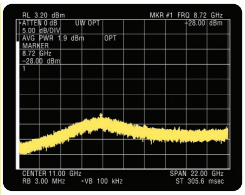
Need to test 40 Gb/s?

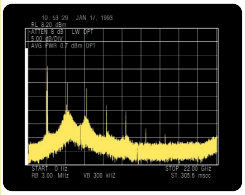
Solutions to accelerate the
next generation optical internet

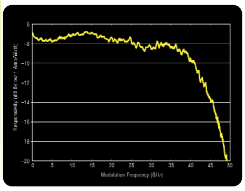
Agilent Technologies
Innovating the HP Way

Tools to get the job done

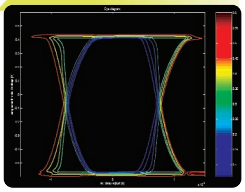
Working at the forefront of technology places demands on you and your test equipment. With exceptional performance expected while facing the pressures of reduced time to market, trust in your measurement results is vital. Whether you are developing leading edge fiber-optic components, or verifying system performance during installation or trialing, Agilent Technologies provides solutions that enable you to see the whole picture.

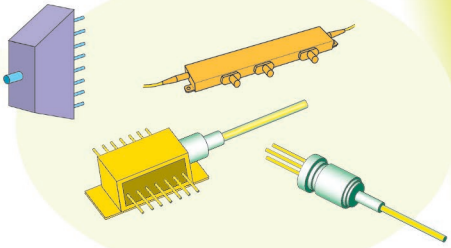






Components & Modules





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MUX/ De-MUX Characterization

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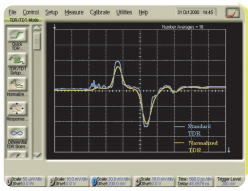
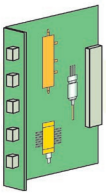
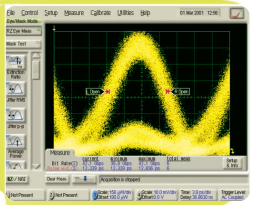
Active Component Measurements

Line Cards







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Backplane Measurements With TDR

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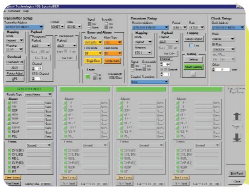
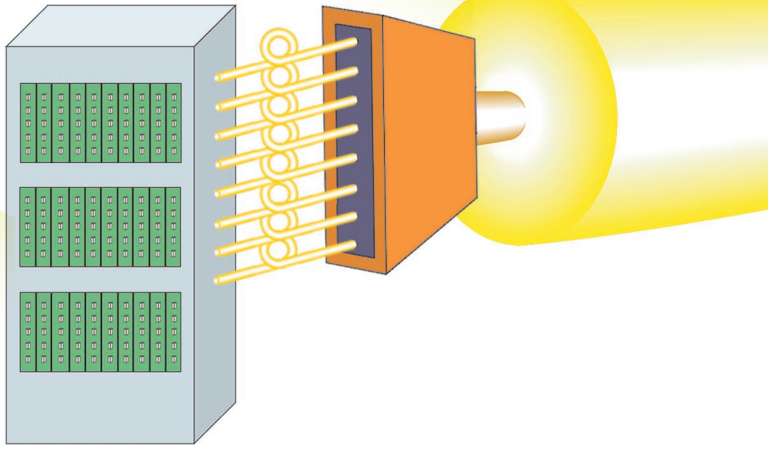
RZ Waveform Test

