone)
- Alarm management with PASS/FAIL analysis
- Smart Link Mapper linear trace view



OTDR module



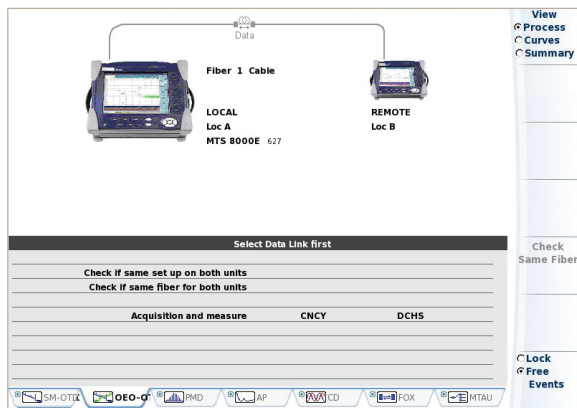
Bidirectional OTDR Measurement Function

Users can conduct OTDR measurements in both fiber link directions. It calculates the average loss for each splice/connector to measure the “true” loss. This removes possible differences in backscattering coefficients between fiber sections driving to incorrect loss or even unrealistic “gainers.” This capability is even more important if the link contains different fiber types from various manufacturers. This process is known as “bidirectional OTDR testing.”

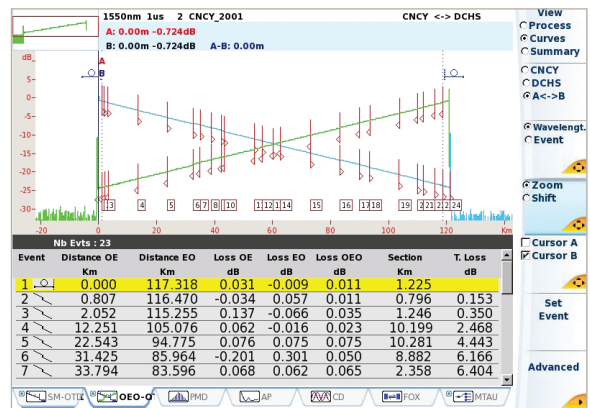
The Ideal End-to-End Solution

JDSU has developed and integrated an innovative automatic bidirectional analysis function directly into the T-BERD/MTS-8000 and -6000 platforms, saving up to more than 70 percent of the time required with traditional bidirectional analysis. Both end-units communicate with each other enabling the coordination of settings and test sequences. Result files are then transferred for immediate analysis.

- Automate the acquisition process
- Check fiber continuity
- Eliminate operator error by using the same setup
- Transfer files through the fiber
- Immediately align traces with the correct parameters
- Obtain true splice loss with both-end analysis



Settings synchronization and continuity check



Both end-results transfer for instantaneous analysis

Dispersion and Advanced Testing

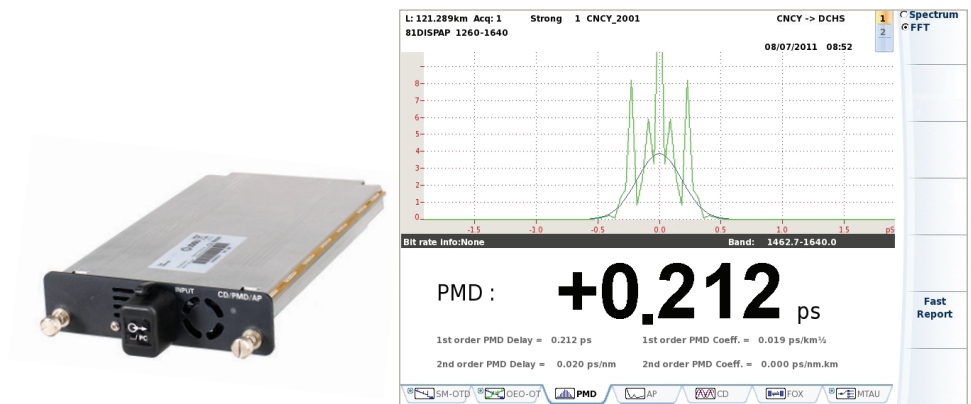
Polarization Mode Dispersion

Polarization mode dispersion (PMD) is caused by the birefringence (double refraction) in a fiber that is not perfectly circular, or one that has suffered external stresses, such as bending, twisting, or temperature variations. The difference between the indexes of the two opposing modes creates a time delay that broadens the transmission pulse as it travels along the fiber. PMD is the most complex phenomenon to deal with as it varies randomly with time. Moreover, it is essential to have an idea of the magnitude of PMD in order to determine the actual limits of transmission systems.

