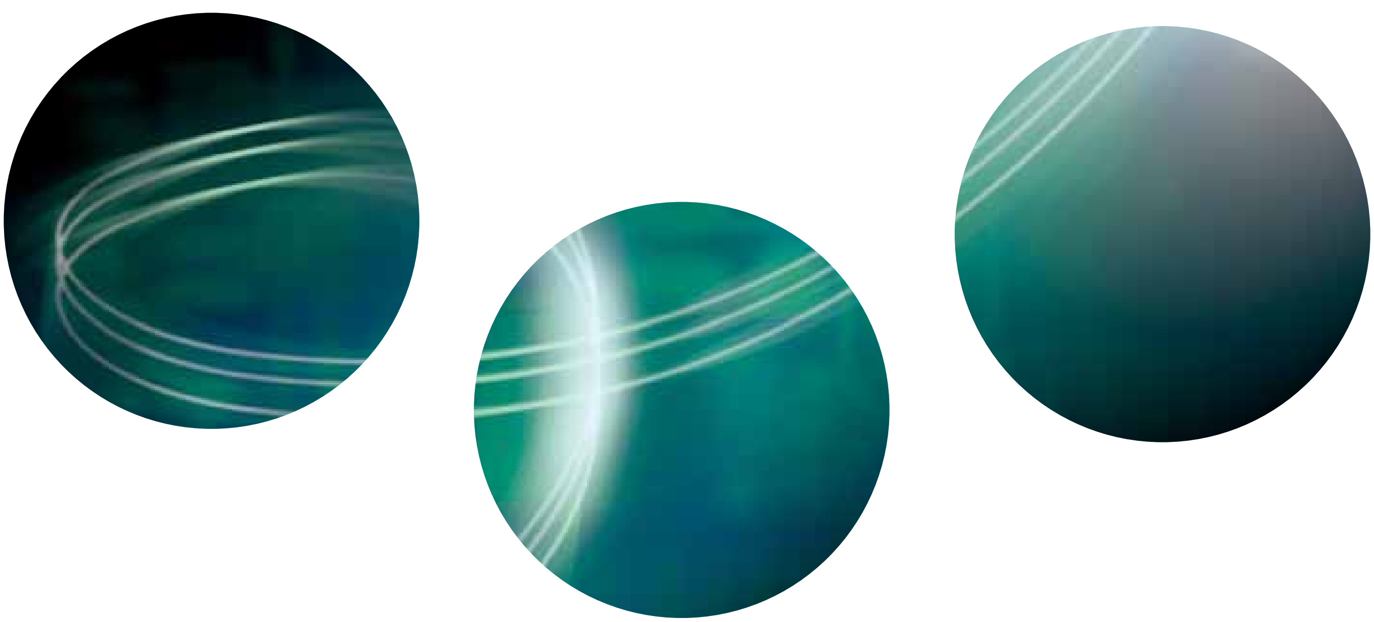
Lightwave Catalog 2005

Enabling service and device innovation
for communications and computing



Agilent Technologies

Agilent Computing and Networking Solutions

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Agilents' test solutions support the development of computer and communications devices, elements, systems and services that enable high-speed computation and communications.

Data Networking Test

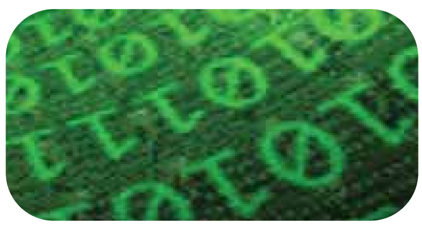
- **Transport Test**
- **Routing and Switching**
- **Layer 4-7**

Multi-services test solutions for converging network infrastructure, enable the acceleration of next-generation triple-play devices from backbone, metro, enterprise, access, to backplanes.

Digital Verification Solutions

- **Computer Protocol Test**
- **Physical Layer Test**
- **Storage Area Networking**

Digital microwave solutions (BERTs, DCAs, PCI Express) for high-speed communications buses and backplanes allow more complete characterization of new devices and designs.



Broadband Infrastructure Test

- **Broadband Infrastructure Deployment**
- **Triple Play Service Test**
- **Optical Component Test**

Optical, electrical, protocol and service level testing for the installation, commissioning and troubleshooting of triple play services and infrastructure. Photonic testing of next generation low cost optical devices.

Introduction

Enabling Service & Device Innovation For Communications & Computing

The increasing availability of mobile phones with video capability, wireless PCs, cable services such as VoIP (Voice over Internet Protocol) and entertainment programming from telecommunications companies drives the need to converge previously disparate technologies - voice, video and data - into one network architecture. Triple-play is the new game in town, and ubiquitous high-speed computation and communication become the enablers of the digital lifestyle.

Agilent´s test solutions support the development of computer and communication devices, elements, systems and services that enable high-speed computation and communication:

- Data Networking Test
- Digital Verification Solutions
- Broadband Infrastructure

Today our test portfolio includes: multi-services test solutions for next-generation triple-play devices with backbone, metro, enterprise and internet access; digital microwave solutions (BERTs, DCAs, PCI Express) for high-speed communication buses and backplanes; optical, electrical, protocol and service level testing for the installation and commissioning of broadband and triple-play services and infrastructures; photonic testing of next-generation low-cost optical devices.

These products demonstrate our commitment to creating innovative optical communications test solutions early in the market life cycle and at competitive prices.

Whatever your role in the world of optical high-speed computation and communications, whether you design, build and test basic components, deliver complete systems or provide integrated subscriber services, Agilent's 2005 Lightwave Catalog has the right test solution for your specific needs. We would be pleased to be at your service with our technical expertise, love of innovation and appreciation of quality to enable you to reach your business goals and allow your customers to enjoy a next-generation digital lifestyle.

Werner Hüttemann
Vice President and General Manager
Computing and Networking Solutions Business Unit

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An acknowledged world leader in the field of computer and communications device testing with more than twenty years' experience in optical measurement technology, Agilent offers a wide range of innovative test and measurement solutions to accelerate the progress of next-generation intelligent optical networks and enable high-speed computation and communications.

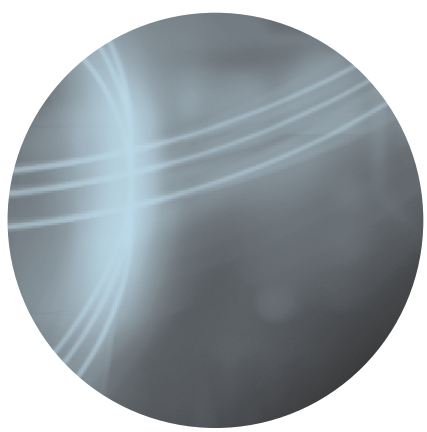
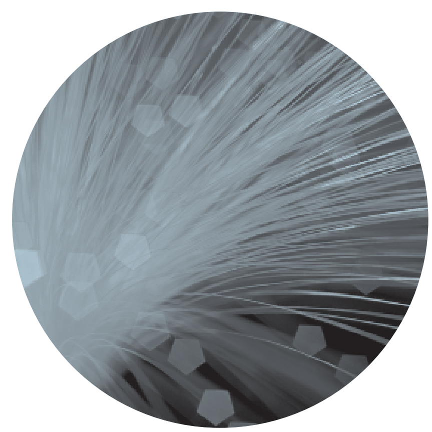
OPTICAL AND PHOTONICS TEST – ENABLING BROADBAND INFRASTRUCTURE

HIGH QUALITY CHARACTERIZATION – DONE QUICKLY

ACCELERATING TRIPLE PLAY SERVICE DEPLOYMENT

LITERATURE AND SERVICE

Optical and Photonics Test – Enabling Broadband Infrastructure

Gigabit Ethernet and Fibre Channel

Fiber optic technology is increasingly being adopted into short reach applications such as Ethernet-LAN and computer-peripherals interfacing to allow maximum data transfer rates in segments like Gigabit Ethernet (GbE) and Fibre Channel (FC). Accompanying progress in IEEE standardization, manufacturers have been developing and commercializing optical components to serve the needs of these segments.

It is a common goal of the industry to minimize the price of the optical components, especially optical transceivers, in order to speed up their adoption. This creates a price competitive situation in the market and demands improvements in component manufacturability.
These short-reach segments typically use multimode fiber, with signal wavelengths of 850 or 1310 nm. Multimode transmission at high data rates is possible over these shorter distances and helps to reduce costs and simplify installation and maintenance.

Optimizing test and measurement allows improvement of throughput and yield to reduce cost of sales. As manufacturing matures, key specification parameters are only evaluated in fully automated systems, even using "plug-and-play" production lines to further lower operation costs.
An example for an optimized test system for optical transceivers is shown in Figure 1.

Tx/Rx Test **Frequency Resp. Test**

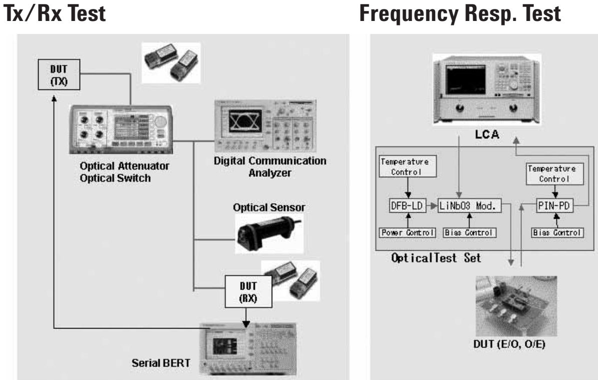


Figure 1. GbE and FC Solution

Passive Optical Network

The last mile of telecommunications fiber deployment to the home and office, fiber-to-the-home (FTTH) and premises (FTTP), is today being achieved with passive optical networks (PON). Broadband service above 100 Mb/s is now privately used at an affordable price range of <100$/month. The dream of broadband access is coming true. Fiber optic technology provides voice, data and even video over a single fiber.

The Passive Optical Network (PON), as standardized by the ITU, provides bi-directional operation from multiple optical network units (ONU), located at or close to the users, to an optical line terminal (OLT) at the provider end of the network. Splitters are used to distribute the connection to all of the ONU, which take turns communicating with the OLT. The transmitter at the customer side uses a wavelength near 1310nm, while signals to the customer are at 1490 or 1550nm or both.

Characterization of basic components such as the transmitter and receiver of the ONU and ONT assures proper performance of the network. The physical layer test of the ONU and OLT is illustrated in Figure 2, where the device performance in the network is simulated. A combination of spectral and amplitude characterization of CW signals (like Tx power and wavelength or filter isolation), time-domain measurements (rise/fall time, extinction ratio) and bit-error rate for overall performance provides a complete test environment for the transceiver modules of the ONU and OLT.

ONU/ONT Module Functional Test

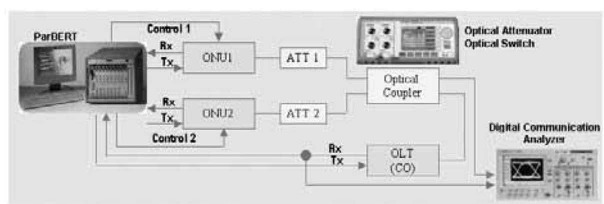


Figure 2. PON Solution

Coarse Wavelength Division Multiplexing
Improvements in the bandwidth of access network, including commercialization of FTTx, are expected to increase the push for expanded metro area network (MAN) development. Coarse wavelength division multiplexing (CWDM) is often the technology of choice for the MAN, allowing use of the complete single-mode fiber wavelength range over unamplified spans while keeping down the costs of the transmitters and wavelength multiplexers.

The CWDM concept of spacing the wavelength channels 20 nm apart is also adopted for the LX-4 method of multiplexing 4 wavelengths in the O-band over multimode fiber to provide 10 Gb/s parallel transmission over spans too long for 10Gb/s serial transmission.

Avoiding crosstalk between the CWDM signals requires the wavelength filters to have high isolation. Measuring this isolation with a tunable laser source (TLS) can be hindered if the spontaneous emission, SSE, is not sufficiently suppressed. The wide pass band of CWDM filters can transmit too much SSE. Using tunable lasers, configured to the desired wavelength range and optimized for low SSE and high power stability for spectral characterization provides high dynamic range of >75dB and allows simultaneous measurement of multiple output channels, including polarization dependence with fast swept-wavelength measurements. Ease of customization for automated manufacturing test is supported with Agilent's software library such as Plug&Play drivers to allow minimum investment cost for maximum operational efficiency.

WDM Test

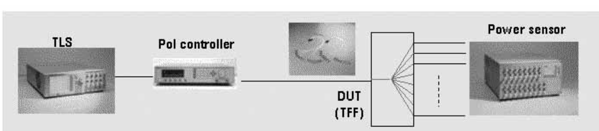


Figure 3. CWDM test solution

WDM Networking at 10Gb/s and Beyond
WDM networks are deployed to enhance bandwidth and connectivity, including to countries still in need of a modern communications infrastructure. Optimization of optical components and fibers in these high-performance networks is required to provide cost-effective networks and assure reliability. The amount of traffic carried by the fiber is increased by adding channels (with closer spacing) and raising the data rates.

The high channel count and close spacing of DWDM systems require tight control of multiplexer isolation, demanding high-dynamic testing with low-SSE tunable lasers to measure the channels in parallel for speed and low cost. Operation over long spans and multiple amplifiers also requires assurance of low PDL in components for signal stability. This can be provided by swept-wavelength measurements using the Mueller Matrix method with the setup above, including polarization control.