Network Elements & Systems

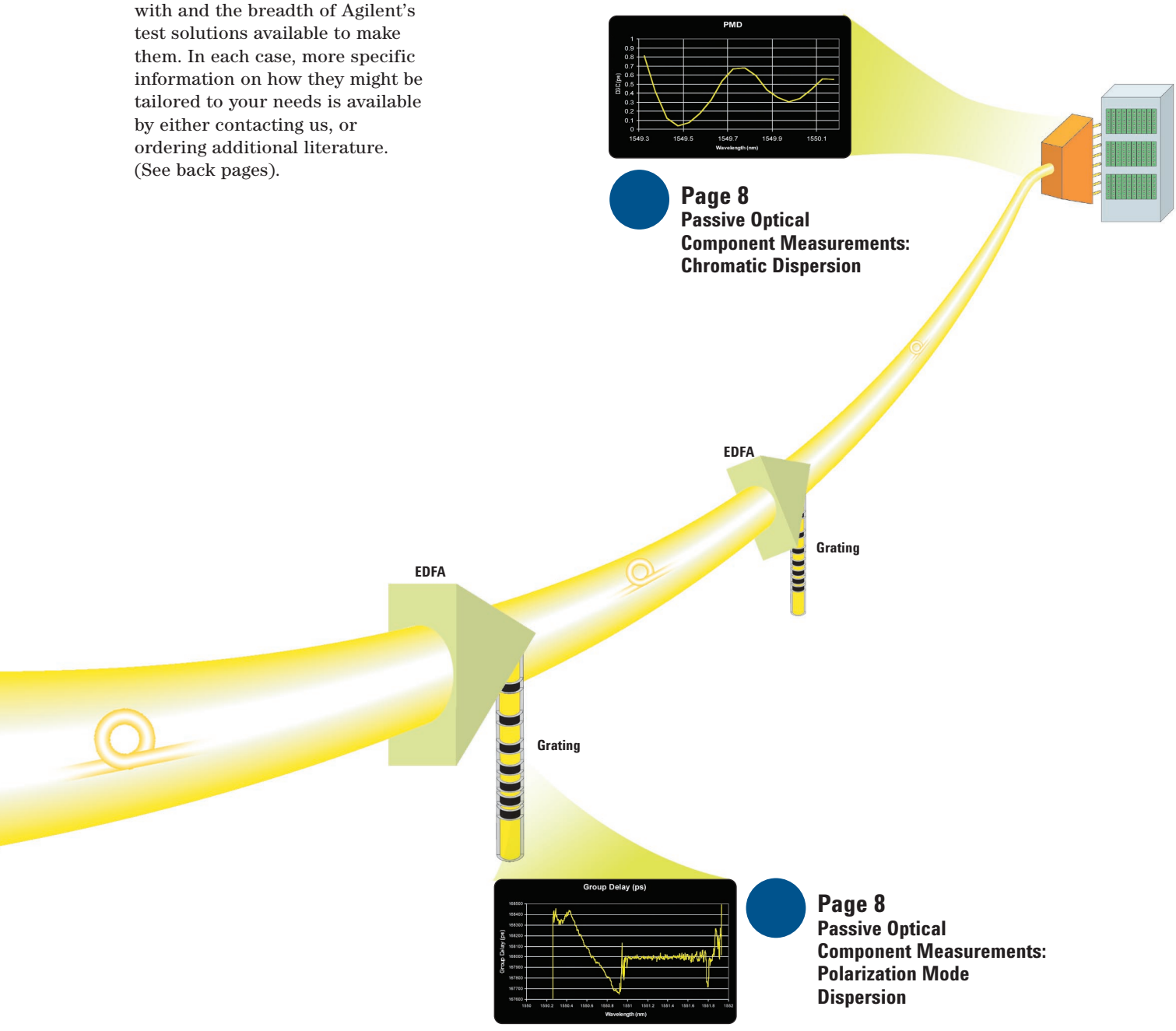




Page 6
Element and System: Tributary Loading and Test

The telecommunications industry is undergoing the most significant series of changes since its inception, and this will require testing that is above and beyond the usual. You know Agilent has always applied relentless innovation to help you meet your design challenges, but did you know about our 40 Gb/s solutions? Here we take a look at some of the measurements that you are faced with and the breadth of Agilent's test solutions available to make them. In each case, more specific information on how they might be tailored to your needs is available by either contacting us, or ordering additional literature. (See back pages).

Agilent Technologies – providing greater certainty.



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Passive Optical Component Measurements: Chromatic Dispersion

Page 8
Passive Optical Component Measurements: Polarization Mode Dispersion

RZ Waveform Testing

- Lasers & Receivers
- Network Elements
- Systems

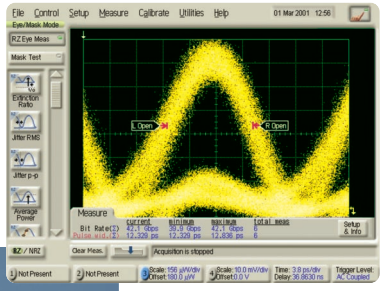
Accurate views of your 40 Gb/s waveforms

