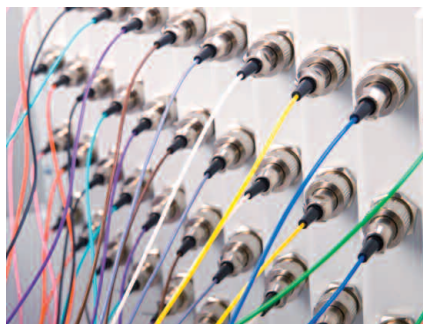


## Optical Link and Network Characterization Solutions



The growing demand for 10 Gigabit Ethernet (GigE) and 10 Gb/s synchronous optical network/synchronous digital hierarchy (SONET/SDH) systems and the emergence of 40G increases requirements for fully characterizing fiber links. The various transmission types, associated bit rates, and equipment manufacturer specifications add to the complexity of testing these networks, because they dictate the type of tests to perform as well as the measurement limits considered. Optical link and network characterization cannot be performed simply with one test function. Rather, it is a comprehensive collection of point-to-point, physical-layer optical tests that measure and determine the quality and potential transmission capacity of an optical fiber.

### Link Characterization

Link characterization measures fiber performance and the quality of its interconnections, such as splices or connectors.

The suite of tests used primarily depends upon the user's methods and procedures, which could be unidirectional or bidirectional and could comprise some or all of the following measurements covering the required parameters.

### Network Characterization

Network characterization provides the baseline measurements for the network before turning up the transmission system. Measurements are performed through the optical amplifiers, dispersion compensators, and any elements in line. There is a limited suite of tests compared to the ones done for link characterization.

### Measurement Steps and Limits

Link and network characterization measurements are performed during fiber installation, final commissioning, upgrades, and maintenance. If one or more measurements are not in accordance with defined thresholds (provided by either international standards or the operators/equipment manufacturers), the network will not function properly or cannot be upgraded to high bit rate transmission.

Test Parameters	Measurement Tools
Connector Inspection	Video Inspection Scope
IL Measurement	OFI Module
Distance Measurement (Fiber length)	OTDR Module
Connectors/Splice Measurements	OTDR Module
Reflectance Measurements	OTDR Module
ORL Measurements	OFI Module
PMD Measurements	PMD Analyzer
CD Measurement	CD Analyzer
AP Measurements	Spectral Analyzer

Test Parameters	Measurement Tools
Connector Inspection	Video Inspection Scope
PMD Measurements	PMD Analyzer
CD Measurement	CD Analyzer
AP Measurements	Spectral Analyzer

Bit Rate Per Channel	SONET /SDH	PMD Delay Limit (ps)	Maximum CD at 1550 nm (ps)
2.5 Gb/s	OC-48/STM-16	40	18,000
10 Gb/s	OC-192/STM-64	10	1176
40 Gb/s	OC-768/STM-256	2.5	74
10 GigE	—	5	735

Main dispersion thresholds according to transmission rates (non-return to zero [NRZ] coding format).

## Link Characterization Solution

### The Power of One Performing the Work of Many

To perform complete link characterization, technicians need a field solution that combines various test equipment into one platform that is battery operated, portable, lightweight, and shock-proof. The JDSU T-BERD®/MTS-8000 test platform provides the ideal solution for performing link characterization in the field.

The JDSU T-BERD/MTS-8000 provides a unique solution that includes all of the required test tools in one single platform.

- OTDR+IL/ORL+CD+PMD+AP simultaneously
- Most compact link characterization solution on the market
- Connection check capability with video inspection scope
- Speak while you test: use the built-in talk set option on a dark fiber to talk and transfer data

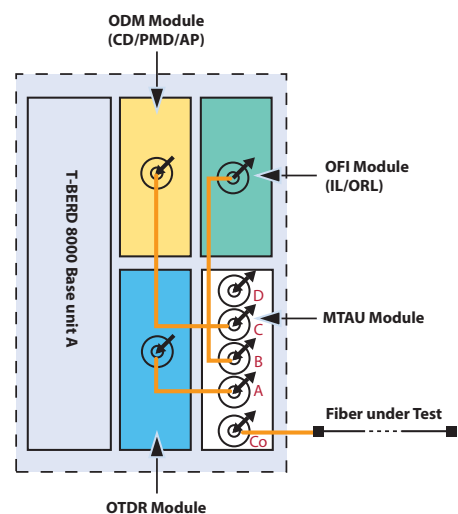
### Reduce Handling Time and Risk of Errors: The One-Connect Solution

Combine the JDSU innovative solution of the Multi-Test Access Module (MTAU) with the automated test sequence to the T-BERD/MTS-8000 for a complete fiber link characterization configuration that makes your job easier, more productive, and more consistent.