Assuring that the fiber and components serve not only the need of today but also the next five to ten years, expandable to 10Gb/s and beyond, also requires control of dispersion, both chromatic dispersion and polarization mode dispersion. These are primarily properties of the fiber, but also in components like filters to a sufficient degree to impede signals at 40Gb/s and sometimes already at 10Gb/s.

Agilent's 86038B Polarization Dispersion and Loss Analyzer (PDLA) gives the performance needed in testing all parameters of IL, PDL, GD, DGD, CD and PMD, and can be configured for any wavelength from 1260 to 1640nm, as shown in Figure 4.

Polarization Dispersion and Loss Test

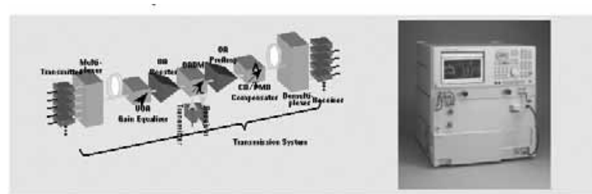


Figure 4. Component and Network Test for 10Gb/s and beyond

Signal transmission over optical fibers relies on preserving the waveform from transmitter to receiver. But when light goes through optical fibers, the timing of the pulses can be smeared by fiber dispersion. Chromatic dispersion (CD) delays the signal depending on the wavelength of the light and polarization mode dispersion (PMD) makes the delay dependent on the polarization of the light. Because a signal is distributed over a range of wavelengths and polarization, the pulses become dispersed. Although this group delay (GD) actually varies by small amounts, the short duration of the pulses, or bits, at today's high data rates makes this significant. For example, the bit duration of a 10 Gb/s signal is only 100 ps.

Dispersion must be considered and sometimes even compensated in the design of optical networks. The attainable transmission distances are limited by the amount of total dispersion. Calculations for the accumulation of CD and PMD along a link are detailed in IEC 61282-7 and IEC 61282-3, respectively, from the International Electrotechnical Commission. The tolerable dispersion depends primarily on the data rate. The amount of tolerable dispersion, related to the dispersion penalty parameter, also depends on the width of the wavelength range (linewidth) used by the signal. This linewidth increases with data rate, but also increases if the transmitter wavelength shifts with modulation, called chirp. Time-resolved chirp measurement is described in IEC 61280-2-10.

Methods have been developed and standardized for measuring CD and PMD in fibers, and recently also for other optical components, which bring other requirements like higher wavelength resolution. The IEC standard 60793-1-42 describes measurements for CD in fibers while IEC 60793-1-48 details methods for fiber PMD. Recently, to reduce test costs and enhance accuracy, instrumentation has been developed to obtain CD and PMD from the same measurement. This is done by measuring GD dependence on both wavelength and polarization. One of the methods used in the Agilent 86038B Photonic Dispersion and Loss Analyzer, is well known as modulation phase shift (MPS) and is already included for CD in IEC 60793-1-42, as well as a draft document for PMD test in links, to be IEC 61280-4-4. The other newer method, swept-wavelength interferometry, is used in the Agilent 81910A All-Parameter Analyzer and is especially powerful for high-resolution analysis of optical components.

Accuracy of CD Measurements Depends on Resolution

Methods like MPS measure relative GD, the difference in delay from one GD measurement to the next, expressed in ps. Varying the wavelength between each measurement results in a spectrum of relative GD vs. wavelength. So the parameters whose uncertainty can be directly specified are GD and wavelength. For fibers, and devices used to compensate fiber dispersion, the rate of GD change over wavelength, the CD, is needed and expressed as ps/nm. For fiber the CD per length, ps/nm-km, is useful as CD scales with length. So how can CD measurement uncertainty be derived from the instrument specifications?

The CD uncertainty has a contribution due to GD uncertainty and another due to relative wavelength uncertainty. As illustrated in Fig. 1, the CD uncertainty also depends upon the wavelength step over which the GD slope is determined; the CD uncertainty can be reduced by using wider wavelength resolution. As a formula:

$$D = \frac{\Delta\tau}{\Delta\lambda} \quad \text{and} \quad \varepsilon_D = \frac{1}{\Delta\lambda}\,\varepsilon_{\Delta\tau} + D\,\frac{\varepsilon_{\Delta\tau}}{\Delta\lambda}$$

where the dispersion is *D*, the change in GD and wavelength are $\Delta\tau$ and $\Delta\lambda$ and the uncertainty for each parameter is given by ε. The dispersion uncertainty depends on the wavelength step, $\Delta\lambda$, and the relative wavelength uncertainty contributes proportionally to the dispersion, *D*. So for measuring fibers or dispersion compensators with high CD, very high relative wavelength accuracy is important. For example, if relative GD uncertainty is ±50 fs and relative wavelength uncertainty is ±1 pm, then the CD uncertainty is ±0.05 ps/nm + 0.1% for 1-nm resolution but ±0.005 ps/nm + 0.01%, averaged over 10 nm resolution. For a fiber with 1000 ps/nm CD, about 60 km standard single-mode fiber, this would be ±1.05 ps/nm or ±0.105 ps/nm, respective of the resolution. The GD uncertainty itself can also be significantly reduced by smoothing over points taken within the chosen resolution window.

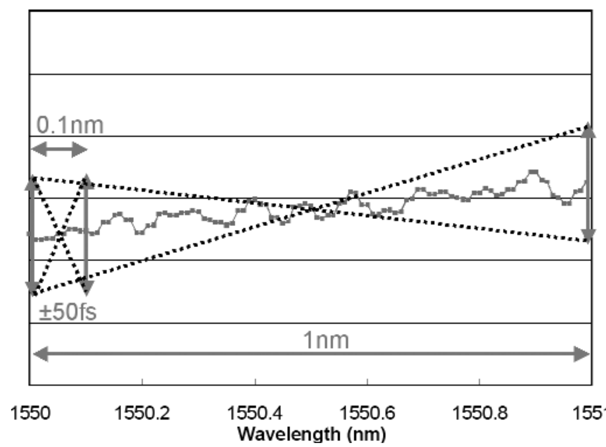


Figure 1. Group delay spectrum showing how the uncertainty in the CD, the slope, depends on the chosen wavelength resolution.

Fiber PMD Accuracy Depends on Wavelength Range

Polarization-resolved GD can be used to obtain the differential group delay, DGD. The DGD value gives the delay time difference between the fast and slow polarization states in the fiber and is also expressed in units of ps. The DGD of fiber usually varies with wavelength, and the DGD at the wavelength of a signal determines the amount of its degradation. However, as explained below, for fiber it is also important to determine the average DGD over a wide wavelength range. This average is called PMD.

The wavelength dependence occurs because the signal polarization changes along the fiber differently depending on the wavelength, so the fast and slow axis of the fiber segments are aligned differently for different wavelengths. When the alignment is higher, the segments tend to add together, while anti-aligned segments cancel each other, reducing the total DGD.

The DGD of a fiber also changes with time, because environmental effects like temperature and stress change the optical properties of the fiber along its length, and also the way the polarization of the light changes along the fiber. The DGD spectrum measured one day may not be the same as that measured at a later time. Any measured DGD value could occur at any other wavelength at another time.

Because of this variability with time, an "average" value, PMD, is used to calculate the probability of the DGD exceeding the tolerance level of the network. The PMD parameter represents the DGD spectrum and its time dependence with a single value. The statistical behavior of PMD also means that doubling the fiber length does not double the PMD. Instead it increases with the square root of length and the fiber PMD coefficient is given in units of ps/km$^{-1/2}$. A typical PMD limit for 10 Gb/s signals is 10 ps or 10% of the bit duration.

DGD can be averaged over time or wavelength to determine PMD. But time averaging is impractical because the DGD may only change on a time-scale of days or slower. This means that a tolerable measurement duration usually does not give a sufficient sample of the possible DGD behavior. Instead, PMD measurement methods average DGD over wavelength, requiring a wavelength range giving adequate sampling. The necessary range is found to depend on the PMD value itself [1]. Fig. 2 shows DGD spectra for two fibers with different PMD levels, although from the same loose-tube buffer with 2.5 km length. The DGD varies more rapidly over wavelength when the average value is higher. Obviously the measured average value depends on the actual wavelength range chosen and for lower PMD, a wider wavelength range must be sampled. While a measurement gives an "accurate" measure of the fiber PMD for a certain wavelength range at a given time, the validity of this PMD value at a later time depends on sufficient sampling.

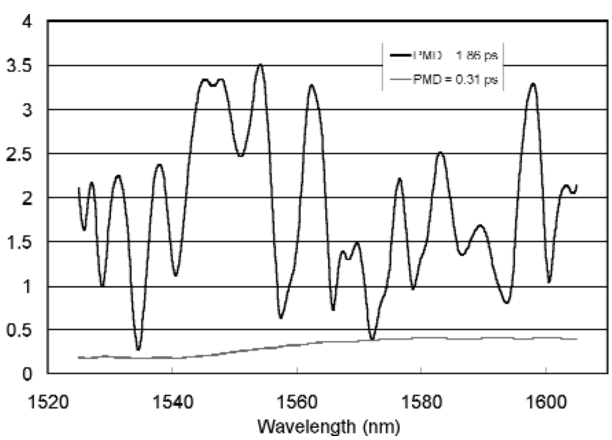


Figure 2. Differential group delay spectra for two 2.5-km fibers, showing how the variation over wavelength depends on the average level.

This corresponds to analysis indicating an uncertainty contribution for PMD measurement, ΔPMD, with limited wavelength range according to:

$$\frac{\Delta PMD}{PMD} = \frac{\alpha}{\sqrt{PMD * 2\pi * \Delta f}}$$

where Δf is the measurement range (expressed as frequency) and α is a constant (0.9 in Ref. [1] and 1.12 in Ref. [2]). For some sample PMD values and measurement ranges, the resulting uncertainty is given in Table 1, using a=1.12.

Table 1. Relative PMD uncertainty due to finite wavelength range, BW, of measurement. Results calculated for measurements centered at 1550 nm using α=1.12.

Relative PMD	BW=10nm	BW=50nm	BW=100nm	BW=200nm
Uncertainty	Δf=1.25THz	Δf=6.25THz	Δf=12.5THz	Δf=25THz
PMD=0.1ps	±130%	±56%	±40%	±28%
PMD=1.0ps	±40%	±18%	±13%	±8.9%
PMD=10ps	±13%	±5.6%	±4.0%	±2.8%

Interaction of CD and PMD in Measurement Accuracy

CD and PMD together in a device add additional sources of uncertainty to dispersion measurements, which can be reduced by simultaneous CD and PMD measurement. First, the DGD contributes directly to the GD uncertainty ε_τ, if the polarization of the test signal is not controlled or averaged. The contribution to CD uncertainty is given by:

$$\varepsilon_D = \pm \frac{DGD}{\Delta\lambda}$$

which would be an average contribution of ±1 ps/nm, at 1-nm resolution, for a fiber with 1 ps PMD; a major contribution. But measuring the polarization dependence of the GD and using the polarization-averaged GD values can eliminate this error.

However, since signals are polarized, using polarization-averaged GD to determine CD, is only valid if the GD slope is the same for any given polarization. But the GD curve for fixed input polarization can be tilted with respect to the average. This polarization-dependent CD can be determined if the instrumentation also measures the way PMD depends on wavelength, known as 2nd-order PMD. This is an advantage over measurements that only determine average PMD.

CD primarily affects DGD or PMD uncertainty by converting wavelength uncertainty or instability into delay uncertainty. For a 1000 ps/nm CD fiber, a 1 pm wavelength uncertainty makes 1 ps DGD uncertainty. Especially in swept-wavelength DGD measurements, which are very desirable for speed purposes, high wavelength accuracy and repeatability are important.

The Role of Speed and Stability

Optimizing measurement speed can reduce uncertainty. Fast measurements help stability and reduce costs, but increasing the averaging with more measurement time reduces the uncertainty. In many GD measurements, the uncertainty is statistical noise, so that doubling the time reduces uncertainty by a factor of $\sqrt{2}$. The benefit of averaging depends on the stability of both instrumentation and fiber. Consider particularly the effect of temperature on the fiber GD, which changes by about .001% with a 1°C temperature change. Then a 20 km fiber, which has about 100 µs GD, will change by about 1ps/s when the temperature changes 4°C/hour. Thus temperature stability is very important, both in the instrument and tested device. Measuring shorter lengths of fiber reduces this problem, to the extent allowed by fiber homogeneity. But using measurements of short fibers to calculate for longer spans requires a higher accuracy in the measurement, and wider wavelength range for PMD measurement. Which loops us back to the importance of these measurement specifications!

References

[1] N. Gisin, et al., “How Accurately Can One Measure a Statistical Quantity Like Polarization-Mode Dispersion”, IEEE Photon. Technol. Lett. 8, 1671 (1996).
[2] M. Shtaif and A. Mecozzi, “Study of the frequency autocorrelation of the differential group delay in fibers with polarization mode dispersion”, Opt. Lett. 25, 707 (2000).