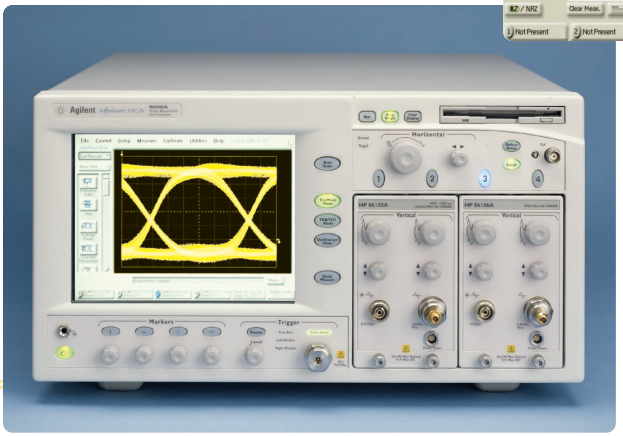
Whether it's research, development, or manufacturing, the ability to see your waveforms will always be important. At 40 Gb/s, the edge speeds and pulse widths can be less than 10 ps. At these speeds you should ask yourself whether what you see is an accurate representation of the waveform or whether it has been altered due to some limitation of the oscilloscope.

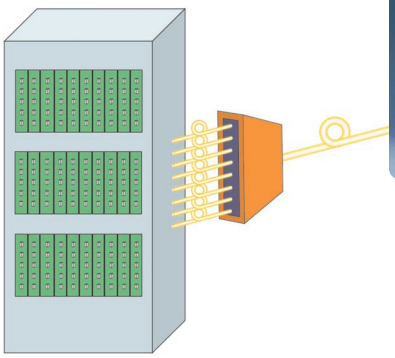
With a bit period of only 25 ps, even small amounts of jitter can become significant. If your oscilloscope has 1.5 ps r.m.s. of jitter, this will result in 9 ps peak-to-peak or more. This will appear as significant eye closure, even if your original signal is perfect. The oscilloscope timebase needs to allow settings in the 4 to 2 ps/division range to get a precision view of a single 40 Gb/s eye.

The precision with which you can determine the shape and speed of a 40 Gb/s signal is dependent upon optical receiver design within the instrument. Fast edge speeds require very wide measurement bandwidths. Determining the true shape of a waveform also requires a wide bandwidth. Yet the frequency response must be carefully controlled to minimize overshoot and ringing. Signal reflections must be controlled to minimize intersymbol interference.

The Agilent 86100A Infiniium DCA has been improved specifically for 40 Gb/s waveform analysis. The trigger circuitry has been designed for a dramatic decrease in jitter. The timebase resolution has advanced from 10 ps/division to 2 ps/division, a 5 times improvement. The new Agilent 86109B plug-in module provides the higher bandwidth you will need to get the job done. The channel has both a 40 GHz bandwidth to measure fast edge speeds and a 30 GHz bandwidth for optimum pulse fidelity.



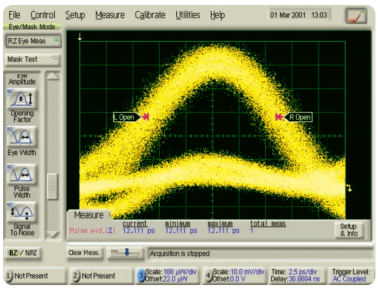




Waveform fidelity and accuracy from the 86100A

Performing return-to-zero waveform measurements

A return-to-zero (RZ) signaling scheme can provide an attractive method to overcome some of the performance barriers encountered when using optical fiber. Many designers will take advantage of an RZ modulation format as the work begins to develop 40 Gb/s systems. Some ultra-long distance transmission systems operating at rates below 40 Gb/s are also RZ format based.



RZ Pulse Measurement on the 86100A

In the development and production of RZ communication systems, it will be essential to accurately measure waveforms. Many of the measurements commonly used to characterize an NRZ eye can also be applied to RZ eyes. These include rise and falltimes, eye height and width, and '1' and '0' levels. There are unique characteristics of an RZ signal for which new measurements need to be created. Contrast ratio is a measure of how well '1' pulses actually return to a zero level. The definition for extinction ratio is modified to account for 1 pulses starting from and returning to zero.

The internal algorithms an oscilloscope uses to quantify an NRZ eye generally fail for RZ signals. Thus the 86100A Infiniium DCA now includes an extensive measurement set designed specifically for RZ pulses. These measurements include:

- RMS Jitter
- Falltime
- Eye height
- Eye width
- Bit rate
- One level
- Pulse width
- Duty cycle
- Extinction ratio
- Zero level
- Signal-to-noise ratio
- Peak-to peak jitter
- Risetime
- Eye amplitude
- Eye opening factor
- Contrast ratio

Simply configure the oscilloscope for RZ measurements and start testing.

