FIBER CHARACTERIZATION TEST EQUIPMENT

Evaluating and selecting a solution that will grow with your DWDM network

Introduction

Competitive market pressures demand that service providers continuously upgrade and maintain their networks to ensure the delivery of higher-speed, higher-quality applications and services to customers

Providing quality service requires constant verification that the network's fiber infrastructure and equipment can meet exacting performance standards and operate reliably. Often this means acquiring new technologies such as 2.5 Gbps transmission and dense wavelength division multiplexing (DWDM). However, these new technologies require a reassessment of current testing tools and procedures due to the size and complexity of networks today.

Fiber characterization enables network operators to have a more precise idea of their network and how and where to localize faults. Operating companies need to be able to test the network in order to pinpoint potential and existing problems.

Fiber characterization testing – past, present and future

So far, the conventional tools to perform fiber characterization have been optical time domain reflectometers (OTDRs) and light source/power meters. But the complexity and number of tests that must be performed to ensure high-quality transmissions have prohibited many outside plant managers from acquiring all of the equipment they need, preventing many from exceeding, or even keeping up with, the competition. And, much of the purchased equipment used to perform complete DWDM fiber characterization tests contain features and functions tailored to long-haul carriers' requirements, which make the test equipment too complex and too expensive for medium-haul carriers to deploy on a larger scale with many more test locations.

Long-haul carriers have dealt with the effects of dispersion for many years. Extremely long spans, where fiber-induced impairments are sufficient to cause bit errors on 565 Mbps and OC-12 systems, are tested using equipment and techniques developed specifically to test for these impairments. Now, because of widespread implementation of 2.5 Gbps and higher single- and multi-wavelength systems, dispersion testing is required on medium-haul runs (<30 dB) as well.

Transmission equipment vendors such as Nortel, Alcatel or Lucent can provide fiber characterization tests before installing equipment, but their timeframe for performing the tests may not always coincide with the service provider's turn-up schedule. This can result in substantial delays in service provisioning or increased time to repair, leading to project postponements and missed turn-up commitments.

In addition, if the network fails to perform as promised, the operating company needs to test the network and pinpoint the source of the problem. Furthermore, the capability to retest fiber characterization values is useful for ongoing network maintenance.

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The advent of OC-192 (10 Gbps),OC-768 (40 Gbps), and DWDM require carriers to perform dispersion tests on installed optical fibers to ensure that they are suitable transmission media for these high bit rates. In many cases, the carriers also rely on the results of these tests to select and configure upgraded transmission equipment for proper performance. However, the test requirements for medium-haul dispersion testing are significantly different than those for long-haul dispersion testing (see table 1). First of all, the number of testing locations are significantly higher. Also, as the majority of medium-haul links exhibits 30 dB insertion loss or less, very high dynamic ranges are not necessary. In addition, with bit rates of 2.5 Gbps or higher, dispersion impairments of 40 picoseconds are the maximum the system allows. Consequently, it is unnecessary to measure far beyond this range.

Fiber characterization testing – tools of the trade

Outside plant managers typically possess optical test equipment for insertion loss (IL) (1310/1550 nm), OTDR testing, and in some cases, optical return loss (ORL) testing for both long-haul and medium-haul networks. This equipment is generally used to conduct conventional fiber characterization testing for single lambda (L), OC-48 and below transmission.

As testing requirements change and expand, the methods used by technicians to perform complete fiber characterization testing also needs to change. Although tests for fiber characterization may differ slightly for each transmission equipment vendor and system, there are a host of conventional tests that most transmission engineers are required to perform (see table 2).

A more economical and efficient option for multiple, complex tests on outside plant equipment is to use modular, optical test instruments that offer a full range of interoperable testing solutions for almost every type of optical cable network and application. Such test sets are designed to take accurate measurements, perform multiple functions, and provide upgrades, which means that technicians need to carry only one lightweight and durable unit. These units contain advanced features and modular components that can be plugged in to meet both conventional testing and next-generation testing requirements. A singleplatform, modular testing solution reduces the need to purchase, carry, and learn how to operate multiple pieces of test equipment. Moreover, it allows more fibers to be tested in less time, which in turn enables faster installation and network provisioning, and improves repair times.