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Flexible
Modular instrumentation to generate the best fit for each application

Scalable
The right form factor for each setup in R&D and manufacturing

Efficient
Plug&Play drivers and the Photonic Foundation Library from Agilent provide a variety of application functions for increased measurement performance

Fast
Modules and controllers optimized for high test speed and data throughput

Ergonomic
High contrast displays and convenient controls for enhanced bench top usability

Lightwave Multimeter


Lightwave Multichannel System


Tunable laser modules
(Use with 8164B mainframe)


Compact tunable laser modules


Distributed feedback (DFB) laser modules

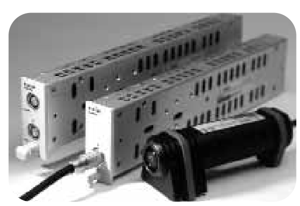

Fabry-Perot laser modules


Attenuator modules


Switch modules


Return loss modules


Power sensor modules


Optical heads


Lightwave Measurement System

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Optical Component Test	Passive Component Test													Optical Amplifier Test			Bit Error Ratio Test		
	Mux/DeMux/V-Mux	TFF Test	FBG Filter Test	Connector Test	Switch Test	TFF Align-/Adjustment	Fiber to AWG Alignment/AWG Chip Test	Coupler/Splitter/Combiner	Isolator/Circulator	Variable Optical Attenuator	Gain Flattening Filter	Dispersion Compensators	Interleaver	EDFA	Raman Amplifiers	SOA	Rx/Tx	Line Card	System Test
Tunable Laser 81600B OPT 200, 160, 150, 140, 130	•	•	•		•	•	•	•	•	•	•	•	•						
Hi Power Tunable Laser OPT 142, 132					•			•	•	•	•	•	•	•	•	•			
Compact Tunable Laser 81980A/81940A/81944A 81689A/81949A					•			•	•	•	•	•	•	•	•	•	•	•	•
Distributed Feedback (DFB) Laser 81662A, 81663A														•	•	•			•
Fabry-Perot Laser 81650A/51A/54A 81655A/56A/57A				•	•	•	•	•	•										
Power Meter 81630B/34B/35B/36B	•	•	•	•	•	•	•			•	•	•	•	•	•		•	•	•
Optical Heads 81623B/24B/26B/28B						•		•	•	•	•	•	•				•	•	•
Return Loss Modules 81610A/81613A			•	•	•	•	•	•	•	•	•	•	•	•					
Attenuator 81670A/71A/76A/77A/78A														•	•	•			
Switches 81591B/94B/95B	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Polarization Controller 8169A	•	•	•		•		•	•	•	•	•	•	•	•		•			
Mainframes																			
8163B				•		•		•	•	•						•		•	•
8164B	•	•	•		•		•	•	•	•	•			•	•	•	•	•	•
8166B	•				•		•							•	•		•	•	•
All Parameter Test 86038B	•	•	•						•	•	•	•	•						

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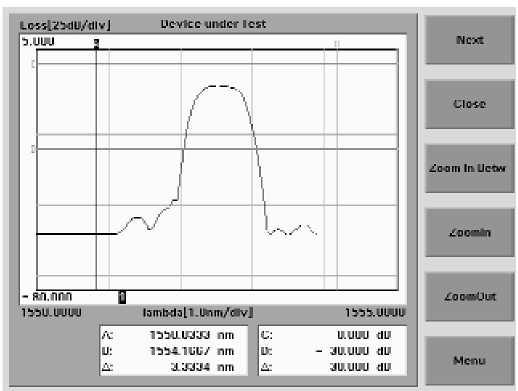
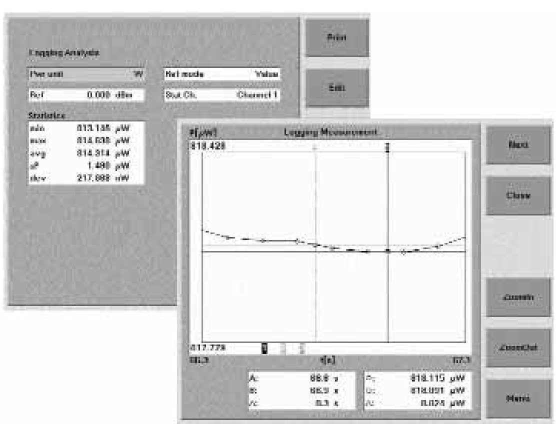
- **Benchtop and smart carry-along instrument**
- **Ready-to-use applications for ease of operation**
- **Cost effective solution for component test**
- **High-contrast color display**
- **Backward compatible with 815x and 816x-series modules**

The Agilent 8163B – Modular Stimulus-Response Solutions with Excellent Performance

The two slots Agilent 8163B lightwave multimeter is one of the basic measurement tools in the fiber optics industry. Its modularity and compact format make it flexible enough to meet changing measurement needs, whether measuring optical power and loss with laser and power meter modules or using attenuator and switch as signal conditioning.



Insertion loss test result using laser source and power meter



Logging application for flatness and PDL test

Built-In Applications

- Passive component test (PACT) — test pigtailed or connectorized devices over all wavelengths with a compact tunable laser module and a power meter module
- Return loss/loss — measure the return loss and insertion loss of your devices with one of the 8161xA return loss modules and a power meter module
- Stability — check the long term power stability of the device under test with a source module and a power meter module or power head
- Logging — perform statistical analysis on the power readings of your device

Easy-Hands-On and Remote Operation

At one glance you get all information about instrument settings on the high-contrast color display. The wide viewing angle allows for clear readings, even when the instrument cannot be placed right in front of you. Its compactness and light weighted body is a smart and portable solution for manufacturing. When the need of system automation is considered for advanced manufacturability, GPIB and RS-232C ports together with Agilent's software library support easy system integration.

Signal conditioning operation for active component

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- **High speed, high power, high dynamics measurement for passive component test**
- **Ready-to-use application for ease of operation**
- **Remote control for system automation**
- **Backward compatible with 815x and 816x series modules**

Agilent's spectrum analysis solution compared with conventional solution

The Agilent 8164B – The Platform for Testing Fiber Optic Components

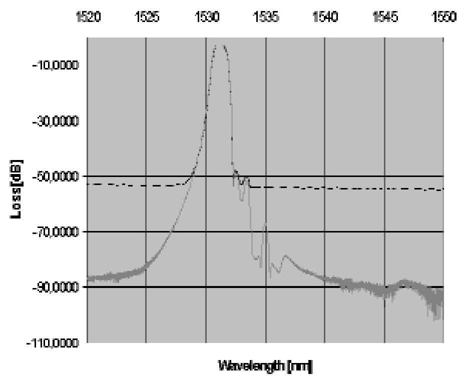
The Agilent 8164B Lightwave Measurement System supports a wide range of tunable laser modules together with measurement capabilities of up to 8 channel power meter ports in one-box, to fit into today's requirement of AWG and CWDM applications. Its GPIB and RS-232C ports provide connectivity for remote controlling capability that can be utilized for system automation supported with Agilent's software library. For easy standalone operation of the 8164B, a 3.5 inch floppy disk drive, VGA port, PS/2 keyboard connector, and parallel printer port are provided.

Built-In Applications

- Passive component test (PACT) — test pigtailed or connectorized devices over all wavelengths with an Agilent tunable laser module and our power meter modules
- Stability — check the long term power stability of your device with a source module and a power meter module or power head
- Logging — Perform statistical analysis on the power readings of your device. Save the results to disk or print out a hardcopy

High Speed, High Power, High Dynamics

High standard performance is compressed within a small compact form, a factor of Agilent's lightwave mainframe that enables optical component research and development for new technology. Such challenge can only be solved with minimum measurement uncertainties by analysing spectral characteristic of device under test with >70 dB dynamic range and pico-meter wavelength accuracy in loss properties such as IL, RL, and PDL. The same is true for dispersion property in a component supporting higher data rates. All these capabilities are supported in one-box.



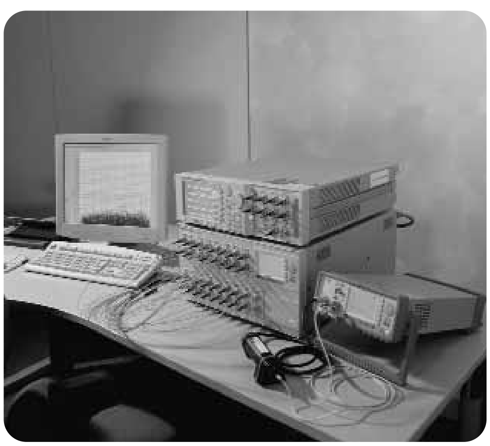
Agilent's spectrum analysis solution compared with conventional solution

Improve Cost of Manufacturing

Optical component markets are matured and competitive price is a key success factor to win market share. The Agilent 8164B is especially designed for component manufacturing with it's flexibility of pluggable modules that provide the test environment for multiple applications. Today's tests need for WDM component, for example, can be easily reconfigured to fit the need of production in amplifier tests by just changing its modules, saving extra cost for an additional mainframe. Ease of manufacturing automation with Agilent's Plug&Playsoftware library supported with the mainframe also plays an important role in return of instrument investment by improving yield and volume production.

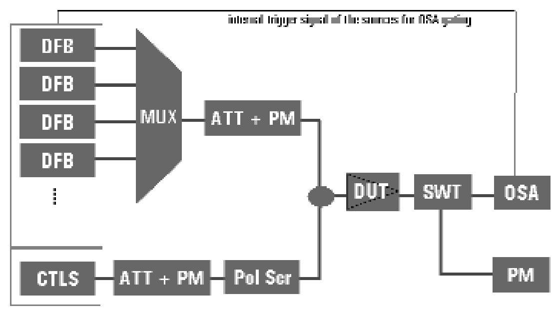
- **Extender platform to flexibly adjust high channel-count applications**
- **Variety of plug-in modules for optimized setup**
- **Synchronize with laser module for simultaneous measurement**

The Agilent 8166B – Lightwave Multichannel System
The Agilent 8166B lightwave multichannel system is the mainframe of choice for applications that involve testing high-channel count devices or devices with a need for a complete array of sources or sensors.
For multi-port device such as WDM component, the ability to synchronize with tunable laser source even with other mainframe ensures simultaneous data logging at all plugged power meter. The platform offers 17 slots which can be equipped with any combination of modules to configure your own research and manufacturing test system.



40ch spectrum analysis synchronizing tunable laser source and power meter

Flexible Module Configuration for Complex Manufacturing Line
Simple configuration of instrument for one test parameter adds up and creates complex mechanism of manufacturing line when tests are moved from R&D to Production. Integrating all necessary test instruments into one box can minimize such complexity. General setup of EDFA can be build with a series of DFB bank together with switch, attenuator, and power meters. The Agilent's 8166B hosts 17 slots with customer specific module configuration.

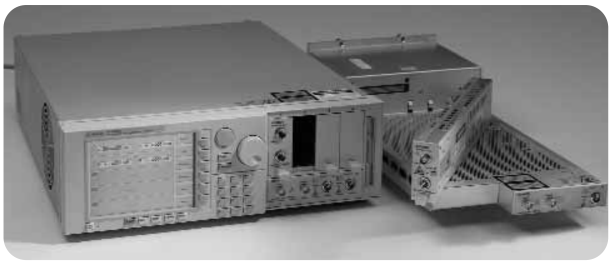


EDFA test system with configurable channel count

Further more, complexity of system configuration in manufacturing environment could induce operational mistake and a need of engineering skill for operation. One advantage of configuring all necessary test instrument into one box is to crease an environment for ease of integration. GPIB and RS-232C ports together with Agilent's software library lower integration and maintenance cost of system. Same process and procedures are repeated constantly without any human error by just clicking single button for setting, measurement, report.

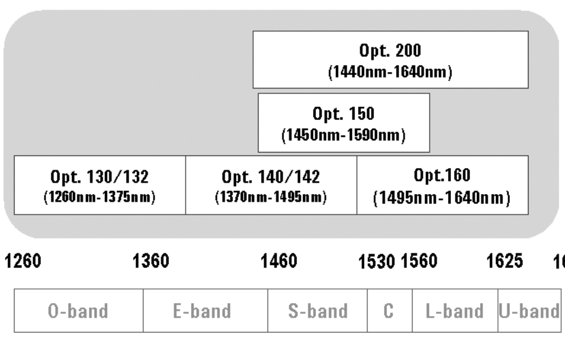
www.agilent.com/find/lightwave

- **Complete wavelength coverage from 1260 nm to 1640 nm**
- **Low SSE output for high dynamic range**
- **Built-in wavelength meter for high wavelength accuracy**
- **Sweep speeds up to 80 nm/s to reduce test times**
- **No compromise of measurement accuracy for sweep speed**



Tuning Range from 1260 nm to 1640 nm

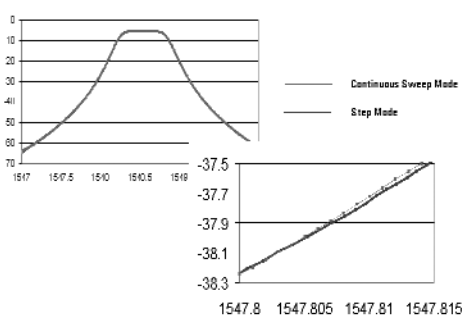
Agilent offers a family of tunable laser sources to cover the wavelength range of 1260 nm to 1640 nm. Whether you are measuring Dense Wavelength Division Multiplexing (DWDM) devices or a WDM device, such as an LX4 component for 10 Gigabit Ethernet, Agilent has a laser to fit your testing needs.