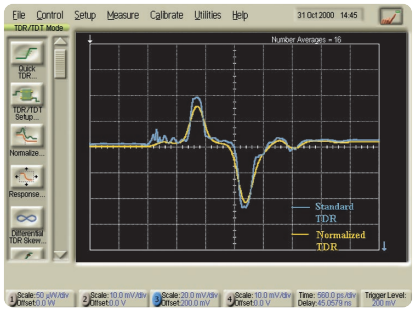
Element and Backplane Testing

- **Backplanes**
- **Circuit Boards**
- **Packages**

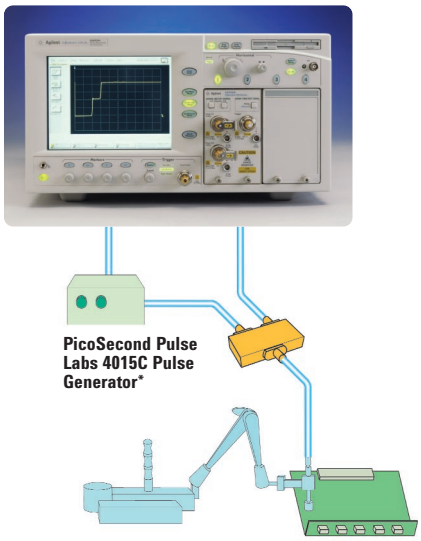
Designing backplanes, microstrip structures and interconnects for 40 Gb/s systems can be a challenging signal integrity task. While simulation tools can be helpful predicting eventual performance, real confidence only comes from using measurement tools that can accurately verify the real-world response to fast edge speeds.

Time Domain Reflectometry (TDR) is one of the tools used most frequently by digital design engineers to relate physical interconnect structures to such parameters as characteristic impedance, reflection coefficient, propagation velocity and edge effects.

For improved accuracy, TDR normalization sets the measurement reference plane precisely at the device under test, taking out the effects of the test fixture. This technique uses a two-port calibration with a precision 50-Ohm load and a short. The processing power of the 86100A builds a digital filter that corrects for test fixture errors in the frequency domain.



TDR Normalization removes test fixture errors



PicoSecond Pulse Labs 4015C Pulse Generator*

Increased resolution TDR test setup using the 86100A to measure 10 ps risetime pulses

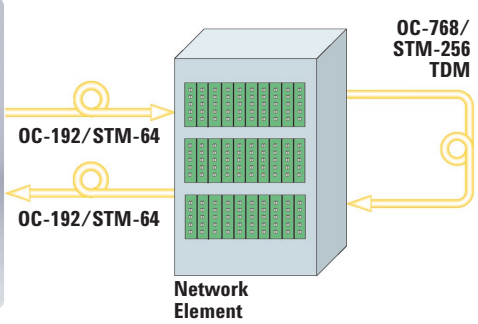
*PicoSecond Pulse Labs: USA (303) 443-1249; www.picosecond.com

Tributary Loading and Test

- Network Elements
- Line Cards
- Systems

With any new system design, many complex elements have to come together and work flawlessly, from circuit boards to complex protocol stacks and firmware. The real test of whether your customers are satisfied is when the system is loaded with traffic, and stressed to the limit. Here we show some methods that can give you confidence that your design will do the job right, first time.

SpectraIBER 10G

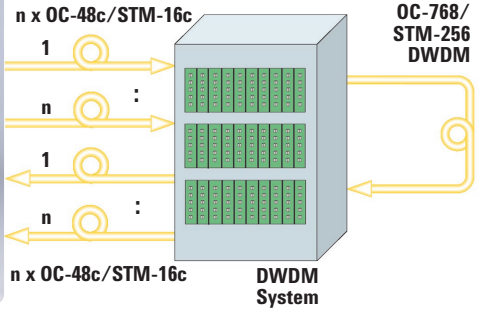


OC-192/STM-64 serial tributary test with channelized payloads

Test OC-192/STM-64 tributary cards in OC-768/STM-256 TDM systems

- Comprehensive functional tests from OC-192c/STM-64c to STS-1/VC-3 payloads, including errors and alarms
- Unique service disruption measurement, protection switching control and APS capture

SpectraIBER 2.5G

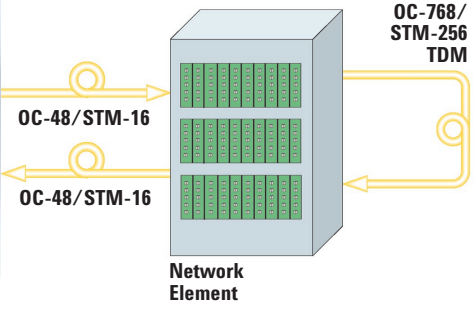


OC-48/STM-16 parallel tributary loading with concatenated payloads

Test OC-48/STM-16 and lower rate tributary cards in DWDM system with multiplexed OC-768/STM-256 transponders