Conventional tests

OTDR – When technicians perform physical plant testing they typically use an OTDR that supports 1310 and 1550 nm to confirm splice loss, fiber attenuation rates, discrete reflectance and fiber length (see figure 1, Conventional testing). For DWDM testing (which usually also goes up to the 1600 nm range), however, a three-lambda OTDR that performs tests at 1310, 1550, and 1625 nm is required.

Medium-haul versus long-haul dispersion testing

Long-haul (all bit rates)	Medium-haul (2.5 Gbps)
Measurement of high levels of dispersion (up to 160 ps) which can affect 565 Mbps links	Measurement of dispersion up to 40 ps (at which 2.5 Gbps is impaired)
High dynamic range 35 dB+	85% of the links <30 dB

Required tests

All links (conventional tests)	Insertion loss (IL) Optical return loss (ORL) OTDR
Long-haul links > 565 Mbps	Chromatic dispersion (CD) Polarization mode dispersion (PMD) Spectral attenuation (multi-lambda)
Moderate-haul links 2.5 Gbps+ (single or multi-lambda)	Chromatic dispersion (CD) Polarization mode dispersion (PMD) Spectral attenuation (multi-lambda)

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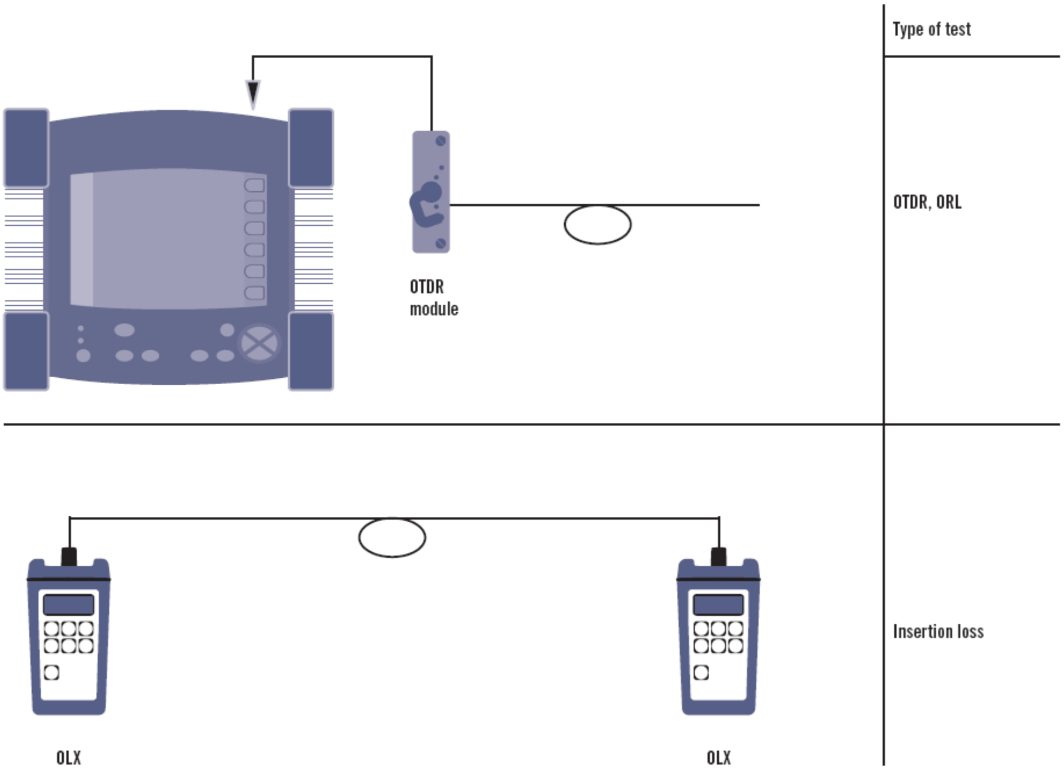
Insertion loss (IL)

Insertion loss testing is typically performed with a power meter and a light source with both 1310 and 1550 nm wavelength outputs (see figure 1). For high-fiber count testing, it is convenient to have a power meter with memory and download capability for reporting purposes.Although test results can typically be obtained from testing in only one direction, bidirectional tests are performed using an automated bidirectional test set. These sets test the insertion loss of the fiber at both wavelengths and in both directions, which saves time. And, because it automatically calibrates to the transmitted wavelength, it reduces the possibility that the wavelength will be improperly calibrated between the light source and power meter. As DWDM systems begin to populate the L band (1600 nm area), a three-lambda light source and meter will be required for 1310, 1550, 1625 nm. Communication between technicians is required as DWDM testing is performed at both ends. Because radios typically do not have sufficient range, cell phones are often used. But, cell-phone costs and coverage as well as restrictions on using cell phones in central offices significantly reduce their usefulness. However, an automated three-lambda bidirectional test set that contains a fiber talk set or supports short messaging permits the two technicians to communicate, greatly enhancing their productivity. In addition, with the capability to set user-defined thresholds that flag each test as a Go/No-Go for later loss analysis, this multifunction test set would further expedite the testing process.