- Interconnect the MTAU with all test modules
- One fiber connection completes a suite of tests
- Reduce handling time and risk of errors
- Total test time: Less than 3.5 minutes per fiber to complete IL/ORL, OTDR, PMD, CD, and AP



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



Schematic of the innovative JDSU Multi-Test Access Unit connection to the relevant link characterization test functions

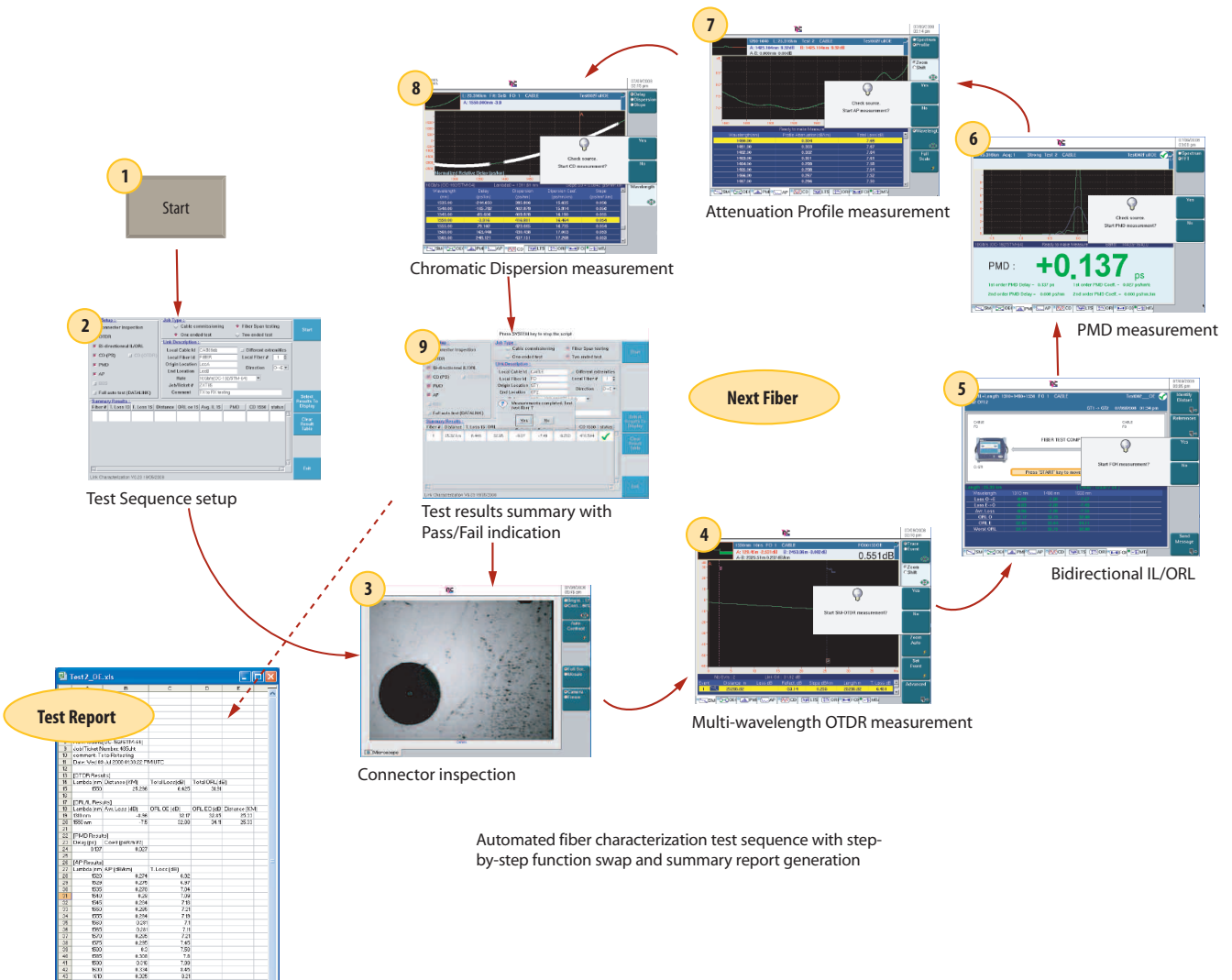
### Automated Fiber Characterization Test Sequence

Combined with the MTAU module, the innovative and powerful T-BERD/MTS-8000 solution provides technicians with the best tool for performing their job correctly and efficiently.

- Automatic test function for one-button test of individual applications
- Step-by-step fiber characterization process
- Online and dynamic report generation
- Advanced characterization features for complex testing situations
- Proven for any test scenario and any technician skill level

Test results are automatically saved in one directory, requiring no technician intervention.