- Full bandwidth, system integrity test with SONET/SDH concatenated payloads or unframed PRBS patterns
- Cost-effectively load and test tributary channels in parallel, while saving space and time

OmniBER



OC-48/STM-16 serial tributary test with channelized payloads

Test OC-48/STM-16 and lower rate tributary cards in OC-768/STM-256 TDM system

- Comprehensive functional tests from OC-48c/STM-16c to DS1/E1 payloads, including errors and alarms
- Unique service disruption measurement, protection switching control and APS capture
- Accurate and repeatable jitter tests from OC-48/STM-16 to DS1/E1

Mux Testing

- MUXES & DeMUXES
- SERDES

40 Gb/s testing using 2.6 Gb/s tributaries and a golden device

A powerful way of testing the performance of multiplexers, de-multiplexers and SERDES devices is to measure them back-to-back using a golden device by stimulating them with a parallel bit error ratio tester (BERT). This way, it is possible to identify the cause of errors as early in the design phase as possible. Using such a method, component performance may be easily verified, as well as high speed transmission line and other performance limiting effects.

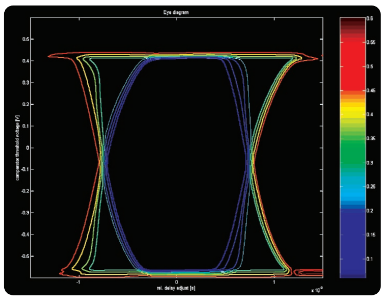
MUX/ DeMUX testing

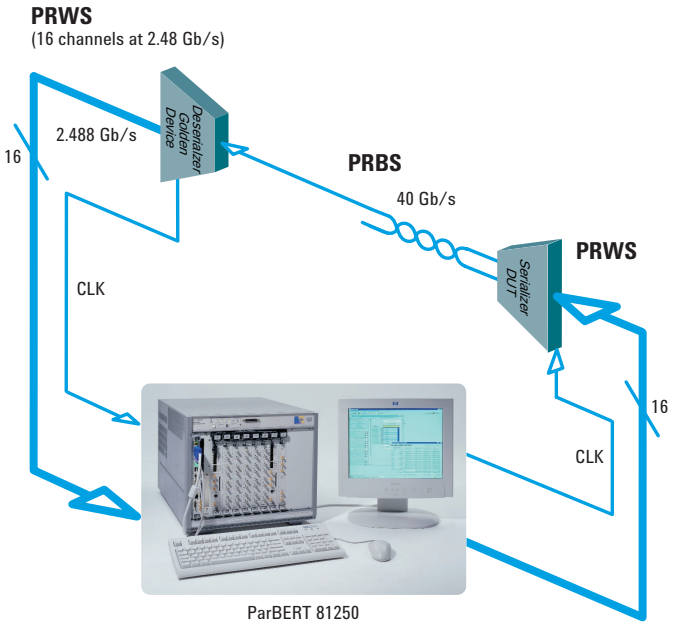
With a back-to-back setup, the performance of the test device can be explored. Revealing measurements such as set-up and hold times and input sensitivities can be performed for tributary lines.

Setup and hold times can be examined by moving the data-channels together simultaneously in time relative to the clock. As the start of the eye approaches the clock signal, a point is reached where the setup and hold time of the input device is violated and BER errors occur. This measurement shows the worst-case setup time. The data can then be backed away from the clock until no errors occur and then each channel in turn can be move in 1 ps steps to determine the first channel to fail setup time. Moving the end of the eye closer to the clock will determine the hold time. You can then use this information to troubleshoot MUX designs for routing errors and crosstalk.

Similarly, the input sensitivities of the device can be examined by stimulating the device across all channels, and achieving error-free operation. The input voltage of all channels simultaneously may then be reduced in steps until errors occur. By backing off the voltage by several steps, then stepping down individual channels until errors occur, it is again possible to identify the channel most likely to be limiting performance.

Once a back-to-back configuration of a MUX and DeMUX has been established, it is then possible to use these as a golden pair. Having established that a 40 Gb/s link runs error free between the two devices, you can then insert 40 Gb/s devices into the path and see the effect on error performance.