PMD and ODM Modules for High-Performance PMD Testing

There are different test methods for measuring PMD in the field. The Fixed Analyzer method is the most relevant and flexible and the module can be manufactured without moving parts, increasing robustness and durability. The combination of the PMD module and the handheld OBS-55 provides technicians a PMD test-point solution. The handheld OBS-500/550 or the broadband source modules combined with the CD and AP tests in the ODM modules are ideal solutions for complete dispersion testing.

- The Fixed Analyzer PMD method combines performance, robustness, and durability
- Quickly and accurately measures PMD delay, PMD coefficient, and second-order values
- The most compact PMD test solution
- Shock- and vibration-proof design (with no moving parts)
- Measures through multiple amplifiers
- High-performance 0.08 ps min PMD measurement capability with up to 65 dB dynamic range



Dispersion module with PMD results

Chromatic Dispersion Testing

Chromatic dispersion (CD) describes the spreading of color-dependent light as it propagates or pulses down a fiber wavelength. Variations in the pulse through spreading can cause the different light waves (colors) to travel at different speeds within the medium resulting in errors and information loss.

Medium-Range ODM for Metro Networks and ODM for Long-Haul and Ultra-Long-Haul Networks

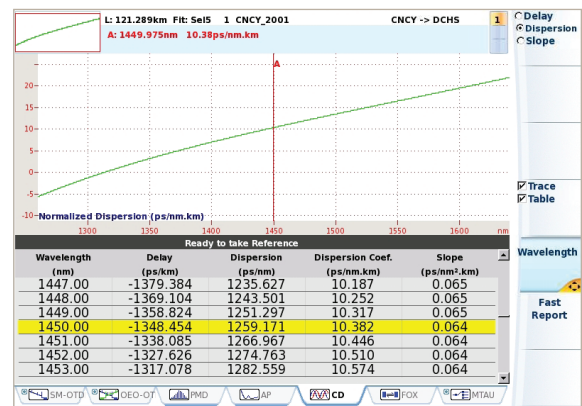
The chromatic dispersion test is performed over a given wavelength range with correlated results to the transmission system limits according to the implemented bit rates.

The JDSU phase-shift method with the ODM solutions measures CD. The measurement module is used at one end of the fiber in conjunction with a broadband source (OBS-500/550 or integrated broadband source modules) at the other end.

- Fast, accurate, and flexible phase shift method
- The only full-band CD analyzer with measurement points in the 1260 to 1460 nm bands
- Most compact CD/PMD module available
- Fast CD acquisition time (from 10 s)
- Test through non-bidirectional components, such as EDFAs and filters)
- Reference internal/online wavelengths
- Uses a plug-in module or handheld broadband source at the far end



ODM module



Attenuation Profile or Spectral Attenuation Testing

Every fiber presents varying levels of attenuation across the transmission spectrum. The purpose of measuring the attenuation profile (AP) is to characterize and measure the wavelength attenuation.

Historically, this measurement was required primarily for long-haul applications. However, increased CWDM deployments and extended DWDM wavelength ranges require a clear picture of the fiber's AP to evaluate its suitability for such applications.

The Only Full-Band Attenuation Profile Analyzer

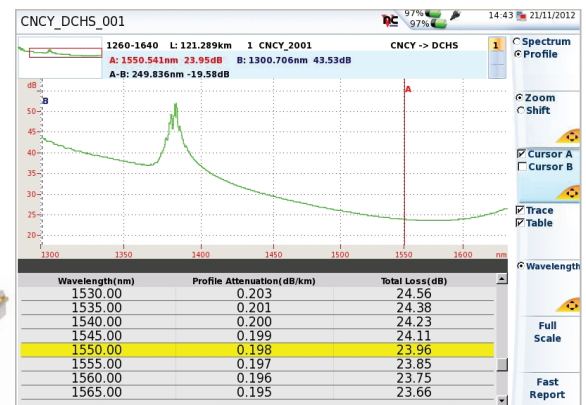
Several methods can be used to measure the attenuation profile, which is highly related to DWDM/CWDM installation. Therefore, using a spectral analysis solution offers the best tool for characterizing fiber and performing system verification tests.

The JDSU Attenuation Profile field test analyzer solution (medium- and long-range ODM modules) offers unprecedented performance that sets it apart as the first of its kind.

- dB/km over the full 1260 to 1640 nm wavelength range
- Covers the full CWDM and DWDM transmission band
- Water peak (1383 nm area) characterization
- Accelerate measurements with simultaneous wavelength testing
- High dynamic range (65 dB) and low uncertainty (0.003 dB/km)



ODM module showing AP result



Additional Products and Test Tools

Broadband Sources for CD, PMD, and AP Tests

Not only does the handheld Broadband Source solution support DWDM component qualification, it also conducts physical layer tests, including CD, PMD, and AP measurements.