Agilent TSL portfolio

It Sweeps as Precisely as it Steps

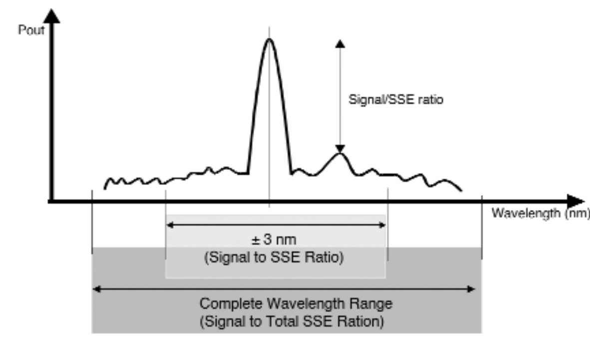
As manufacturing yields become more demanding it is critical for your test instruments to have optimal performance for any measurement condition. The 81600B offers several sweep speeds up to 80 nm/s without compromising measurement accuracy. In contrast to other lasers, the 81600B sweeps with the same precision as it steps; without the use of an external wavelength-tracking filter. No compromise on sweep speed.



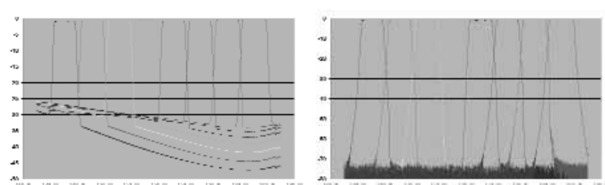
No compromise on sweep speed

Advantage of Using Suppressed Laser Noise (SSE)

Source Spontaneous Emission (SSE), the sum of all spontaneous emissions inside the laser diode of the tunable laser, is broadband light output in addition to the monochromatic laser line. This emission limits the noise floor of the tunable laser, which, in turn, limits the dynamic range of your measurements. The Agilent tunable laser source offers a low signal to source spontaneous emission ratio. For you, this means more dynamic range to enable your measurements to completely characterize DWDM devices with high channel isolation.



Agilent laser noise definition



Low SSE and high power measurement result

Reduce Cost of Test

For DWDM components, high wavelength accuracy and dynamic range are most important. For CWDM components, a wide wavelength range, high power stability, dynamic range and low cost targets are key. Agilent's state-of-the-art tunable lasers meet the demanding requirements of high tech optical manufacturing facilities with fast sweep speed, high wavelength accuracy and power stability. This will reduce your test time while increasing your throughput, hence, reducing the cost of test in manufacturing to give you the competitive advantage.

Protect your Investment

Upgrade your earlier model Agilent tunable laser (8164xA/B, 8168xA/B) to the latest 81600B.

TLS Upgrade Option

From	to 81600B#200
81640A/B	
81680A/B	
81480A/B	#UG1
81642A/B	
81682A/B	
81482B	

	132/142	130/140/150/160	200
Output Power, peak (typ)	≥+9/+8.5dBm	Output 1: ≥-4/-4.5/-1/-2dBm Output 2: ≥+5/+5.5/+7/+7dBm	Output 1: ≥+3dBm Output 2: ≥+9dBm
Signal to SSE ratio	≥45/42dB/nm	Output 1: ≥63/63/65/64dB/nm Output 2: ≥42/42/45/45dB/nm	Output 1: ≥70dB/nm Output 2: ≥48dB/nm
Signal to total SSE ratio	≥28dB	Output 1: >58/60/60/59dB Output 2: ≥26/28/30/27dB (typ)	Output 1: ≥65dB Output 2: ≥30dB (typ)
Wavelength Repeatability		±0.8pm, typ ±0.5pm	
Wavelength Stability (typ)		£±1pm (24h)	
Power Repeatability		±3mdB (typ)	

Parameter	Common to all family products			
	Stepped Mode	Continuous sweep mode (typ.)		
		at 5 nm/s	at 40 nm/s	at 80 nm/s
Abs. wavelength accuracy	±10pm, typ. ±3.6pm	±4.0pm	±4.6pm	±6.1pm
Rel. wavelength accuracy	±5pm, typ. ±2pm	±2.4pm	±2.8pm	±4.0pm
Dyn. wavelength repeatability	±0.8pm typ. ±0.5pm	±0.3pm	±0.4pm	±0.7pm
Dyn. power reproducibility		±0.005dB	±0.001dB	±0.015dB
Dyn. Rel. power flatness		±0.01dB	±0.02dB	±0.04dB

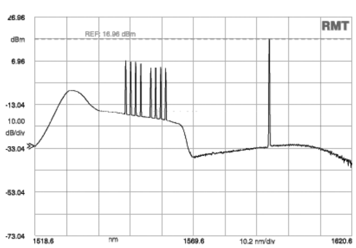
- **Modular design for multichannel platform**
- **110 nm coverage in one module**
- **Device characterization at high power levels +13 dBm**
- **SBS suppression feature enables high launch power**
- **Built-in wavelength meter for active wavelength control**
- **Dynamic power control for excellent repeatability**

High Power Compact Tunable Lasers for S-, C- and L-band

The Agilent 819xxA compact tunable laser sources supply an output power of up to +13dBm. Each module covers a total wavelength range of 110nm, either in the S+C-band with the high power in C (81980A and 81989A), or in the C+L-band with the high power in the L-band (81940A, 81944A, 81949A).

Device Characterization at High Power Levels

The high optical output power of the 819xxA tunable lasers enhances test stations for optical amplifier, active components and broadband passive optical components. It helps overcome losses in test setups or in the device under test itself. Thus, engineers can test optical amplifiers such as EDFAs, Raman amplifiers, SOAs and EDWAs to their limits. These tunable lasers provide the high power required to speed the development of innovative devices by enabling the test and measurement of nonlinear effects.



Stimulated signal spectrum with one controlling channel of tunable laser source

SBS Suppression Feature Enables High Launch Power

The new SBS-suppression feature prevents the reflection of light induced by Stimulated Brillouin Scattering (SBS). It enables the launch of the high power into long fibers without intensity modulation, which is detrimental in time-domain measurements.

Compact tunable laser source with dual power meter in one box

Coherence Control Reduces Interference-Induced Power Fluctuations

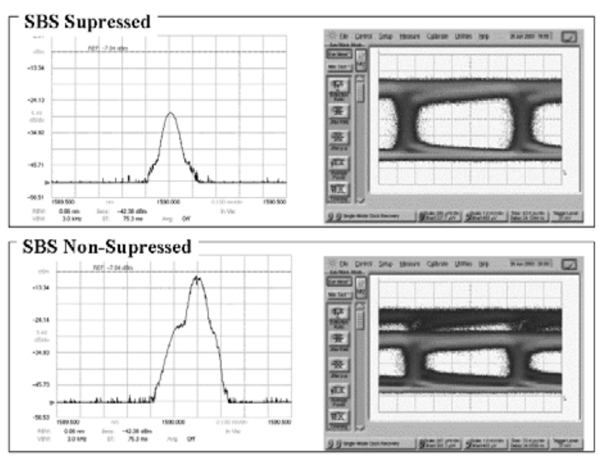
A high-frequency modulation function is used to increase the effective linewidth to reduce power fluctuations caused by coherent interference effects. The modulation pattern is optimized for stable power measurements even in the presence of reflections.

Internal Modulation

The internal modulation feature enables an efficient and simple time-domain extinction (TDE) method for Erbium-based optical amplifier test when used together with the external gating feature of the Agilent OSA. It also supports the transient testing of optical amplifiers by simulating channel add / drop events.

Cost Effective Passive Component Test

Agilent's compact tunable laser sources provide excellent wavelength and power accuracies to enable reliable swept wavelength measurement for passive component test in a cost effective way. The built-in wavelength meter with a closed feedback loop for enhanced wavelength accuracy allows dynamic wavelength logging in continuous sweep mode.
The integrated dynamic power control loop guarantees highly repeatable measurements.



Laser characteristics in long fiber with and without SBS suppression

81980A and 81989A Compact Tunable Laser Source, 1465 nm – 1575 nm
81940A and 81949A Compact Tunable Laser Source, 1520 nm – 1630 nm

	Agilent 81980A, 81940A	Agilent 81989A, 81949A
Wavelength Range	1465 nm to 1575 nm (81980A and 81989A) 1520 nm to 1630 nm (81940A and 81949A)	
Wavelength Resolution	1 pm, 125 MHz at 1550 nm	5 pm, 625 MHz at 1550 nm
Mode-hop Free Tuning Range	Full wavelength range	
Maximum Tuning Speed	50 nm/s	
Absolute Wavelength Accuracy	±20 pm	±100 pm
Relative Wavelength Accuracy	±10 pm, typ. ±5 pm	±50 pm
Wavelength Repeatability	±2.5 pm, typ. ±1 pm	±5 pm
Wavelength Stability (typ., over 24 h)[3]	±2.5 pm	±5 pm
Linewidth (typ.), Coherence Control Off	100 kHz	
Effective Linewidth (typ.),	>50 MHz for 1525 nm – 1575 nm (81980A and 81989A)	
Coherence Control On1	>50 MHz for 1570 nm – 1620 nm (81940A and 81949A)	
Maximum Output Power	+10 dBm	
(Continuous Power During Tuning)	≥+13 dBm for 1525 nm – 1575 nm (81980A and 81989A) ≥+13 dBm for 1570 nm – 1620 nm (81940A and 81949A)	
Minimum Output Power	+6 dBm	
Power Linearity (typ.)	±0.1 dB	
Power Stability[3]	±0.01 dB over 1 hour typ. ±0.0075 dB over 1 hour typ. ±0.03 dB over 24 hours	
Power Flatness Versus Wavelength	±0.3 dB, typ. ±0.15 dB	
Power Repeatability (typ.)	±10 mdB	
Side-mode Suppression Ratio (typ.)[1]	≥45 dB	
Signal to Source Spontaneous Emission Ratio[2]	≥45 dB 48 dB/nm for 1525 nm – 1575 nm (81980A and 81989A) 48 dB/nm for 1570 nm – 1620 nm (81940A and 81949A)	
Signal to Total Source Spontaneous Emission Ratio (typ.)[1]	≥25 dB ≥30 dB for 1525 nm – 1575 nm (81980A and 81989A) ≥30 dB for 1570 nm – 1620 nm (81940A and 81949A)	
Relative Intensity Noise (RIN) (typ.)[1]	–145 dB/Hz	
Dimensions (H x W x D)	75 mm x 32 mm x 335 mm	

1 At maximum output power as specified per wavelength range.
2 Value for 1 nm resolution bandwidth.
3 At constant temperature ±0.5 K.

	Ordering information
8163B or 8164B or 8166B	Light wave Measurement System (mainframe)
81980A	Compact Tunable Laser Source 1465 – 1575 nm, step and sweep mode
81989A	Compact Tunable Laser Source 1465 – 1575 nm, step mode only
81940A	Compact Tunable Laser Source 1520 – 1630 nm, step and sweep mode
81949A	Compact Tunable Laser Source 1520 – 1630 nm, step mode only

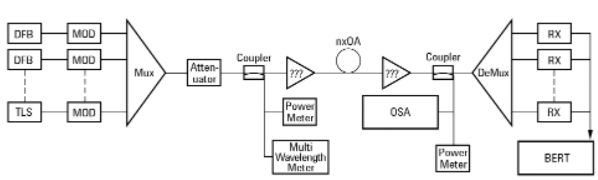
* All tunable lasers must be ordered with one connector option.
# 071 for PMF, straight output
# 072 for PMF, angled output
* One Agilent 81000xl-series connector interface is required

- **Center wavelengths from 1529 to 1610 nm**
- **Fine tuning capability ±850 pm**
- **Excellent power and wavelength stability**
- **Up to 20 mW output power**

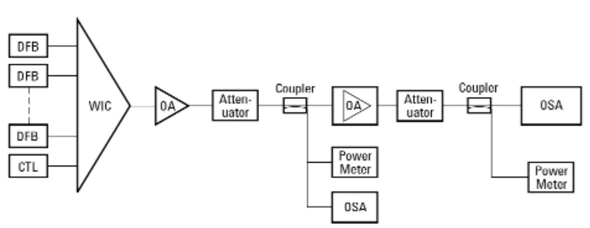
DFB Lasers for C- and L-Bands
The Agilent 81662A and 81663A DFB laser modules operate at a wavelength channel on the ITU grid within the C and L-bands. The modules can
be fine tuned by ±850 pm around this ITU channel. All modules are calibrated for constant power and wavelength to avoid drift after attenuating or detuning.

High Output Power
The Agilent 81662A modules supply +10 dBm output power where as the 81663A modules offer +13 dBm output power to overcome power penalties given in today's test setups. Their excellent power and wavelength stability is key for accurate testing of optical amplifiers, such as, EDFA, TDFA, SOA and Raman.

Applications
- Optical amplifier test
- DWDM transmission system test
- Stimulus-response measurement



Typical optical amplifier test setup



Typical DWDM transmission system test setup

Testing Optical Amplifiers
A set of DFB lasers is the ideal test load for modern optical amplifiers due to their excellent stability and price versus performance ratio. These sources address the ever increasing demand for higher stimulus power and support the trend towards higher power amplifiers.

Test of Integrated Zero Loss Devices
The migration of amplification to passive components producing, integrated zero loss devices creates new challenges for test equipment. The 81662A and 81663A DFB lasers' standard option is a PMF fiber output, bringing polarization issues under control. The DFB laser sources support the trend of waveguide based devices and integrated optics.

DFB Laser Modules for High Channel Count DWDM Systems
DFB laser modules are best suited to address the test requirements of today's DWDM transmission systems. Their fine tuning capability provides flexibility, as is sometimes desired by DWDM submarine systems, and reduced costs for spare grids. The modularity of the lightwave solution platform allows the user to easily match his test setups with the latest requirements of DWDM systems. Most importantly it leaves room for future expansions and refinements.