ParBERT 81250

Using the ParBERT 81250, it is possible to stimulate up to 64 parallel channels and also detect on 64 channels at speeds up to 2.6 Gb/s. With this flexible tool, it is easy to generate user-defined memory based patterns and hardware based pseudo-random word sequences (PRWS). These special patterns are such that when the parallel channels are multiplexed together, they form a serial stream that represents a standard 2^n-1 PRBS. This way, the test stream produced can be used to exercise 40 Gb/s components with industry standard patterns. De-multiplexing the PRBS into many channels of PRWS then provides the input to the ParBERT error detectors.

The ParBERT provides fully independent channel control and an extensive suite of semiconductor device characterization tools to speed up development time. These include the measurements described above as well as device power dissipation, propagation delay, eye contour, and bathtub jitter.

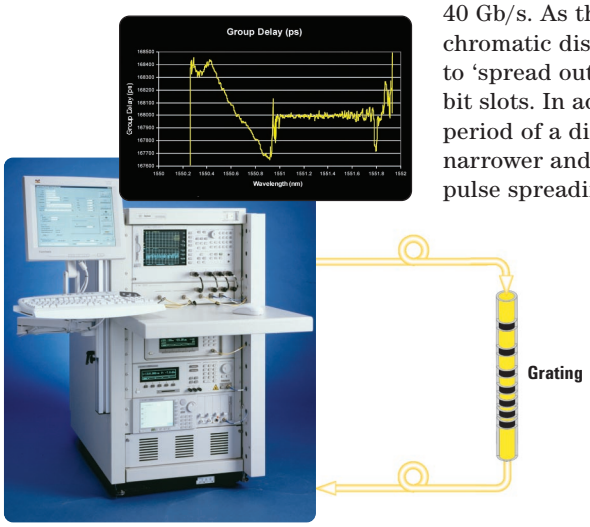
Passive Optical Component Testing

- Fibers
- Optical MUXES & DeMUXES
- Isolators
- Dispersion Compensators

The quick and accurate way to characterize chromatic dispersion

Chromatic dispersion can limit the performance of optical components and signals. This is a problem at 10 GB/s and a serious one at 40 Gb/s. As the data rate increase, chromatic dispersion causes pulses to 'spread out' into the adjacent bit slots. In addition, the bit period of a digital signal becomes narrower and more sensitive to pulse spreading.

The Agilent 86037C CD system is ideal for chromatic dispersion measurements in R&D and manufacturing environments. It uses the standardized modulation phase-shift (MPS) technique for group delay and dispersion measurements. The 86037C features operation up to 1640 nm and the software allows both fast stepped measurements and very fast sweeping preview mode measurements. This system offers high wavelength resolution and accuracy, wide dynamic range and high repeatability for measuring high-speed lightwave components and systems. It is ideally suited to both components and fiber.



86037C Chromatic Dispersion Test System

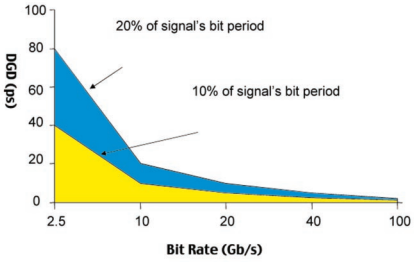
Verify that your devices PMD performance is up to the task for your customers network

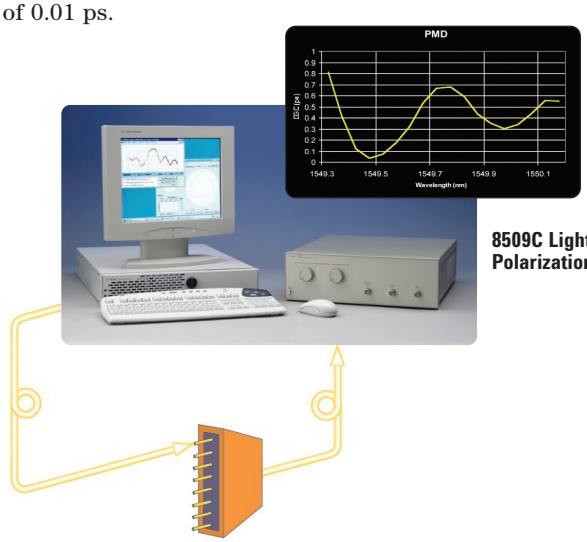
Polarization mode dispersion can limit fiber optic transmission performance. It is caused by birefringence in the optical transmission medium, which in turn causes polarization components of a signal to travel at different group velocities.