Optimized for field CD, PMD, and AP applications, the portable OBS-500/550 with its long battery life perfectly complements the ODM modules.

The integrated broadband source modules can be plugged into the T-BERD/MTS-8000 or -6000 test platforms for a remote all-in-one solution (for example, adding an OTDR or FiberComplete).

- Unique set of PMD, CD, and AP test functions in one solution
- Shock- and vibration-proof instrument with no moving parts
- High-performance instrument with high dynamic range and accuracy



Broadband sources: Handheld and plug-in module configurations

Optical Talk Set

The built-in talk set option for the T-BERD/MTS platforms facilitates communication between both ends of the fiber link during testing. Users can also remotely control the far-end unit to automate test sequences or to transfer results for immediate analysis.

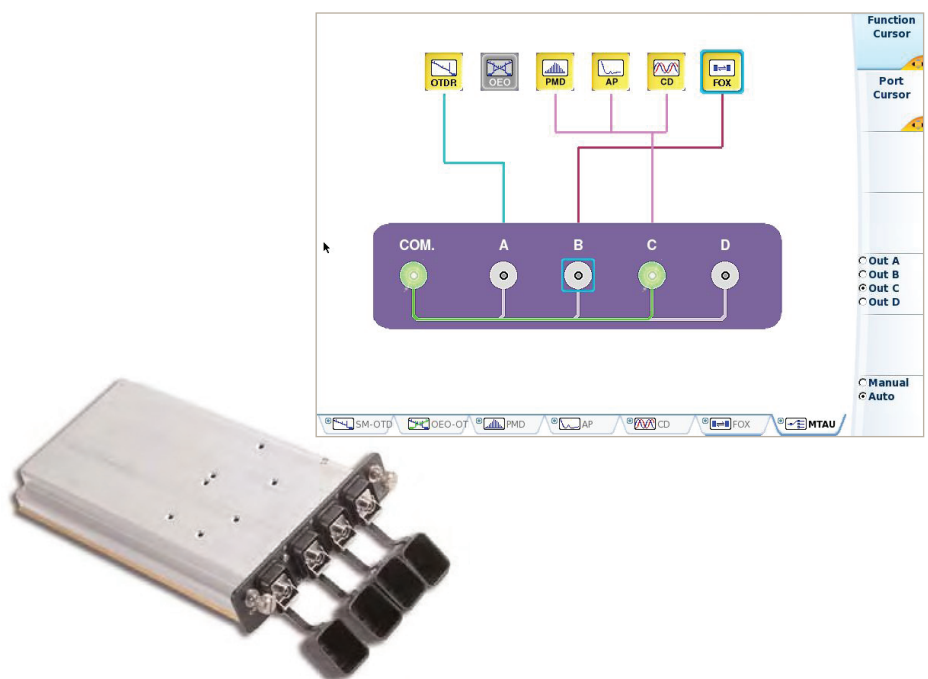
Multi-Test Access Unit Module

Fiber link or network characterization consists of performing a sequence of functional tests normally conducted using several test modules, connecting and disconnecting the fiber, and changing the test settings each time. Performing this task manually is a complex, time-consuming process that increases fiber handling and presents a greater risk for errors and test inconsistencies.

The E81MTAUx is available in two configurations. The 1x2 configuration for use with our new fiber characterization packages integrates FiberComplete into the test sequence. It is highly efficient and uses only one switch on the primary test side. The 1x4 configuration can integrate more test modules similar to our legacy fiber characterization kits.

The E81MTAU switches fully integrate the otherwise complex process of connecting and disconnecting fiber to complete the test suite in a matter of minutes.

- Simplifies fiber characterization and fiber commissioning (OTDR and IL)
- Cuts fiber characterization time in half
- Integrates up to six test functions (IL, ORL, OTDR, CD, PMD, AP)
- Reduces fiber connects/disconnects
- Connects up to four modules
- Automatically switches from one test module to another



MTAU optical switch and graphical interface

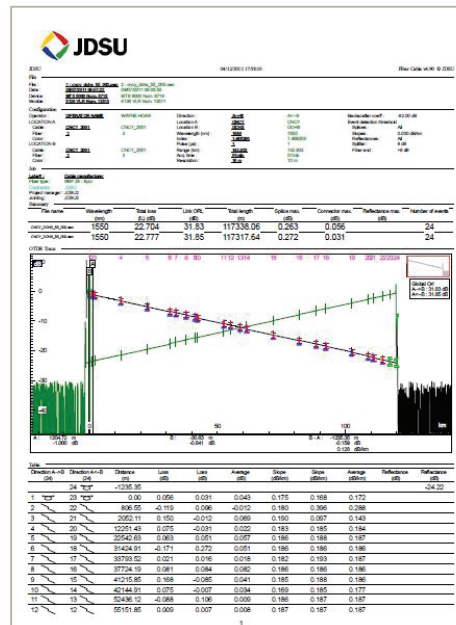
Post-Process and Document Field Measurements