A summary result is generated at the end of the test sequence to provide quick Pass/Fail analysis. The test set automatically creates a text file which includes all test results (loss, optical return loss [ORL], chromatic dispersion [CD], polarization mode dispersion [PMD], and attenuation profile [AP]) in a pre-defined format.



## Network Characterization Solution

### Characterizing a Fiber Network with All Elements In-Line

Characterizing a complete fiber network requires using measurement methods that can test through the various elements, such as amplifiers and dispersion compensators.

The JDSU T-BERD/MTS-8000 or T-BERD/MTS-6000 and the high-performance Optical Dispersion Measurement (ODM) Module enable technicians to provide network baseline measurements before turning up the transmission system.

- Perform CD, PMD, and AP tests with all network elements in-line
- Perform measurements through amplifiers
- Perform qualification and validation of the existing dispersion compensating fibers
- Perform end-to-end measurement CD test to confirm the correct amount of compensation implemented
- Perform end-to-end PMD measurement to verify the insertion of network elements do not add excessive PMD
- Conduct AP testing to confirm the location of optical amplifiers and verify loss characteristics over wavelength of fiber links



JDSU Network Characterization Solution with  
T-BERD/MTS-6000 and ODM Module

## Link and Network Characterization Test Summary

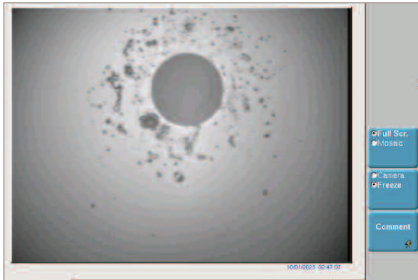
Although a complete fiber characterization suite includes all the aforementioned measurements, test scenarios can vary from one operator to another, depending on the link or network qualification required or the methods and procedures in place. For example, an adequate procedure may consist of only optical time domain reflectometry (OTDR), CD, and PMD. See the Link and network characterization test summary table below.

	Connector Inspection	IL/ORL (OFI Module)	OTDR Module Range	CD (ODM Module)	CD (OTDR Module)	PMD (ODM Module)	AP (ODM Module)	Multi Test Access (MTAU Module)
New Metro Link Installation (10G+)	✓	✓	✓	✓	✓	✓	✓	✓
New Long-Haul Link Installation (10G+)	✓	✓	✓	✓		✓	✓	✓
New Ultra-Long-Haul Link Installation (10G+)	✓	✓	✓	✓		✓	✓	✓
Planning/Upgrading Existing Fiber Plant (10G+)	✓	✓	✓	✓		✓	✓	✓
Fiber Network Maintenance	✓	✓	✓	✓		✓		✓
Metro, Long-Haul, and Ultra-Long-Haul Network Characterization (Amplifiers, CD Compensators, and ROADMs)	✓			✓		✓	✓	
Submarine Network Characterization (Amplifiers, CD Compensators)	✓			✓		✓	✓	
Aerial Link Characterization	✓				✓	✓		

Table 1. Link and Network Characterization Test Summary

## 6

## Connector Inspection



### Dirt is everywhere

For example, it is airborne, on hands, bulkhead adapters, and dust caps

### Dirt damages fiber

Mating dirty connectors embeds the debris into the glass

Frequently, problems that occur during link characterization measurement occur because of the fiber connectors themselves. Connectors must be properly cleaned, and their cleanliness must be verified prior to use. Because connectors are the only elements that can be easily disconnected they are often subjected to dirt or scratches prior to reconnection, which accounts for the occurrence of more than 80 percent of the link/system failures.

The JDSU T-BERD test platforms offer technicians the ability to inspect the connector surface. They support video inspection scope plug-in and operation, display the connector images, and perform online comparisons during the cleaning process (before and after).

- Video inspection probe for bulkhead and patchcord connectors
- 200x and 400x magnification switching capabilities
- Image capture button for connector snapshot without losing focus
- Uses T-BERD/MTS-8000 large screen (10.4 in)
- Allows image freezing
- Stores and reloads images
- Compare up to 4 images on the same screen



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

## Conventional Testing

### Insertion Loss and Optical Return Loss

Insertion loss (IL) measurements are crucial tests to perform, as each combination of system transmitter/receiver has a power range limit beyond which it distorts signals or prevents them from being transmitted.