As data rates increase, the impact of PMD increases because as the bit period of a digital signal becomes smaller, polarization mode delay represents a greater portion of a bit period. There may be relatively minor effects on a 2.5 Gb/s signal while 10 and 40 Gb/s signals suffer degraded bit error rates (BER). To maintain data transmission integrity, it is important to keep overall differential group (DGD) delay to within 10 to 20% of the bit period signal.

The Agilent 8509C lightwave polarization analyzer provides R&D and manufacturing with high-speed, accurate, easy-to-understand measurements of optical fiber components and signals through L-band.

Agilent 8509C can be used to measure the PMD of fiber and components down to the region of 0.01 ps.

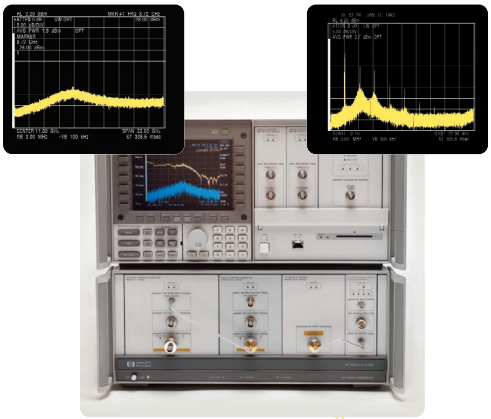




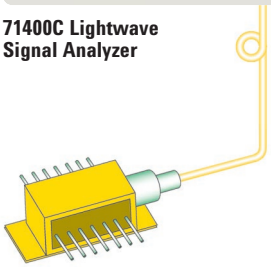
8509C Lightwave Polarization Analyzer

Frequency Domain Test of Active Components

- Lasers
- Receivers
- Photodiodes
- Modulators



71400C Lightwave Signal Analyzer



Calibrated Measurements of Laser Performance

A key component of any lightwave system is the laser source. Accurate characterization of the laser is important for overall system performance. To completely characterize a single mode laser requires measurement of relative intensity noise (RIN), linewidth, modulation performance, and chirp.

RIN is effectively the laser's carrier-to-noise and is a measure of the source's dynamic range. If the noise level decreases, or the average power increases, the RIN value improves. For long distance transmission, better carrier-to-noise values translate into cleaner transmissions, fewer errors and longer spans, making it highly desirable to use very low RIN sources.

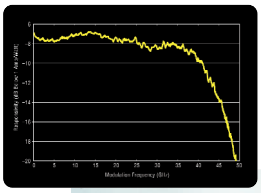
Similarly the linewidth of the source is analogous to the device's phase noise performance. The ideal linewidth profile is a Lorentzian, and deviation from this gives a good indication of the quality of the device. Chromatic Dispersion is directly proportional to the linewidth of the source. For optimal transmission of fast bit rate signals in DWDM systems, narrow and stable linewidths are required.

The Agilent 71400C and 71401C lightwave signal analyzers are used to make measurements to characterize laser performance, and are recognized within the industry for their accuracy. They contain automated routines that make measurements of the key parameters of RIN and linewidth simple and repeatable.

Accurate characterization of 40 Gb/s optical components

Modern lightwave transmission systems require accurate and repeatable characterization of their optoelectronic, optical, and electrical components to guarantee high-speed performance. The Agilent 86030A 50 GHz lightwave component analyzer improves the design and specification of these lightwave components by accurately characterizing their bandwidth and reflection characteristics.

For manufacturers building 40 Gb/s electro-optical, optical, and electrical components used in high-speed OC-768 lightwave systems, the 86030A is necessary to completely characterize these components at modulation frequencies up to 50 GHz. Components such as photodiode receivers, lasers, lightwave modulators, and other optical and electrical components used in 40 Gb/s lightwave systems can be characterized in either an R&D or manufacturing environment with the 86030A.



86030A 50 GHz Lightwave Component Analyzer

Product Descriptions — Error Domain and Functional Testing

ParBERT 81250 2.6 Gb/s Parallel Bit Error Ratio Test System

ParBERT 81250 generates and analyzes pseudo random word sequences (PRWS) and standard PRBS on parallel lines up to 2^{31}-1. Scalable up to 64 channels, it allows sequencing and looping of user data, and is capable of supplying DUT control signals.