Optical return loss (ORL)

Although an OTDR can measure ORL, many managers prefer or require continuous wave (CW) testing, which is performed with a dedicated ORL meter, often referred to as a back reflection meter. Most automated bidirectional IL test sets have a light source and power meter coupled to a single port, which allows them to be configured to perform ORL testing. This means that one piece of equipment can perform both IL and ORL tests, reducing the amount of equipment technicians must carry in the field. And, technicians only have to learn how to operate one piece of equipment to perform both tests.



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Next-generation tests

Previously, it was a common practice to adopt long-haul fiber characterization (see figure 2, Long-haul testing with dispersion) methods for medium-haul applications. However, this approach is expensive and too complex for wide deployment. Fortunately, test instruments that perform conventional and dispersion testing on medium-haul links can be easily and economically upgraded to perform tests on long-haul links.

Because medium-haul spans are operated at higher speeds, dispersion testing formerly required for long-haul spans only is now required. These new testing measurements include spectral attenuation, polarization mode dispersion (PMD), and chromatic dispersion (see figure 3, Medium-haul testing with dispersion).

Spectral attenuation

Using a source and phase meter or an optical spectrum analyzer (OSA), spectral attenuation tests are performed so that transmission engineers can select properly "gain flattened" network components. Technicians can use either a powerful, AC powered, stand-alone diffraction grating based OSA or a compact Fabry-Perot-based OSA module that can be installed in an OTDR field-and-battery operated platform. The second option is the most effective and cost-efficient approach because it reduces the amount of equipment that technicians need to carry and learn how to use. The benefit of using an OSA for this method of testing is that it is also required for DWDM system turn-up, extending the initial investment.

Polarization mode dispersion

High PMD levels can cause impairments on long-haul, OC-48 (and below) systems. For this reason, long-haul systems require PMD tests that are traditionally performed with a stand-alone interferometer, a relatively expensive piece of equipment that can measure very high levels of PMD. However, 2.5 Gbps systems become impaired at relatively low PMD levels (40 picoseconds), therefore, the same high measurement levels are not required (see table 1).

An OSA with a polarizer, additional software and the same optical broadband source used for spectral attenuation testing would characterize the fiber and also measure PMD. This method, described in TIA/EIA FOTP-113 "PMD by the fixed analyzer method", is mathematically equivalent to interferometric testing (TIA/EIA FOTP-124 "PMD by interferometer") and is suitable to measure the full range of PMD levels that are likely to cause impairments on OC-48 and higher-speed systems, which would meet medium-haul testing requirements.

		Type of test
2 Lambda OTDR		OTDR Optical return loss
Power meter/light source	Power meter/light source	Insertion loss
Broadband source	Interferometer	Polarization mode dispersion
Light source Tx	Phase meter	Chromatic dispersion
Broadband source	Phase meter	Spectral analysis