OFS-100 FiberTrace Post-Processing and Measurement Report

- IL/ORL, OTDR, CD, PMD, AP, and OSA results analysis
- Automated batch processing capability
- PASS/FAIL function
- Customize printouts
- Generate a report for a single fiber

OFS-200 FiberCable Link/Network Characterization Report Generation

- Direct access keys simplify the process and increase efficiency
- Complete fiber characterization reporting capability includes bidirectional IL, ORL, OTDR, CD, PMD, and AP results
- Advanced OTDR functions for loopback and mid-point management
- Powerful report preview avoids processing errors
- Generate a report for multiple fibers



Test report example

JDSU Link Characterization Test Kits



T-BERD/MTS-8000



T-BERD/MTS-6000A



OBS-500/550

| Description | Part Number |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| Unidirectional automated link characterization kit T-BERD/MTS-8000 test platform equipped with: <ul style="list-style-type: none"> • Inspection scope with PASS/FAIL analysis • OTDR module B at 1310/1550 nm • Medium-range CD, PMD, and AP dispersion tests • 1x2 optical switch module • Handheld broadband source • Carrying case with lid organizer • Accessories: keyboard, test patch cords, quick cards | TB8000-FC1-B2E MTS8000-FC1-B2E |
| Unidirectional automated link characterization kit with T-BERD/MTS-8000 test platform equipped with: <ul style="list-style-type: none"> • Inspection scope with PASS/FAIL analysis • OTDR module B at 1310/1550/1625 nm • Medium-range CD, PMD, and AP dispersion tests • 1x2 optical switch module • Handheld broadband source • Carrying case with lid organizer • Accessories: keyboard, test patch cords, quick cards | TB8000-FC1-B3E MTS8000-FC1-B3E |
| Unidirectional automated link characterization kit with T-BERD/MTS-8000 test platform equipped with: <ul style="list-style-type: none"> • Inspection scope with PASS/FAIL analysis • OTDR module C at 1310/1550/1625 nm • Long-range CD, PMD, and AP dispersion tests • 1x2 optical switch module • Handheld broadband source • Carrying case with lid organizer • Accessories: keyboard, test patch cords, quick cards | TB8000-FC1-C3E MTS8000-FC1-C3E |
| Bidirectional automated link characterization kit with: <ul style="list-style-type: none"> 1x T-BERD/MTS-8000 test platform equipped with: <ul style="list-style-type: none"> • Inspection scope with PASS/FAIL analysis • FiberComplete module B at 1310/1550/1625 nm • Medium-range CD, PMD, and AP dispersion tests • 1x2 optical switch module • Carrying case with lid organizer • Accessories: keyboard, test patch cords, quick cards 1x T-BERD/MTS-6000A platform equipped with: <ul style="list-style-type: none"> • Inspection scope with PASS/FAIL analysis • FiberComplete module C at 1310/1550/1625 nm + broadband source) • Carrying case with lid organizer • Accessories: test patch cords, quick cards | TB8000-FC2-B3E |
| Bidirectional automated link characterization kit with: <ul style="list-style-type: none"> 1x T-BERD/MTS-8000 test platform equipped with: <ul style="list-style-type: none"> • Inspection scope with Pass/Fail analysis • FiberComplete module C at 1310/1550/1625 nm • Very long-range CD, PMD and AP dispersion tests • 1x2 optical switch module • Carrying case with lid organizer • Accessories: keyboard, test patch cords, quick cards 1x T-BERD/MTS-6000A platform equipped with: <ul style="list-style-type: none"> • Inspection scope with PASS/FAIL analysis • FiberComplete module C at 1310/1550/1625 nm + broadband source) • Carrying case with lid organizer • Accessories: test patch cords, quick cards | TB8000-FC2-C3E MTS8000-FC2-C3E |
| T-BERD/MTS-6000A test platform equipped with: <ul style="list-style-type: none"> • Medium-range CD, PMD, AP dispersion tests • Handheld light source for the far end • Carrying case with lid organizer • Accessories: keyboard, test patch cords, mouse, quick cards | TB6000-NC1-MR MTS6000-NC1-MR |
| T-BERD/MTS-6000A test platform equipped with: <ul style="list-style-type: none"> • Medium-range CD, PMD, AP dispersion tests • Handheld light source for the far end • Carrying case with lid organizer • Accessories: keyboard, test patch cords, mouse, quick cards | TB6000-NC1 MTS6000-NC1 |

Network and Service Enablement Regional Sales

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