PnP Software Drivers for Fast Process Automation
The powerful and easy to use Plug&Play drivers allow fast implementation of complex measurement control programs.

Ordering information
Agilent DFB sources are available in the ITU Grid wavelengths from 1529.55 nm (196 THz) to 1610.06 nm (186.2 THZ) with 100 GHz spacing. For detailedorder information and special wavelengths please contact your Agilent Technologies sales representative or visit our website: www.agilent.com

Specifications

Specifications describe the instruments' warranted performance. Supplementary performance characteristics provide information about non-warranted instrument performance in the form of nominal value, and are printed in *italic*. Typical specifications are printed in **bold.**

		81662A[1]	81663A[1]
Type		CW DFB laser with built-in isolator	CW DFB laser with built-in isolator
Wavelength[2]		ITU Grid (100 GHz)	ITU Grid (100 GHz)
	Tuning Range	**typ. >±500 pm**	**typ. >±850 pm**
	Display Resolution	10 pm	10 pm
	Repeatability[3]	±3 pm **(±1 pm)**	±5 pm **(±2 pm)**
	Stability (15 minutes)[3,4]	±3 pm **(±1 pm)**	±5 pm **(±2 pm)**
	Stability (24 hours)[3,4]	**±5 pm**	**±5 pm**
Fiber Type		Panda PMF 9/125 µm	Panda PMF 9/125 µm
Output Connector[5]		Compatible to angled contact APC, ASC, DIN47256/4108	Compatible to angled contact APC, ASC, DIN47256/4108
Power	Maximum Output[6,7] CW Stability (15 minutes)[3] CW Stability (24 hours)[3,4]	**typ. >+10 dBm (10 mW)** **typ. ±0.005 dB** **typ. ±0.03 dB t**	**typ. >+13 dBm (20 mW)** **typ. ±0.003 dB** **yp. ±0.01 dB**
Side Mode Suppression Ratio (SMSR)[7]		**typ. 45 dB**	**typ. 50 dB**
Polarization Extinction Ratio (PER)		**typ. >20 dB**	**typ. >20 dB**
Dimensions		75 mm H x 32 mm W x 335 mm D (2.8 in x 1.3 in x 13.2 in)	
Weight		0.5 kg	
Recalibration Period		1 year	
Operating Temperature		15°C to 35°C	
Warm-up Time[4]		60 minutes	
Laser Classification		FDA Laser Class IIIb according to 21 CFR 1040.10 IEC Laser Class 3A according to IEC 60825-1	
Supplementary Performance Characteristics		• Internal digital modulation mode: free selection 200 Hz to 100 kHz. All output signals are pulse shaped, duty cycle 50% • Internal coherence control for linewidth broadening • ON-switching with fast output power stabilization <20 s • Output power "attenuation" at default wavelength 6 dB in steps of 0.1 dB • Tuning speed over full range 30 s • Polarization maintaining fiber orientation: TE mode in slow axis, in line with connector key	

[1] ITU-grid wavelength is shown on display as the default.
[2] Via GPIB tuning resolution <10 pm.
[3] If previously stored at the same temperature, 20 minutes.
[4] Controlled environment T = ±1°C.
[5] At maximum power setting and default wavelength at the end of a 2 m SM patchcord.
[6] Connector interface not included.
[7] Valid for serial numbers starting with prefix DE417 and above.

Ordering information

Agilent DFB sources are available in the ITU Grid from 1529.55 nm (196THz) to 1610.06 nm (186.2 THZ) with 100 GHz spacing.
For detailed order information and special wavelengths please contact your AgilentTechnologies sales representative or visit our website**: www.agilent.com**

Ordering Information

For the most up-to-date information on the 81662A and 81663A DFB tunable laser modules, please contact your Agilent Technologies sales representative.

81662A/81663A Option	ITU Frequency (THz)	Center Wavelength (nm)
309	196.00	1,529.55
311	195.90	1,530.33
313	195.80	1,531.12
315	195.70	1,531.90
317	195.60	1,532.68
319	195.50	1,533.47
321	195.40	1,534.25
323	195.30	1,535.04
325	195.20	1,535.82
327	195.10	1,536.61
329	195.00	1,537.40
331	194.90	1,538.19
333	194.80	1,538.98
335	194.70	1,539.77
337	194.60	1,540.56
339	194.50	1,541.35
341	194.40	1,542.14
343	194.30	1,542.94
345	194.20	1,543.73
347	1194.10	1,544.53
349	194.00	1,545.32
351	193.90	1,546.12
353	193.80	1,546.92
355	193.70	1,547.72
357	193.60	1,548.51
359	193.50	1,549.32
361	193.40	1,550.12
363	193.30	1,550.92
365	193.20	1,551.72
367	193.10	1,552.52
369	193.00	1,553.33
371	192.90	1,554.13
373	192.80	1,554.94
375	192.70	1,555.75
377	192.60	1,556.55
379	192.50	1,557.36
381	192.40	1,558.17
383	192.30	1,558.98
385	192.20	1,559.79
387	192.10	1,560.61
389	192.00	1,561.42
391	191.90	1,562.23
393	191.80	1,563.05
395	191.70	1,563.86
397	191.60	1,564.68
399	191.50	1,565.50
401	191.40	1,566.31
403	191.30	1,567.13
405	191.20	1,567.95

81662A/81663A Option	ITU Frequency (THz)	Center Wavelength (nm)
407	191.10	1,568.77
413	190.80	1,571.24
415	190.70	1,572.06
417	190.60	1,572.89
419	190.50	1,573.71
421	190.40	1,574.54
423	190.30	1,575.37
425	190.20	1,576.20
427	190.10	1,577.03
429	190.00	1,577.86
431	189.90	1,578.69
433	189.80	1,579.52
435	189.70	1,580.35
437	189.60	1,581.18
439	189.50	1,582.02
441	189.40	1,582.85
443	189.30	1,583.69
445	189.20	1,584.53
447	189.10	1,585.36
449	189.00	1,586.20
451	188.90	1,587.04
453	188.80	1,587.88
455	188.70	1,588.73
457	188.60	1,589.57
459	188.50	1,590.41
461	188.40	1,591.26
463	188.30	1,592.10
465	188.20	1,592.95
467	188.10	1,593.79
469	188.00	1,594.64
471	187.90	1,595.49
473	187.80	1,596.34
475	187.70	1,597.19
477	187.60	1,598.04
479	187.50	1,598.89
481	187.40	1,599.75
483	187.30	1,600.60
485	187.20	1,601.46
487	187.10	1,602.31
489	187.00	1,603.17
491	186.90	1,604.03
493	186.80	1,604.88
495	186.70	1,605.74
497	186.60	1,606.60
499	186.50	1,607.47
501	186.40	1,608.33
503	186.30	1,609.19
505	186.20	1,610.06

- **SMF with 1310nm, 1550nm or 1310/1550nm and MMF with 850nm**
- **Selectable 1mW or 20mW output power**
- **Excellent CW power stability of <±0.005dB (15 min.)**
- **Return loss test in combination with Agilent Return Loss module**

Flexible Application Fit

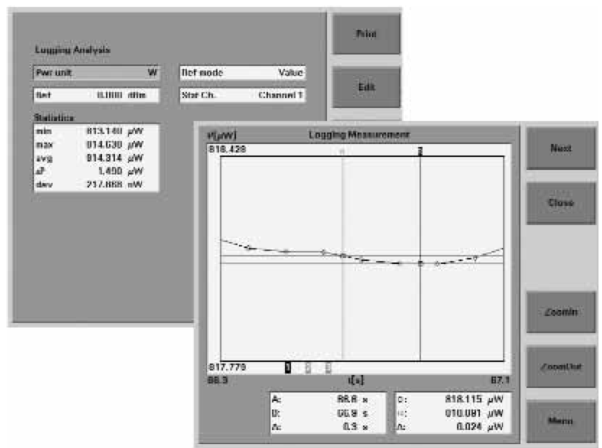
Agilent 8165xA Fabry-Perot laser source are a family of plug-in modules for Agilent's Lightwave Solution Platform. Laser module offers ideal power and loss characterization solutions for optical component and fiber with wavelength at 850nm, 1310nm and 1550nm, mainly used in optical telecommunication including today's fiber to the home (FTTH) and short reach applications such as Fibre Channel and Gigabit Ethernet.

Ideal Solution for IL, RL and PDL Tests

Combination of Agilent's Fabry-Perot laser source and wide variety of power meters (or optical heads) provides the basic setup for insertion loss (IL) characterization. Operations of single click to reference and single connection of test device immediately show results of IL. Such measurements can be continuously repeated over time with ensured laser stability of <±0.005dB to test in different environmental conditions for durability which is normally required by fiber and sub-component manufacturers. Agilent's 8161xA return loss module can utilize an external laser source such as Fabry-Perot laser to setup Return loss (RL) test. Adding Agilent 8169A Polarization Controller enables testing of polarization property of optical components.

Ease of Manual Operation

The test environment is at the same time simple and works with small footprint. Manual manufacturing operation on work-bench requires a friendly operating environment which allows users to operate without instrument training. Mainframe's built-in applications including stability, logging and PACT provide an application-fit environment for instrument operation.



Logging application for flatness and PDL test using Fabry-Perot laser module

PnP Software Drivers for Fast Process Automation

The powerful and easy to use Plug&Play drivers allow fast implementation of complex measurement control programs.

Standard modules, 0dBm

	Agilent 81650A	Agilent 81651A	Agilent 81654A	Agilent 81655A E01[5]
Type	Fabry-Perot Laser			
Center wavelength[1]	1310 nm ±15 nm	1550 nm ±15 nm	1310/1550nm ± 15 nm	850nm ± 10 nm
Fiber type	single-mode 9/125mm			Standard multi-mode 50/125mm
Spectral bandwidth (rms)[1,2]	<3.5 nm	<4.5 nm	<3.5nm/ 4.5nm	<5.0 nm
Output power	>0 dBm (1mW)			>3 dBm (2mW)
CW power stability[3,4]				
short term (15 min.)	<± 0.005 dB typ. <±0.003 dB with coherence control active			typ. <± 0.005 dB
long term (24 h)	typ. ± 0.03 dB			typ.<± 0.05 dB
to back reflection (RL ≥ 14dB)	typ±0.003 dB			
Dimensions (H x W x D)	75 mm x 32 mm x 335 mm (2.8" x 1.3" x 13.2")			
Weight	0.5 kg			
Recalibration period	2 years			
Operating temperature	0°C to 45°C			
Humidity	Non condensing			
Warm-up time	60 minutes[3]			

High power modules, 13dBm

	Agilent 81655A	Agilent 81656A	Agilent 81657A
Type		Fabry-Perot Laser	
Center wavelength[1]	1310 nm ± 15 nm	1550 nm ± 15 nm	1310/1550 nm ± 15 nm
Fiber type		Standard single-mode 9 / 125 mm	
Spectral bandwidth (rms)[1,2]	<5.5 nm	<7.5 nm	<5.5 nm/7.5 nm
Output power		>+13 dBm (20 mW)	
CW power stability[3,4]			
short term (15 min.)		<±0.005 dB typ <± 0.003 dB with coherence control active	
long term (24 h)		typ. ±0.03 dB	
to back reflection (RL ≥14dB)		typ. ±0.003 dB	
Dimensions (H x W x D)		75 mm H x 32 mm W x 335 mm (2.8" x 1.3" x 13.2")	
Weight		0.5 kg	
Recalibration period		2 years	
Operating temperature		0°C to 45 °C	
Humidity		Non condensing	
Warm-up time		60 min [3]	

[1] Central wavelength is shown on display
[2] rms: root mean square
[3] Warm-up time 20 min, if previously stored at the same temperature.
[4] Controlled environment (DT = ± 1°C).
[5] Special Option

Supplementary Performance Characteristics

Internal digital modulation mode

270 Hz, 330 Hz, 1 kHz, 2 kHz and free selection 200 Hz to 10 kHz.

All output signals are pulse shaped, duty cycle 50 %.

Internal coherence control for linewidth broadening

Output attenuation

The output power of all source modules can be attenuated from 0dB to 6dB in steps of 0.1 dB.

Agilent 8163xA/B and 8162xB Optical Power Meter

- **Complete wavelength range, 750 nm – 1800 nm**
- **Low uncertainty of ≤±0.8% at reference conditions**
- **Low PDL of ≤±0.005 dB, for polarization sensitive tests**
- **High dynamic range of 55 dB**
- **High power measurements of up to +40 dBm**
- **Support of high channel count testing with dual power sensor**
- **Support of bare-fiber and open-beam applications with a 5 mm detector**
- **Synchronous measurements with a laser source or external modulation**

Wide Variety of Optical Power Sensors and Optical Heads

The superiority of Agilent's stimulus-response test solutions guarantee performance. Agilent has been an industry leader in optical instrumentation since the early 1980s - excellence in laser sources, reliable power sensor modules and large detector optical heads.

Passive Component Test

For multi-channel devices, such as, CWDM and AWG, for R&D or the manufacturing environment, accurate measurements at a minimum cost are in demand. The modular design provides the user with the flexibility to add power meters or mainframes for high channel count or high dynamic range applications. Testing of free space optics, such as, thin film filter (TFF) and waveguide alignment, are easily supported with the optical head. Its 5mm detector and long, moveable reach provides the user with easy handling.

Active Component Test

High power amplifiers and sources are developed today in order to transmit signals over longer distances and to support a high loss environment for complex systems. High power measurements of +40 dBm, can be accomplished without an attenuator, which could add to the measurement uncertainty.