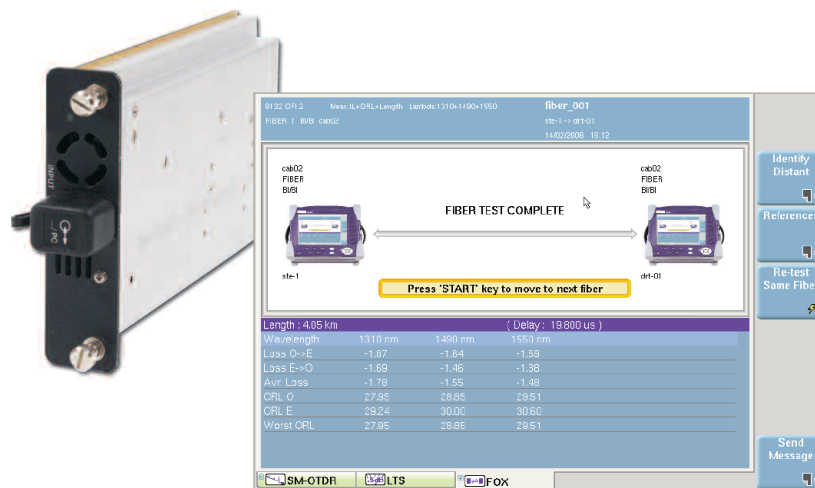
A link's ORL represents that portion of light that is reflected back toward the laser source represented as a ratio between the power transmitted and that received at the fiber's origin. Various physical phenomena can cause the laser source to reflect, such as reflections on connectors, Rayleigh back-scattering, or diffusion.

### Multi-Function Loss Test Module with the E81xxOFI Series

The Multi-function Loss Test Module combines a high-precision loss test set and an ORL meter, which enables performing bidirectional IL and ORL tests on all wavelengths in one automated test sequence.

A combination of large storage and automatic functions, such as auto-lambda and auto-store, facilitates testing cables with high fiber counts.

- Single-slot plug-in module for bidirectional IL, return loss (RL), and fiber length measurements
- Testing at telecom wavelengths: 1310, 1550, and 1625 nm
- One-button automated testing
- Continuity check
- Automated bidirectional IL
- Automated bidirectional ORL
- Length testing
- Pass/Fail analysis
- Store complete test results in both test units



## Optical Time Domain Reflectometry

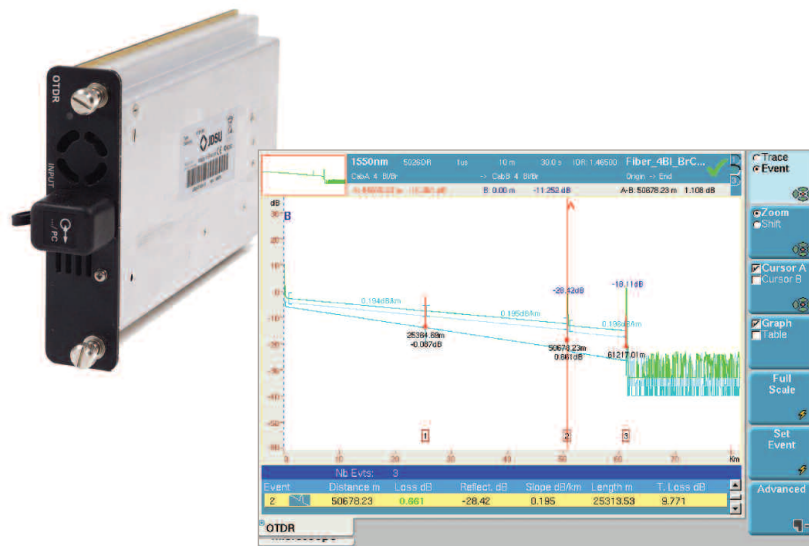
Fiber links are made of sections of fiber optic cables that are connected using splices (fusion or mechanical) and connectors. Each individual section and event must be characterized, which could be called event characterization. That consists of measuring the attenuation of the fiber section, loss of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

The OTDR is the only instrument capable of measuring splice and connector loss and reflectance. It obtains the signature of the fiber with distance and loss/reflectance information for each individual event present along the link.

### OTDR Module Range with the E8100 Series for Metro, Long-Haul, and Ultra-Long-Haul Networks (MR, LR, VLR, and UHD)

The E8100 Series provides unprecedented levels of speed, processing power, resolution, and dynamic range. Use extremely short dead zones, down to 0.8 m, to pinpoint faults close to cable junctions or splice points. An outstanding dynamic range in excess of 50 dB at 1550 nm indicates that even the longest spans of fiber can be tested. The fiber is characterized 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 (up to 0.8 m event dead zone)
- Alarm management with Pass/Fail analysis