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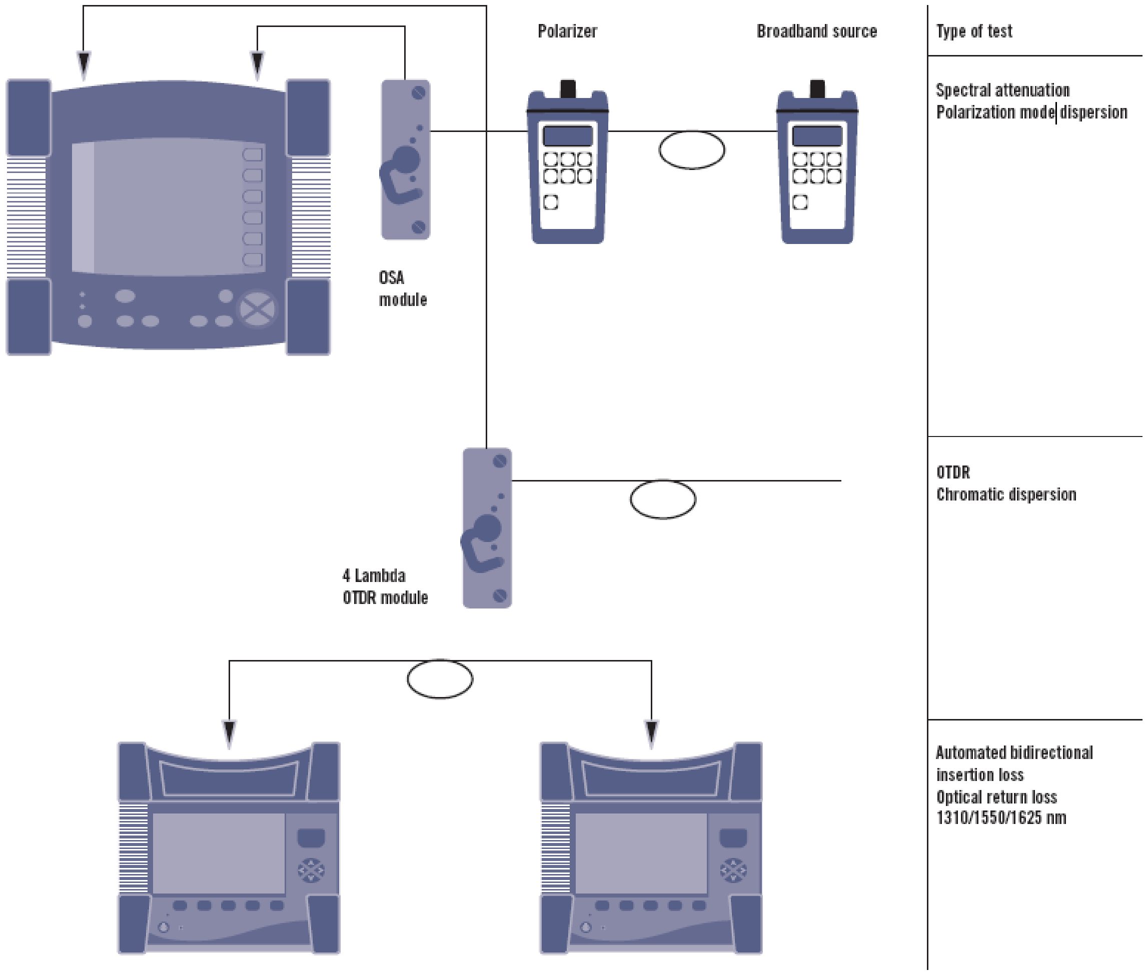
Chromatic dispersion

Technicians currently use the phase shift method to test for chromatic dispersion on long-haul systems. This two-ended method, described in TIA/EIA FOTP-169 "CD by the phase shift method", requires the use of a stand-alone phase shift analyzer, a precise piece of equipment with a high dynamic range. At a cost of approximately $100,000, this equipment is cost prohibitive for wide deployment.

Although medium-haul systems do not require this range of testing capability, chromatic dispersion testing must still be performed. New testing solutions allow chromatic dispersion tests to be performed using the same test instruments that contain an OTDR and an OSA. For example, all outside plant teams require at least a 1310/1550 nm OTDR.

The operators that are moving into DWDM need technicians with 1550/ 1625 nm OTDRs or trilambda (1310/ 1550/1625 nm) OTDRs, which can be purchased at a cost incrementally above that of conventional two-lambda units. Currently, there are also "quad-lambda"OTDRs that perform all of the conventional OTDR testing in the three common transmission windows, but use a fourth wavelength (typically 1470 nm) that can also measure chromatic dispersion.



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Conclusion

As outside plant crews are increasingly required to test existing fibers for DWDM upgrades, employing the same equipment to perform fiber characterization and dispersion tests on both medium-haul and long-haul links is not the most effective approach.

Outside plant managers need to keep in mind that even as technology advances raise the level of testing accuracy and precision required for medium-haul links, employing the methods, measurement range, and equipment used for long-haul links far exceed medium-haul requirements.

Modular, field upgradeable, and multifunctional test instruments enable outside plant managers to expand conventional testing capability and effectively future-proof their equipment. The benefits of this approach are many: capital equipment expenditures and staff time and costs are reduced while customer satisfaction increases by permitting outside plant managers to consistently meet turn-up dates.