Research and Calibration

Low measurement uncertainty of <±0.8% and low PDL of <±0.005 dB are a couple of the key features found in the Agilent power sensors. All of Agilent's power meter products are NIST and PTB traceable to guarantee precise optical power measurements.

All metrology labs are ISO 17025 certified to meet general requirements for the competence of testing and calibration laboratories.

	Agilent 81635A	Agilent 81634B	Agilent 81630B
Sensor Element	InGaAs (dual)	InGaAs	InGaAs
Wavelength Range	800 nm to 1650 nm	800 nm to 1700 nm	970 nm to 1650 nm
Power Range	–80 dBm to +10 dBm	–110 dBm to +10 dBm	–70 dBm to +28 dBm
Applicable Fiber Type	Standard SM and MM up to 62.5 µm core size, NA ≤0.24	Standard SM and MM up to 100 µm core size, NA ≤0.3	Standard SM and MM up to 100 µm core size, NA ≤0.3
Uncertainty (accuracy) at Reference Conditions	typ. <±3.5 % (800 nm to 1200 nm) ±3 % (1200 nm to 1630 nm)	±2.5 % (1000 nm to 1630 nm)	±3.0 % for 1255 nm to 1630 nm at 980 nm ±3.5 % (add ±0.5% per nm if 980 nm is not the center wavelength) at 1060 nm ±4.0 % (add ±0.6% per nm if 1060 nm is not the center wavelength)
Total Uncertainty	typ. ±5.5% ± 200 pW (800 nm to 1200 nm) ±5% ± 20 pW (1200 nm to 1630 nm)	±4.5% ± 0.5 pW (1000 nm to 1630 nm)	±5 % ± 1.2 nW (1255 nm to 1630 nm) at 980 nm ±5.5 % ± 1.2 nW (add ±0.5% per nm if 980 nm is not the center wavelength) at 1060 nm ±6.0 % ± 1.2 nW (add ±0.6 % per nm if 1060 nm is not the center wavelength)
Relative Uncertainty			
– due to polarization	typ. <±0.015 dB	<±0.005 dB	<±0.01 dB
– spectral ripple (due to interference)	typ. <±0.015 dB	<±0.005 dB	<±0.005 dB
Linearity (power)	CW –60 dBm to +10 dBm	CW –90 dBm to +10 dBm	CW –50 dBm to +28 dBm (970 nm – 1630 nm)
– at 23°C ± 5°C	typ. <±0.02 dB (800 nm to 1200 nm) <±0.02 dB (1200 nm to 1630 nm)	<±0.015 dB (1000 nm to 1630 nm) ≤	±0.05 dB
– at operating temp. range	typ. <±0.06 dB (800 nm to 1200 nm) <±0.06 dB (1200 nm to 1630 nm)	<±0.05 dB (1000 nm to 1630 nm) ≤	±0.15 dB
Return Loss	>40 dB	>55 dB	>55 dB
Noise (peak to peak)	typ. <200 pW (800 nm to 1200 nm) <20 pW (1200 nm to 1630 nm)	<0.2 pW (1200 nm to 1630 nm)	<1.2 nW (1255 nm – 1630 nm)
Averaging Time (minimal)	100 µs	100 µs	100 µs
Analog Output	None	included	included
Dimensions (H x W x D)	75 mm x 32 mm x 335 mm (2.8” x 1.3” x 13.2”)	75 mm x 32 mm x 335 mm (2.8”x 1.3”x 13.2”)	75 mm x 32 mm x 335 mm (2.8”x 1.3”x 13.2”)
Weight	0.5 kg	0.5 kg	0.6 kg
Recommended Recalibration Period	2 years	2 years	2 years
Operating Temperature	+10°C to +40°C	0°C to +45°C	0°C to +35°C
Humidity	Non-condensing	Non-condensing	Non-condensing
Warm-up Time	20 min	20 min	20 min

	Agilent 81636B
Sensor Element	InGaAs
Wavelength Range	1250 nm to 1640 nm
Power Range	–80 dBm to +10 dBm
Applicable Fiber Type	Standard SM and MM up to 62.5 µm core size, NA ≤0.24
Uncertainty (accuracy) at Reference Conditions	±3 % (1260 nm to 1630 nm)
Total Uncertainty	±5% ± 20 pW (1260 nm to 1630 nm)
Relative Uncertainty	
– due to polarization	typ. ±0.015 dB
– spectral ripple (due to interference)	typ. ±0.015 dB
Linearity (power)	CW –60 to +10 dBm, (1260 nm to 1630 nm)
– at 23°C ± 5°C	<±0.02 dB
– at operating temperature range	<±0.06 dB

	Agilent 81636B continued
Return Loss	>40 dB
Noise (peak to peak)	<20 pW (1260 nm – 1630 nm)
Averaging Time (minimal)	25 µs
Dynamic Range at Manual Range Mode	
– at +10 dBm-range	typ. >55 dB
– at ±0 dBm-range	typ. >55 dB
– at –10 dBm-range	typ. >52 dB
– at –20 dBm-range	typ. >45 dB
Noise at Manual Range Mode (peak to peak)	CW –60 to +10 dBm, 1260 nm to 1630 nm
– at +10 dBm-range	<50 nW
– at ±0 dBm-range	<5 nW
– at –10 dBm-range	<1 nW
– at –20 dBm-range	<500 pW
Analog Output	Included
Dimensions (H x W x D)	75 mm x 32 mm x 335 mm (2.8” x 1.3” x 13.2”)
Weight	0.5 kg
Recommended Recalibration Period	2 years
Operating Temperature	+10°C to +40°C
Humidity	Non-condensing
Warm-up Time	0 min

	Agilent 81623B	**Agilent 81623B Calibration Option C85/C86**	**Agilent 81623B Calibration Option C01/C02**
Sensor Element	Ge, ø 5 mm		
Wavelength Range	750 nm to 1800 nm		
Power Range	–80 dBm to +10 dBm		
Applicable Fiber Type Standard Open Beam	SM and MM max 100 µm core size, NA 0.3 Parallel beam max ø 4 mm		
Uncertainty at Reference Conditions	% (1000 nm to 1650 nm) ±3.0 % (800 nm to 1000 nm)	±2.2 % (1000 nm to 1650 nm) ±2.5 % (800 nm to 1000 nm)	±1.7 % (1000 nm to 1650 nm) ±3.0 % (800 nm to 1000 nm)
Total Uncertainty	±3.5% ± 100 pW (1000 nm to 1650 nm) ±4.0% ± 250 pW (800 nm to 1000 nm)	±3.5% ± 100 pW (1000 nm to 1650 nm) ±3.5% ± 250 pW (800 nm to 1000 nm)	±3.0% ± 100 pW (1000 nm to 1650 nm) ±4.0% ± 250 pW (800 nm to 1000 nm)
Relative Uncertainty			
– due to polarization	<±0.01 dB (typ. <±0.005 dB)		
– spectral ripple (due to interference)	<±0.006 dB (typ. <±0.003 dB)		
Linearity (power)	(CW –60 dBm to +10 dBm)		
– at 23°C ±5°C	<±0.025 dB		
– at operating temp. range	<±0.05 dB		
Return Loss		>50 dB, typ. >55 dB	>56 dB
Noise (peak to peak)	<100 pW (1200 nm to 1630 nm) <400 pW (800 nm to 1200 nm)		
Averaging Time (minimal)	100 µs		
Analog Output	included		
Dimensions	57 mm x 66 mm x 156 mm		
Weight	0.5 kg		
Recommended Recalibration Period	2 years		
Operating Temperature	0°C to 40°C		
Humidity	Non-condensing		
Warm-up Time	40 min		

	Agilent 81624B	Agilent 81624B Calibration Option C01/C02	Agilent 81626B	Agilent 81626B Calibration Option C01/C02
Sensor Element	InGaAs, ø 5 mm		InGaAs, ø 5mm	
Wavelength Range	800 nm to 1700 nm		850 nm to 1650nm	
Power Range	–90 dBm to +10 dBm		–70 to +27 dBm (1250 nm to 1650 nm) –70 to +23 dBm (850 nm to 1650 nm)	
Applicable Fiber Type Open Beam	Standard SM and MM max 100 µm core size, NA ≤0.3 Parallel beam max ø 4 mm		Standard SM and MM max 100 µm core size, NA ≤0.3 Parallel beam max ø 4 mm	
Uncertainty at Reference Conditions	±2.2 % (1000 nm to 1630 nm)	±1.5 % (970 nm to 1630 nm)	±3.0 % (950 nm to 1630 nm)	±2.5 % (950 nm to 1630 nm)
Total Uncertainty	±3.5% ± 5 pW (970 nm to 1630 nm)	±2.8% ± 5 pW (950 nm to 1630 nm)	±5.0% ± 500 pW (950 to 1630 nm max 23 dBm)	±4.5% ± 500 pW (1250 to 1630 nm max 27 dBm)
Relative Uncertainty – due to polarization ≤ – spectral ripple (due to interference)	 ±0.005 dB (typ. ±0.002 dB) ≤ ±0.005 dB (typ. <±0.002 dB) ≤		 ±0.005 dB (typ. ±0.002 dB) ±0.005 dB (typ. <±0.002 dB)	
Linearity (power) – at 23°C ±5°C – at operat. temp. range	CW –70 dBm to +10 dBm, 1000 nm to 1630 nm <±0.02 dB <±0.05 dB		CW –50 dBm to +27dBm, 950 nm to 1630 nm <±0.04 dB <±0.15 dB	
Return Loss typ.	60 dB		>45 dB	>47 dB
Noise (peak to peak)	<5 pW		<500 pW	
Averaging Time (min.)	100 µs		100 µs	
Analog Output	included		Included	
Dimensions	57 mm x 66 mm x 156 mm		57 mm x 66 mm x 156 mm	
Weight	0.5 kg		0.5 kg	
Recommended Recalibration Period	2 years		2 years	
Operating Temperature	0°C to 40°C		0°C to +35°C	
Humidity	Non-condensing		Non-condensing	
Warm-up Time	40 min		40 min	

	Agilent 81628B with Integrating Sphere		
Sensor Element	InGaAs		
Wavelength Range	800 nm to 1700 nm		
Power Range	–60 dBm to +40 dBm (800 nm to 1700 nm) For operation higher than 34 dBm[1]		
Damage Power	40.5 dBm		
Applicable Fiber Type **Open Beam**	Single mode NA ≤0.2, Multimode NA ≤0.4 ø ≤3 mm center of sphere		
Uncertainty at Reference Conditions	±3.0 % (970 nm to 1630 nm)		
Total Uncertainty ≤10 dBm >10 dBm to ≤20 dBm >20 dBm to ≤38 dBm	(970 nm to 1630 nm) ±4.0% ± 5 nW ±4.5% ±5%		
Relative Uncertainty – due to polarization – due to speckle noise at source linewidth: 0.1 pm to 100 pm >100 pm	 typ. ≤±0.006 dB typ. ≤±0.02 dB typ. ≤±0.002 dB		
Linearity (power) ≤10 dBm >10 dBm to ≤20 dBm >20 dBm to ≤37 dBm >37 dBm to ≤38 dBm	(CW –40 dBm to +38 dBm), (970 nm to 1630 nm) ≤±0.03 dB ≤±0.06 dB ≤±0.09 dB ≤±0.10 dB at 23°C ± 5°C, for operating temperature range add ±0.03 dB		
Return Loss	typ. >75 dB		
Noise (peak to peak)	<5 nW		
Averaging Time (minimal)	100 µs		
Analog Output	Included		
Dimensions	55 mm x 80 mm x 250 mm	**Operating Temperature**	0°C to +40°C
Weight	0.9 kg (without heat sink)	**Humidity**	Non-condensing
Recommended Recalibration Period	2 years	**Warm-up Time**	40 min

[1] For optical power higher than 34 dBm the attached heat sink MUST be used! For continuous optical power or average optical power higher than 38 dBm the connector adapters will get warmer than permitted according to the safety standard IEC 61010-1. The 81628B Optical Head can handle optical power up to 40 dBm, however, operation above 38 dBm is at the operator's own risk. Agilent Technologies Deutschland GmbH will not be liable for any damage caused by an operation above 38 dBm.

Agilent 81610A and 81613A Return Loss Module

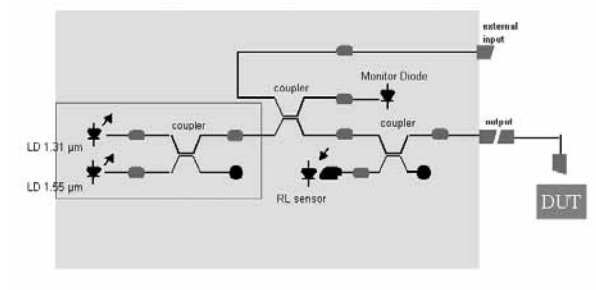
- **Single module for return loss (RL) test**
- **High dynamic range of 75 dB**
- **Built-in Fabry-Perot laser source for 1310 nm and 1550 nm**
- **Use any external laser source, including tunable laser for swept RL applications**
- **Three easy calibration steps for enhanced accuracy**

Plug&Play for RL Measurement

Portability and cost effective; a single mainframe, single module and single connection to the device under test are all you need to make a return loss (RL) measurement. Agilent's RL test solution solves the complex operation of calibration and is able to exclude measurement uncertainties due to coupler / filter usage in your design. In addition, a built-in FP laser at 1310 nm and 1550 nm enables basic component tests.