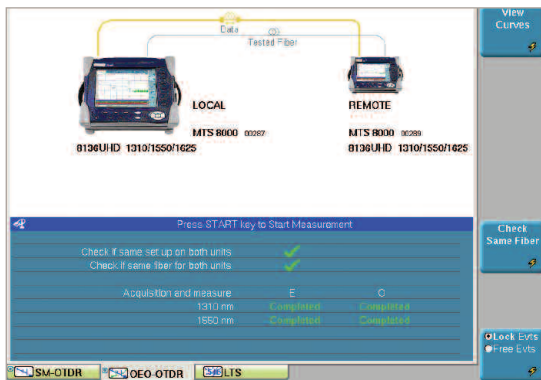
## Bidirectional OTDR Measurement Function

The OTDR measurements are performed in both directions of the fiber link and the average loss calculated for each splice/connector to measure the true loss. This calculation removes possible differences in backscattering coefficients between fiber sections driving to incorrect loss or even, unrealistic gains. This capability is even more important when links contain different fiber types or with fibers from various manufacturers. This process is known as bidirectional OTDR testing.

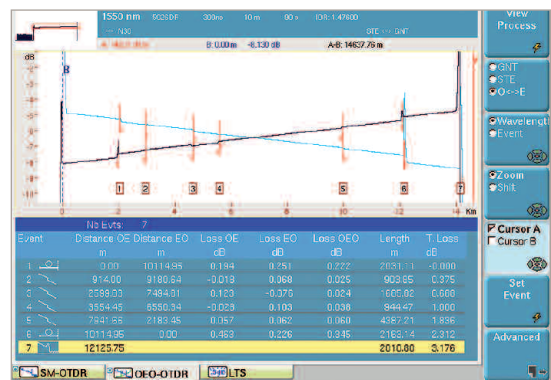
### The Ideal End-to-End Solution

JDSU has developed and integrated an innovative automatic bidirectional analysis function directly into the T-BERD/MTS platforms, saving at least 70% of the time required with traditional bidirectional analysis: Both end units communicate to each other enabling coordination of settings and test sequence. Result files are then transferred for immediate analysis.

- Automate the acquisition process
- Check fiber continuity
- Eliminate operator error by using the same setup
- File transfer through the fiber
- Immediate trace alignment with the correct parameters
- True splice loss with both-end analysis



Settings synchronization and continuity check



Both-end results transfer an instantaneous analysis

## Dispersion and Advanced Testing

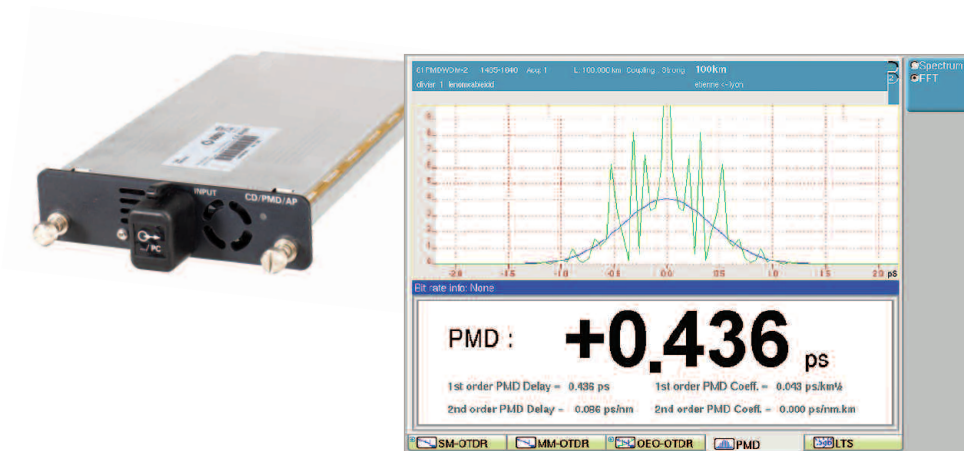
### Polarization Mode Dispersion

Birefringence, or double refraction, causes PMD 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 causes the transmission pulse to broaden when traveling along the fiber. PMD is the most complex phenomenon to manage as it varies randomly with time. Moreover, it is essential to know the magnitude of PMD to determine the actual limits of transmission systems.

### E81PMD and E81DISPAP Modules for High-Performance PMD Testing Based on the Fixed Analyzer Method

Various test methods are employed to measure PMD in the field. The most relevant and flexible method is the Fixed Analyzer solution, which can be manufactured without moving parts for better robustness and durability. Combining the E81PMD Module with the handheld OBS-55 gives technicians a PMD test point solution. For complete dispersion testing with the addition of CD test, the E81DISPAP and the handheld OBS-500/550 or the E81BBS2A Broadband sources are the solutions of choice.