For more information order the following literature:
5968-9188E *Product Overview*
5968-9695E *Application Note*

For more information on the Agilent BER portfolio please visit **http://www.agilent.com/find/BERT**

OmniBER

- Optical OC-1/STM-0 to OC-48/STM-16
- Binary interfaces (electrical clock & data)
- Concatenated & channelized payloads
- ATM/PoS payloads
- Unframed PRBS mode
- Jitter/Wander generation & measurement

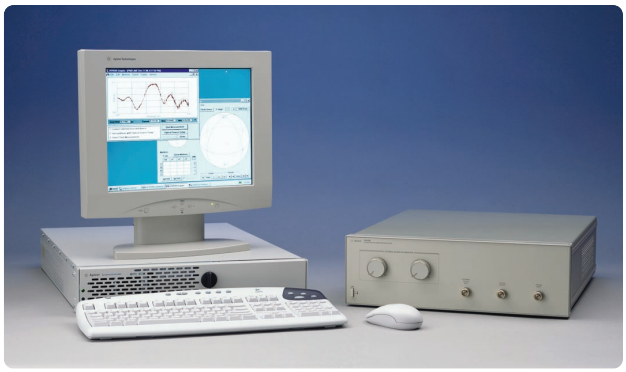
For more information order the following literature:
5968-8740E *Brochure*
5968-8335E *Technical Specifications*
5988-0327EN *Binary Interface Brochure*
5980-3131EN *Binary Interface Specifications*

SpectralBER

- Optical OC-3/STM-1 to OC-192/STM-64
- Concatenated payloads
- Channelized payloads (OC-192/STM-64)
- Unframed PRBS mode (155Mb/s-2.488Gb/s)
- Expandable

For more information order the following literature:
5988-0790EN *Brochure*
5988-0791EN *Technical Specifications*
5988-0792EN *Configuration Guide*

Product Descriptions — Wavelength and Frequency Domains



8509C Polarization Analyzer
When you need to accurately define the polarization performance of optical components, the 8509C is the answer.

For more information order the following literature:
5988-1044EN *Product Overview*

86037C Chromatic Dispersion Test System
Characterizing chromatic dispersion has become a vital consideration with increased communication speeds. Accurately measure positive and negative dispersion coefficients, on elements such as fiber and Bragg gratings.

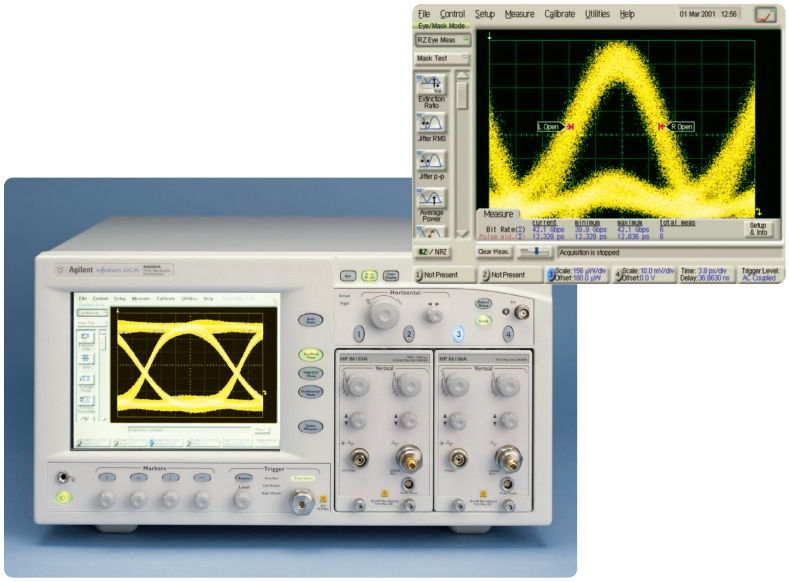
For more information order the following literature:
5980-0815E *Product Overview*

71400C Lightwave Signal Analyzer
An industry standard for the measurement of laser line width, chirp and RIN.

For more information order the following literature:
5980-1929E *Product Overview*

86030A 50 GHz Lightwave Component Analyzer
Fully characterize your active components to 50 GHz in the electrical and optical domains. Ideal for lasers, modulators, photodiodes and receivers.

For more information order the following literature:
5968-9734E *Product Overview*



86100A Infiniium DCA
Wide-Bandwidth Oscilloscope

View optical and electrical waveforms with bandwidths to 50 GHz. Built-in measurements for high-speed digital communications. Modular configurations for a test system to match your specific needs.

For more information order the following literature:
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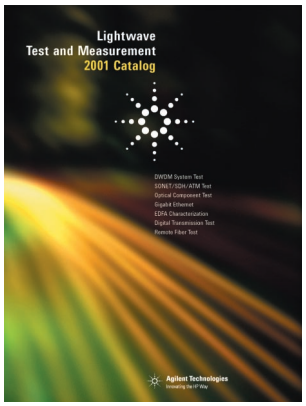

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