Meeting Manufacturing Needs

The need for IL and RL for optical component tests is fulfilled with the RL module when used with an optical power meter - preferably an optical head due to its flexibility. On-board application software supports step-by-step operation with instructions.



Return Loss Module, Optical Assembly

Swept RL Measurement with Tunable Laser Source

Today's passive component devices are not only characterized at a single wavelength, but over a wide wavelength range using a tunable laser source. The swept wavelength measurement concept is applicable for RL measurements using an Agilent tunable laser source (TLS) in synchronous operation of the two modules.

	81610A		**81613A**	
Source	external input only		Fabry-Perot Laser (internal)	
Output Power	—		typ. –4 dBm	
Center Wavelength	—		1310 nm/1550 nm ±20 nm typ.	
Sensor Element	InGaAs		InGaAs	
Fiber Type	Standard single-mode 9/125 µm		Standard single-mode 9/125 µm	
External Input	max input power: 10 dBm min input power: 0 dBm damage input power: 16 dBm		— — —	
Wavelength Range for External Input	1250 nm to 1640 nm		—	
Dynamic Range	70 dB		75 dB	
Relative Uncertainty of Return Loss (RL)	with broadband source	with Agilent FP sources	User calibration	Plug&play
RL ≤55 dB	<±0.25 dB	typ. <±0.5 dB	<±0.5 dB (typ. <±0.3 dB)	typ. <±0.6 dB
RL ≤60 dB	<±0.3 dB	typ. <±1.0 dB	<±0.6 dB (typ. <±0.4 dB)	typ. <±1.5 dB
RL ≤65 dB	<±0.65 dB	typ. <±2.0 dB	<±0.8 dB (typ. <±0.5 dB)	—
RL ≤70 dB	<±1.7 dB	—	<±1.9 dB (typ. <±0.8 dB)	—
RL ≤75 dB	—	—	typ. <±2.0 dB	—
Total Uncertainty add	±0.2 dB add	typ. ±0.2 dB	add ±0.2 dB	add typ. ±0.2 dB
Dimensions (H x W x D)	75 mm x 32 mm x 335 mm (2.8" x 1.3" x 13.2")		75 mm x 32 mm x 335 mm (2.8" x 1.3" x 13.2")	
Weight	0.6 kg		0.6 kg	
Recommended Recalibration Period	2 years		2 years	
Operating Temperature	10 to 40°C		10 to 40°C	
Humidity	Non-condensing		Non-condensing	
Warm-up Time	20 minutes		20 minutes	

- **Low insertion loss of 0.7 dB**
- **Excellent Wavelength flatness**
- **Wide wavelength coverage in both single mode and multi mode fiber**
- **High attenuation resolution of 0.001 dB**
- **Active power control option**

Modular Design, Fit for Various Component and Network Solutions

Agilent's 8157xA variable optical attenuators are a family of plug-in modules for Agilent's Lightwave Solution Platform 8163A/B, 8164A/B and 8166A/B. The attenuator modules 81570A, 81571A and 81578A occupy one slot, while modules 81576A and 81577A occupy two slots. With 17 slots, the Agilent 8166A/B Lightwave Multichannel System can host up to 17 single slot modules or up to 8 dual slot modules.

Variable Optical Attenuators

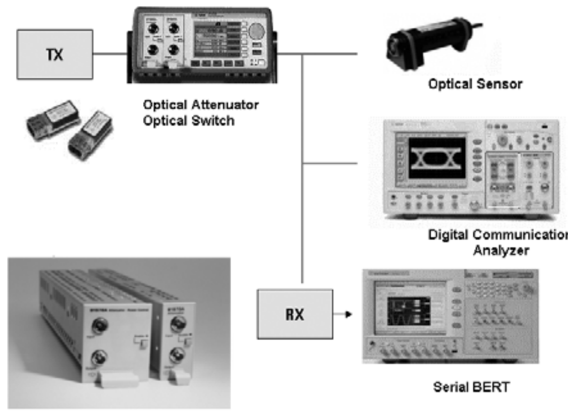
The Agilent 81570A, 81571A and 81578A are small, cost effective attenuator modules with high resolution. They feature excellent wavelength flatness and can handle high input power levels. Various calibration features allow the user to set a reference power. Both the attenuation and the power level, relative to the reference power, can then be set and displayed in the user interface. An integrated shutter, which can be used for protection purposes, or to simulate channel drops, is available.

Attenuators for High Optical Input Power

The Agilent modules feature excellent wavelength flatness and can handle high input power levels of 2 mW. Combined with their low insertion loss, they are ideal for optical amplifier tests, such as characterization of EDFAs and of Raman amplifiers, as well as for other multi-wavelength applications, such as DWDM transmission system test.

Attenuators with Power Control

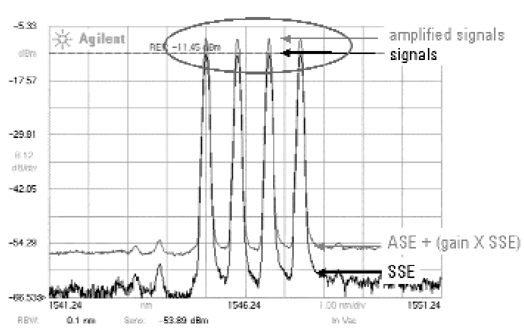
Agilent's 81576A and 81577A attenuators feature power control functionality that allows you to set the output power level of the attenuator. The attenuator module firmware uses the feedback signal from a photo diode after a monitor tap, both integrated in the module, to set the desired power level at the output of the module. When the power control mode is enabled, the module automatically corrects power changes at the input to maintain the output level set by the user. After an initial calibration for the uncertainties at connector interfaces, absolute power levels can be set with high accuracy. The absolute accuracy of these power levels depends on the accuracy of the reference power meter used for calibration.



Tranceiver and Receiver Test

Calibration Processes

The Agilent optical attenuator modules feature excellent wavelength flatness and can handle high input power levels. Combined with their low insertion loss, they are ideal for optical amplifier tests, such as characterization of EDFAs and of Raman amplifiers, as well as for other multi-wavelength applications, such as DWDM transmission system test. One unique feature is a wavelength offset table which enhances calibration capacity by setting the integral power of a DWDM signal with a known spectrum.



Equalized Tx signal in EDFA test using wavelength calibration offset table

	8157xA			81578A-050	81578A-062
Connectivity	Straight (81570A) / Angled (81571A) connector versatile interface	Straight (81576A) / Angled (81577A) connector versatile interface		Straight connector versatile interface	
Fibre Type	9/125 µm SMF28	9/125 µm SMF		50/125 µm MMF	62.5/125 µm MMF
Wavelength Range	1200 – 1700 nm	1250 – 1650 nm		700 nm – 1400 nm	
Attenuation Range	0 – 60 dB			0 – 60 dB	
Resolution	0.001 dB			0.001 dB	
		Attenuation Setting	**Power Setting**		
Repeatability[1]	±0.01 dB	±0.010 dB	±0.015 dB[2]	±0.015 dB[19, 22]	
Accuracy (uncertainty)[1,3]	±0.1 dB[4,5]	±0.1 dB[4,5]	N/A	typ. ±0.15 dB (800 nm – 1350 nm) ±0.2 dB (at 850 nm ±15 nm, 1310 nm ±15 nm)[19,20,21,22]	
Settling Time (typical)[23]	typ. 100 ms	100 ms	300 ms	typ. 100 ms	
Transition Speed (typical)	0.1 – 12 dB/s			typ. 0.1 – 12 dB/s	
Relative Power Meter Uncertainty[16,17]	N/A	±0.03 dB ±200 pW[16]			
Attenuation Flatness[1,5,7,9]	<±0.07 dB (typically ±0.05 dB) for 1520 nm < λ <1620 nm typically ±0.10 dB for 1420 nm < λ <1640 nm				
Spectral Ripple (typical)[8]	±0.003 dB				
Insertion Loss[3,5]	Typically 0.7 dB excluding connectors <1.6 dB (typically 1.0 dB) including connectors[10,11]	Typically 0.9 dB (excluding connectors) <1.8 dB (typically 1.2 dB) Connectors Including[10,11]		typ. 1.0 dB (NA = 0.1) typ. typ. 1.3 dB (NA = 0.2) 2.0 dB (NA = 0.2)[19,22]	typ. 1.0 dB (NA = 0.1) 1.3 dB (NA = 0.2) 2.0 dB (NA = 0.2)[19,22] typ. 3.0 dB (NA = 0.27)
Insertation-Loss Flatness (typical)[1,12,5]	±0.1 dB for 1420 nm < λ <1615nm				
Polarization-Dependent Loss[3,10,12]	<0.08 dBpp (typically 0.03dBpp)	<0.10 dBpp (typically 0.05dBpp)			
Polarization Extinction Ratio	N/A				
Return Loss (typical)	45 dB (81570A) / 57 dB (81571A)[10,12] (at 1550 nm ±15 nm)	45 dB (81576A) 57 dB (81577A)[10,12]		typ. 27 dB[19,22,24]	
Maximum Input Power[14]	+33 dBm			+27 dBm	
Shutter Isolation (typical)	100 dB			typ. 100 dB	
Dimensions (H x W x D)	75 mm x 32mm x335mm (2.8''x1.3''x13.2'')	75 mm x 64mm x335mm (2.8''x2.6''x13.2'')		75 mm x 32 mm x 335 mm (2.8" x 1.3" x 13.2")	
Weight	0.9 kg				
Recommended Recalibration Period	2 years				
Operating Temperature	10°C – 45°C				
Humidity	Non-condensing				
Warm-up Time	30 minutes				

1 At constant temperature.
2 Output power >–40 dBm, input power <+27 dBm. For input power >+27 dBm add typically ±0.01 dB.
3 Temperature within 23ºC ± 5ºC.
4 Input power <+30 dBm; λ = 1550 nm ± 15 nm; typical for 1250 nm < λ <1650 nm.
5 For unpolarized light (SMF versions), or polarized light with TE mode injected in the slow axis (PMF version).
6 Stepsize <1 dB; for full range: typically 6 s.
7 Relative to reference at 0 dB attenuation.
8 Linewidth of source ≥100 MHz.
9 λ disp set to 1550 nm; attenuation ≤20 dB. For attenuation >20 dB: add typically 0.01 dB (_[db] – 20) for 1520 nm < λ <1620 nm. and typically 0.02 dB (_[db] – 20) for 1420 nm < λ <1640 nm.
10 For λ = 1550 nm ± 15 nm.
11 Add typically 0.1 dB for λ = 1310 nm ± 15 nm.
12 Measured with Agilent reference connectors.
13 Excluding connectors, measured using a broadband source.
14 Agilent Technologies assumes no responsibility for damages caused by scratched or poorly cleaned connectors.
16 Wavelength and SOP constant; temperature constant and between 23ºC ±ºC; λ <1630 nm.
17 Input power ≤+27 dBm; for input power >+27 dBm add ±0.02 dB.
18 At constant operating conditions.
19 Effective spectral bandwidth of source >5 nm.
20 For mode launch conditions with NA = 0.2; for every DNA = 0.01 add typ. ±0.01 dB.
21 Temperature within 23°C ±5°C and unpolarized light.
22 At 850nm ±15 nm, 1310 nm ±15 nm.
23 Step size <1 dB, for full range: typ. 6 seconds.
24 The return loss is mainly limited by the return loss of the front panel connectors.

Ordering information

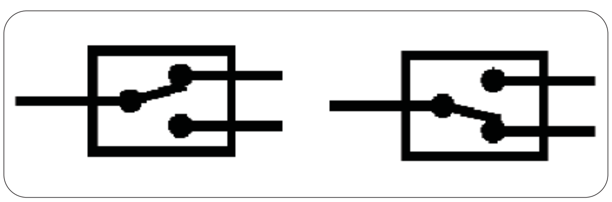
For the most up-to-date information on Agilent 8157xA optical attenuators, please contact your Agilent Technologies sales representative or visit our web site at: **www.agilent.com/find/lightwave**

Connector Interface

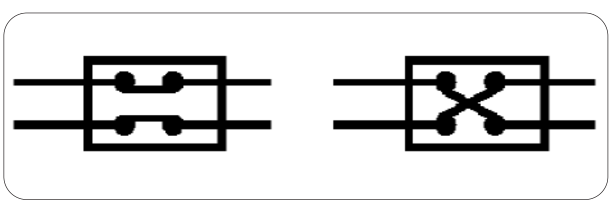
All modules require two connector interfaces, 81000xl series (physical contact).

- **Wide wavelength range for single mode and multi mode applications**
- **Excellent repeatability specified over 10,000 random cycles**
- **Low insertion loss of <1.0 dB**
- **Modular Design, allows up to 17 switches in one mainframe**

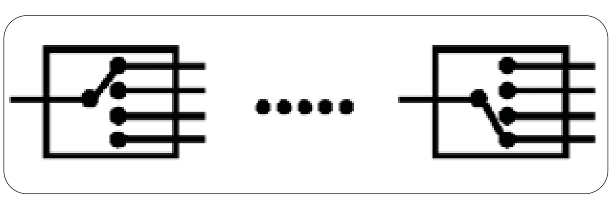
Modular Design for Solution Platform
The Agilent modular optical switches are a family of plug-in modules for Agilent's Lightwave Solution Platform. These modules enable manufacturers of optical and network components to automate their processes by routing optical signals when testing devices such as line cards, amplifiers, and active and passive components. Adding modular optical switches to this instrument platform allows flexible and cost effective all-in-one solutions to be developed for optical component tests in automated test environments.