- Fast, accurate measuring of 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 with 0.08 ps min PMD measurement capability and up to 65 dB dynamic range



## Chromatic Dispersion Testing

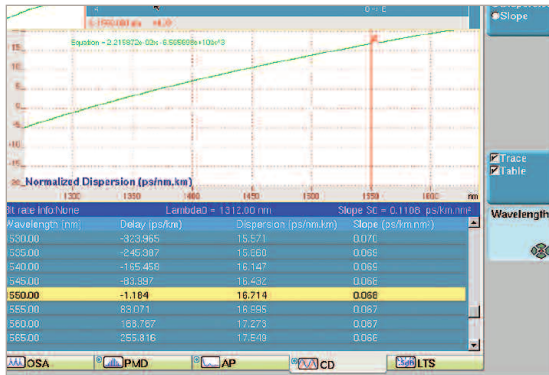
CD occurs because a light pulse is made up of different wavelengths, each traveling at different speeds down the fiber. These different propagation speeds broaden the light pulse when it arrives at the receiver, reducing the signal-to-noise ratio and increasing bit errors.



### E5083CD for Metro Applications and the E81DISPAP or E81CD for Metro, Long-Haul, and Ultra-Long-Haul Networks

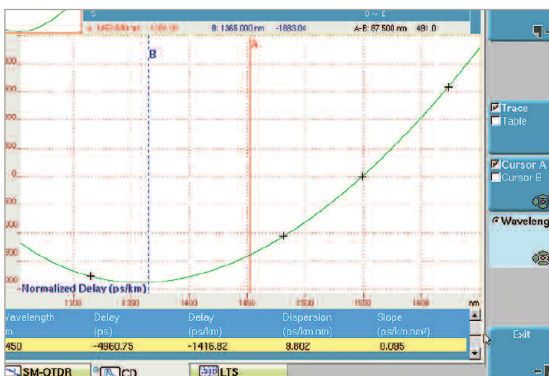
CD is measured over a given wavelength range and results are correlated to the transmission system limits according to the bit rate being implemented.

JDSU offers various test methods: with the E81DISPAP and E81CD providing the Phase Shift method and the E5083CD providing Pulse Delay. Combined with a broadband source (OBS-500/550 or E81BBS2A) at the other end of the fiber, the Phase Shift method is the most flexible and effective. However, the Pulse Delay method requires only one end of the fiber for medium-range applications and can be combined with a multi-wavelength OTDR.



#### Phase Shift Method

- The only full-band CD analyzer with measurement points in the lower bands (1260-1460 nm)
- Most compact CD/PMD module on the market
- Fast CD acquisition time (40 to 80 s)
- Test through non-bidirectional components, such as erbium doped fiber amplifiers (EDFA) and filters
- Internal/online wavelength referencing
- Use of a plug-in or handheld broadband sources at the far end



#### Pulse Delay Method

- Multi-wavelength Pulse Delay measurement method
- Includes acquisition points around 1310, 1480, 1550, and 1625 nm for accurate CD from 1260 to 1650 nm
- Shock- and vibration-proof (with no moving parts)
- Access to only one end of the fiber
- Sectional analysis capability for troubleshooting
- Integrates a four-wavelength OTDR and a light source

### Attenuation Profile (or Spectral Attenuation) Testing

Every fiber presents varying levels of attenuation across the transmission spectrum. The purpose of measuring for AP is to characterize and measure the attenuation as a function of wavelength.

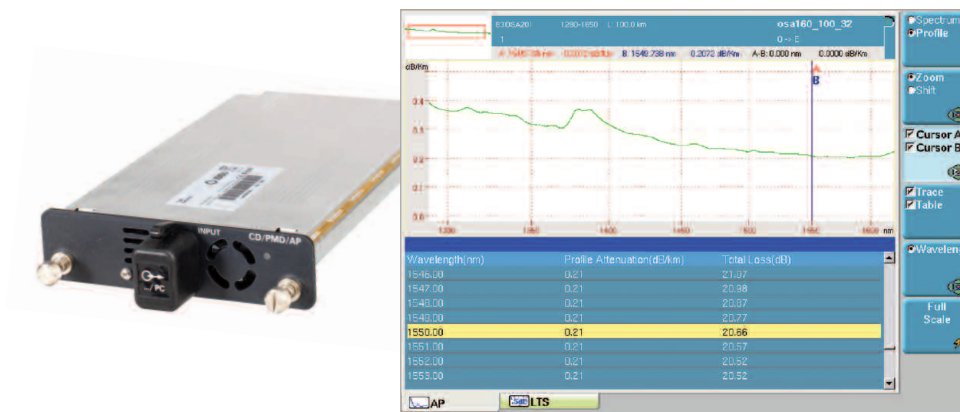
Historically, this measurement was required mainly for long-haul applications. However, as coarse wavelength division multiplexer (CWDM) deployments increase and dense wavelength division multiplexer (DWDM) wavelength ranges are extended, it is necessary to obtain the fiber attenuation profile to evaluate the fiber's suitability for accommodating such applications.

#### E81DISPAP, the Only Full-Band Attenuation Profile Analyzer

There are different methods for measuring the AP. As the measurement is highly related to DWDM/CWDM installation, the use of an OSA provides the best solution for characterizing fiber as well as performing system verification tests.

The JDSU Attenuation Profile solution offers the first true field test analyzer with unprecedented performance, making this the first product of its kind.

- dB loss/km over the full wavelength range: 1260-1640 nm
- Allow CWDM and DWDM transmission band characterization
- Water peak (1383 nm area) characterization
- Fast measurements that test all wavelengths simultaneously
- High dynamic range (65 dB) and uncertainty (0.003 dB/km)



## Additional products and testing tools

### Broadband Sources for CD, PMD, and AP Tests

Not only does the handheld Broadband Source solution support the qualification of DWDM components, but it also provides physical layer testing, including measurements for CD, PMD, and AP.

The OBS-500/550 is optimized for field CD, PMD, and AP applications and offers maximum portability and long battery life. It makes a complementary tool for the E81DISPAP Module.

The E81BBS2A Broadband Source Module can plug into the T-BERD/MTS test platform to offer an all-in-one solution for the remote product, such as an addition to the OTDR. It provides the only full band (1260-1640 nm) wavelength range for all-wave CD, PMD, and AP fiber qualification.

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



### Optical Talk Set

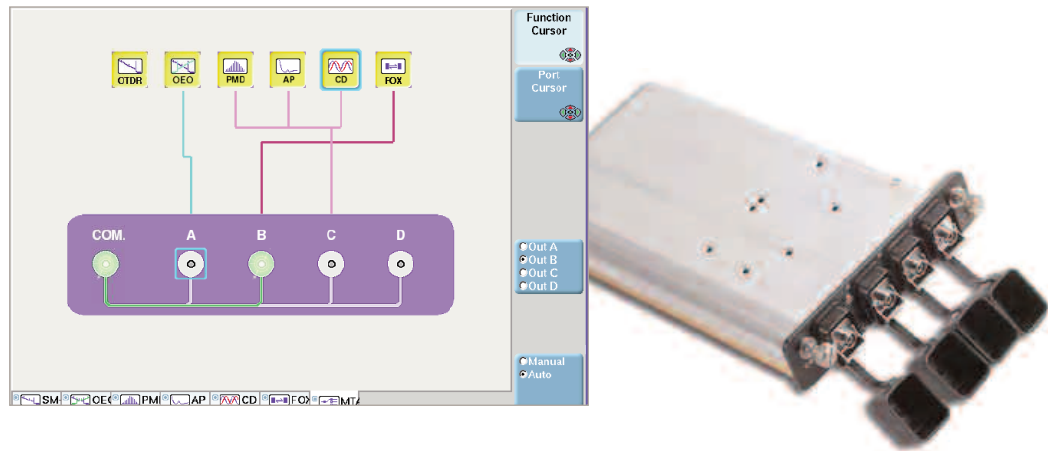
The T-BERD/MTS platforms offer a built-in Talk Set option allowing communication between both ends of the fiber link while running the test. Users can remotely control the far unit for test sequence automation or transfer results to the product at the other end for immediate analysis.

## Multi-Test Access Unit Module

Fiber link or network characterization is always a test sequence of multiple functions usually represented by multiple test modules. Each test module requiring a fiber connection and disconnection, as well as a function swap and multiple settings, which makes the job complex, the process time consuming and the handling, a high risk of errors.

The E81MTAU4 Multi-Test Access Unit responds to this complex process by connecting and disconnecting the fiber only once to perform the complete suite of tests in minutes.

- Makes characterizing and commissioning fiber easier (OTDR and IL)
- 50% time savings for fiber characterization
- Up to 6 interconnected test functions (OTDR, CD, PMD, IL, SA, and ORL)
- Reduces fiber connect/disconnect
- Connect up to 4 modules
- Automatically switches from one module to another



## Post-Process and Document Field Measurements

### **OFS-100 FiberTrace Post-processing and Measurement Report**

- OTDR, CD, PMD, AP, IL/ORL, and OSA results analysis
- Batch processing capability via an automation process
- Pass/Fail function
- Customized printouts
- Ideal for report generation on a single fiber

### **OFS-200 FiberCable Link/Network Characterization Report Generation**

- Direct access keys for easy process and efficiency
- Complete fiber characterization reporting capability including bidirectional OTDR, CD, PMD, AP, IL, and ORL results
- Advanced OTDR functions for loopback and mid-point management
- Powerful report preview to avoid errors during processing
- Ideal for report generation on multiple fibers





T-BERD/MTS-8000



T-BERD/MTS-6000



OBS-500/550

**JDSU Link Characterization Test Kits**

<b>TB8000-FC1-MR2</b>	Unidirectional automated link characterization kit with T-BERD 8000 test platform equipped with: <ul style="list-style-type: none"> <li>– Medium-range OTDR 1310/1550 nm</li> <li>– Medium range dispersion tests: CD, PMD and AP</li> <li>– Handheld broadband source</li> <li>– Carrying case with lid organizer</li> <li>– Accessories: keyboard, test patchcords, mouse, quick cards</li> </ul>
<b>TB8000-FC1-MR3</b>	Unidirectional automated link characterization kit with T-BERD/MTS-8000 test platform equipped with: <ul style="list-style-type: none"> <li>– Medium-range OTDR 1310/1550/1625 nm</li> <li>– Medium range dispersion tests: CD, PMD and AP</li> <li>– Handheld broadband source</li> <li>– Carrying case with lid organizer</li> <li>– Accessories: keyboard, test patchcords, mouse, quick cards</li> </ul>
<b>TB8000-FC1-VLR3</b>	Unidirectional automated link characterization kit with T-BERD/MTS-8000 test platform equipped with: <ul style="list-style-type: none"> <li>– Very-long-range OTDR 1310/1550/1625 nm</li> <li>– Very long range dispersion tests: CD, PMD and AP</li> <li>– Handheld broadband source</li> <li>– Carrying case with lid organizer</li> <li>– Accessories: keyboard, test patchcords, mouse, quick cards</li> </ul>
<b>TB8000-FC2-MR3</b>	Bidirectional automated link characterization kit with 2 x T-BERD/MTS-8000 test platforms equipped with: <ul style="list-style-type: none"> <li>– Medium-range OTDR 1310/1550/1625 nm</li> <li>– Medium range dispersion tests: CD, PMD and AP</li> <li>– Broadband source module</li> <li>– Carrying case with lid organizer</li> <li>– Accessories: keyboard, test patchcords, mouse, quick cards</li> </ul>
<b>TB8000-FC3-MR3</b>	Bidirectional automated link characterization kit with 2 x T-BERD/MTS-8000 test platforms equipped with: <ul style="list-style-type: none"> <li>– Loss test set/ORL meter 1310/1550 nm</li> <li>– Medium-range OTDR 1310/1550/1625 nm</li> <li>– Medium range dispersion tests: CD, PMD and AP</li> <li>– Broadband source module</li> <li>– Carrying case with lid organizer</li> <li>– Accessories: keyboard, test patchcords, mouse, quick cards</li> </ul>
<b>TB8000-FC3-VLR3</b>	Bidirectional automated link characterization kit with 2 x T-BERD/MTS-8000 test platforms equipped with: <ul style="list-style-type: none"> <li>– Loss test set/ORL meter 1310/1550 nm</li> <li>– Very long range OTDR 1310/1550/1625 nm</li> <li>– Very long range dispersion tests: CD, PMD and AP</li> <li>– Broadband source module</li> <li>– Carrying case with lid organizer</li> <li>– Accessories: keyboard, test patchcords, mouse, quick cards</li> </ul>

**JDSU Network Characterization Test Kits**

<b>TB6000-NC1-MR</b>	T-BERD/MTS-6000A test platform equipped with: <ul style="list-style-type: none"> <li>– Medium range dispersion tests: CD, PMD and AP</li> <li>– Handheld broadband source</li> <li>– Carrying case</li> <li>– Accessories: keyboard, test patchcords, mouse, quick cards</li> </ul>
<b>TB6000-NC1</b>	T-BERD/MTS-6000A test platform equipped with: <ul style="list-style-type: none"> <li>– Very long range dispersion tests: CD, PMD and AP</li> <li>– Handheld broadband source</li> <li>– Carrying case</li> <li>– Accessories: keyboard, test patchcords, mouse, quick cards</li> </ul>

**Test & Measurement Regional Sales**

<b>NORTH AMERICA</b> TEL: 1 866 228 3762 FAX: +1 301 353 9216	<b>LATIN AMERICA</b> TEL: +1 954 688 5660 FAX: +1 954 345 9216	<b>ASIA PACIFIC</b> TEL: +852 2892 0990 FAX: +852 2892 0770	<b>EMEA</b> TEL: +49 7121 86 2222 FAX: +49 7121 86 1222	<a href="http://www.jdsu.com/test">www.jdsu.com/test</a>
---	--	---	---	--