The 1 x 2 optical switch has two positions



The 2 x 2 non-blocking (crossover) optical switch also has two positions



The 1 x 4 optical switch also has four positions

Application Fit for Passive and Active Component Tests
Agilent's family of modular switches offers 1x2, 2x2 and 1x4 input/output port switching as plug-in modules for Agilent's 8163A/B, 8164A/B and 8166A/B mainframes. High flexibility makes the switches ideal for signal routing in automated test environments. Each switch type is available with angled or straight connectors, and there are options for SC/APC and FC/APC connector interfaces.

Integrating Switch without Increasing System Uncertainty
Agilent's switching modules are designed for best optical performance. This way you get the flexibility you need for your automated test setups without compromising your measurement uncertainty.

Modular Optical Switch Specifications

	81591B		81594B		81595B	
Switch Type	1 x 2		2 x 2		1 x 4	
Fiber Interface	# 009 single mode	# 062 multimode	# 009 single mode	# 062 multimode	# 009 single mode	# 062 multimode
Fiber Type	9/125 µm SMF	62.5/125 µm MMF	9/125 µm SMF	62.5/125 µm MMF	9/125 µm SMF	62.5/125 µm MMF
Connectivity	FC/APC – R angled	FC/PC straight	FC/APC – R angled	FC/PC straight	FC/APC – R angled	FC/PC straight
Wavelength Range	1270 – 1670 nm	700 – 1400 nm	1270 – 1670 nm	700 – 1400 nm	1270 – 1670 nm	700 – 1400 nm
Insertion Loss	<1.0 dB[3]	<1.0 dB[1]	<1.5 dB[3]	<1.0 dB[1]	<2.0 dB[4]	<2.0 dB[1]
Polarization Dependent Loss	typ. 0.05 dBpp	N/A	typ. 0.05 dBpp	N/A	typ. 0.07 dBpp	N/A
Repeatability[2]	±0.02 dB	±0.02 dB[1]	±0.02 dB	±0.02 dB[1]	±0.03 dB	±0.03 dB[1]
Return Loss	typ. 55 dB	typ. 20 dB	typ. 50 dB	typ. 20 dB	typ. 55 dB	typ. 20 dB
Crosstalk	typ. –70 dB	typ. –70 dB	typ. –70 dB	typ. –70 dB	typ. –70 dB	typ. –70 dB
Switching Time	<10 ms					
Lifetime	>10 million cycles					
Maximum Input Power	+20 dBm					
Dimensions (H x W x D)	75 mm x 32 mm x 335 mm (2.9" x 1.3" x 13.2")					
Weight	0.5 kg					
Operating Temperature	10°C to 45°C					
Storage Temperature[5]	–40°C to 70°C					
Humidity	Non-condensing					
Warm-up Time	30 min.					

[1] Specification is typical with 50/125 µm multimode fiber.
[2] Worst case measurement deviation over 10,000 random switching cycles.
[3] For = 1550 nm; for 1270 nm < < 1670 nm add 0.3 dB.
[4] For = 1550 nm; for 1270 nm < < 1670 nm add 0.6 dB.
[5] Allow minimum acclimatization of 2 hours if previously stored outside operating temperature range before turning on the module.

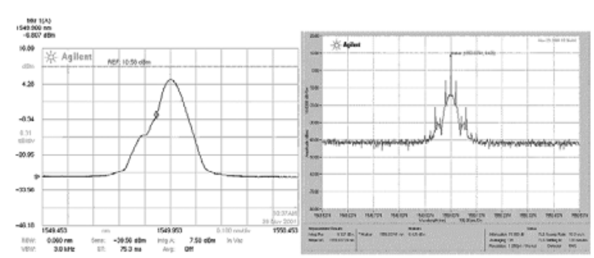
Ordering Information

Modules for single mode fiber interface: #009
Modules for multi mode fiber interface: #062

- **Characterization of a laser linewidth with 1 MHz (0.008 pm) resolution**
- **Laser modulation analysis, including chirp test**
- **Wavelength range 1520nm – 1620 nm**
- **Maximum input power +23 dBm for multiple DWDM signals**

Accelerating the Design of Laser Sources, Transmitters and Systems for Access, Metro or Long-Haul Networks

The need to increase capacity and reduce costs in optical networks is forcing network equipment manufacturers to push performance limits of DFB laser sources to higher data rates or to look for inexpensive modulators at 10 Gb/s and 40 Gb/s. Faced with additional demands to reduce channel spacing and increase transmission rates, designers must observe and precisely control the spectral behavior of these lasers and modulators. The challenge is to measure the laser spectrum and to examine the modulation behavior in sub-picometer measurements. The Agilent 83453B high-resolution spectrometer (HRS) is the first calibrated and integrated system that measures the very narrow spectral characteristics of any laser source or transmitter. The HRS uses the innovative technology of hetrodyne mixing that allows sub-picometer resolution measurements to be made directly in the optical domain. Accurate measurements accelerate laser designs and assure proper system performance for next-generation networks.



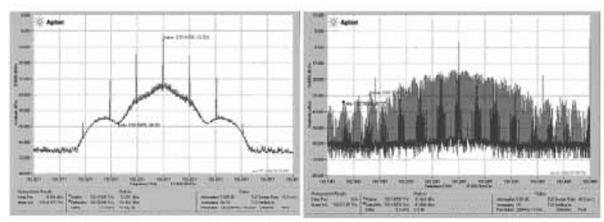
OSA **HRS**

Comparing spectrum measurement between OSA and HRS

Supporting Cost-effective Component Design

DFB laser sources, transceivers and modulators have been pushed to their physical performance limits at higher data rates to support network deployment with the most inexpensive modulation technology. Clear spectral analysis of such optical components during the design phase helps to improve manufacturability during production. The measurable resolution of 1 MHz provides more than a hundred times better resolution than a grating-based optical spectrum analyzer (OSA). All of the necessary components have been integrated into the 83453B system to optimize its performance, delivering a solution with extremely high resolution, dynamic range and wavelength accuracy. Modulated tunable lasers have cavity modes that generate sidebands close to their primary oscillation frequency. Grating based OSA cannot detect these sidebands. The 83453B characterizes spectral aspects of the laser source and transmitter, such as

- Linewidth
- Laser spectral symmetry
- Modulation spectrum including chirp
- Relaxation oscillation of unmodulated signal
- Close-in spurious sidebands
- Spontaneous Brillouin Scattering (SBS)



10 GHz RZ with 2^{7-1} 40 GHz NRZ with 2^{7-1}

Modulation analysis in 10 Gb/s and 40 Gb/s

Agilent Technologies warrants that the specifications listed below will be met under the following instrument operating conditions:

- operating temperature +20°C to +30°C
- wavelength within 1520 to 1620 nm

	High Resolution	Normal Resolution	Wide Resolution
Operating Wavelength Range with 81600B option 200 Tunable Laser	1440 to 1640 nm	1440 to 1640 nm	1440 to 1640 nm
Frequency Span Range	250 MHz to 5 GHz (2 pm to 40 pm)	250 MHz 125 GHz (2 pm to 1 nm)	400 MHz to 12.5 THz (4 pm to 50 nm)
Absolute Frequency Accuracy[1,2] with spans ≤12 GHz (100 pm)		±1.8 GHz (±15 pm)	
Relative Frequency Accuracy[3]			
Span ≤5 GHz (≤40 pm)	±125 MHz (±1 pm)	±190 MHz (±1.5 pm)	–
Span >5 GHz to 125 GHz (0.04 nm to 1 nm)	–	±400 MHz (±3.2 pm)	–
Span 1 nm to 50 nm	–	–	±1.2 GHz (±10 pm)4
Frequency Repeatability over 5 minutes	±50 MHz (±0.4 pm)	±60 MHz (±0.5 pm)	±300 MHz (±2.4 pm)
Nominal Frequency Resolution[4]		Span/Number of Trace Points	
Minimum Frequency Resolution[4]	1 MHz	15 MHz	20 MHz
Power Accuracy[5,6] over full wavelength range at –15 dBm, with spans <12 GHz (0.1 nm)	±5 dB[7]	±2.75 dB	±6 dB[7]
Power Repeatability[8] with spans <12 GHz (0.1 nm), over 5 minutes	±10 dB[7]	±0.75 dB	±8 dB[7]
Power Scale Fidelity with spans 100 pm (–10 dBm to –45 dBm)	±1 dB	±1 dB	–
Polarization Dependence[7]	±1.5 dB	±1.5 dB	–
Displayed Average Noise Level[7] RMS detection; 20 pm span; –5 dBm	–	–65 dBm	–
Dynamic Range9, 10 at 1550 nm	–	≥50 dB	–
Spurious Free Dynamic Range[7]	≥40 dB	≥40 dB	–
Peak Input Power before Saturation[7] with 0 dB attenuation		–5 dBm	
Maximum Safe Total Input Power		+23 dBm	
Optical Attenuation Range		0 to 20 dB in 1 dB steps	
Optical Return Loss[7]		50 dB	

1 Verified at 1525 nm, 1550 nm, and 1615 nm.
2 In cases where the marker resolution (which is span/(trace points –1)) exceeds a frequency/wavelength specification, the marker resolution overrides the specification.
3 Assumes constant temperature over measurement interval.
4 Characteristic
5 Does not include PDL, scale fidelity, or repeatability.
6 With unmodulated linewidths <2 MHz.
7 Characteristic
8 Assumes constant temperature over measurement interval.
9 With a –5 dBm level adjusted for optimum polarization.
10 Applies to any fixed input power level.

General

Dimensions (without computer): 280 mm H x 325 mm W x 560 mm D
Weight: 34 kg (75 lbs)
Operating Temperature Range: +20°C to +30°C
Humidity: 15 .. 85%

Power Requirements

Voltage and Frequency: 110 to 240 V AC, 50 to 60 Hz
Max. Power Consumption: 400 W

Computer Interfacing

Operating System: Windows XP
Remote Control Compatibility: LAN Interface
Data Export: Spreadsheet and Word Processor Compatible (CSV)
Graphics Export: JPEG, Bitmap
Floppy Disk: 3.5 inch 1.44 MB, MS-DOS
CD-ROM: 40 X Maximum Speed
LAN Interface: Ethernet 10/100 Mbit/s
Graphical User Interface: TFT Monitor, XGA
Keyboard/Mouse: PS/2
Additional Interface: Data Acquisition Cards, GPIB

86120B/C and 86122A Multi-Wavelength Meter

- **Characterize WDM spectra during R&D, manufacturing and commissioning**
- **Wavelength accuracy up to ±0.2 ppm**
- **Simultaneously measure wavelengths and powers of up to 1000 channels**
- **Automatic optical signal-to-noise ratio measurements**
- **Automated measurement routines and data logging**

As the demand for access to more information increases, the need for greater capacity on transmission systems drives component manufacturers and network equipment manufacturers to push their capabilities to new limits. The successful design and deployment of DWDM systems requires that stringent performance criteria are met in order to guarantee quality of service. With Agilent multi-wavelength meters, you will be able to address these demands with confidence.

The Performance You Need – When You Need It

The Agilent family of multi-wavelength meters is just that – a family. Each model uses compatible SCPI remote commands. You pay for only the performance you need, when you need it. If your requirements become more demanding in the future, you can substitute another Agilent multi-wavelength meter, avoiding unnecessary cost and time developing new code for your test system. With the new 86122A, you can upgrade to a unit with the best performance available. Agilent multi-wavelength meters allow you to optimize test costs while protecting your investments.

Simultaneously Measure up to 1000 Wavelengths and Powers

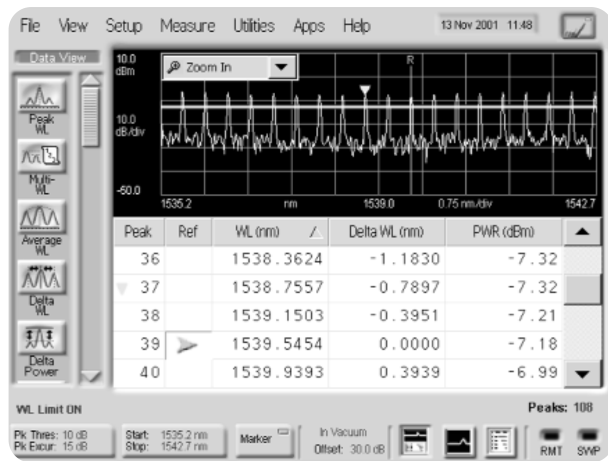
The Agilent 86120B, 86120C and 86122A multi-wavelength meters, like other, Michelson interferometer-based wavelength meters, allow you to measure the average wavelength of the input signal. In addition, the Agilent multi-wavelength meters – with advanced digital processing – accurately and easily differentiate and measure up to 1000 (200 and 100 for the 86120C and 86120B, respectively) discrete wavelengths.

Agilent multi-wavelength meters simultaneously measure the individual powers of discrete wavelengths, offering the following measurement capabilities:

- 1 to 1000 wavelengths and powers
- Average wavelength and total power
- Up to ±0.2 ppm wavelength accuracy
- Up to 5 GHz wavelength resolution
- Calibrated for evaluation in air or vacuum
- Wavelength units in nm, THz, or wave number (cm^{-1})
- Amplitude units in dBm, mW, or µW
- OSNR and averaged OSNR for WDM SONET/SDH systems
- Rugged design to withstand strong shocks and vibration

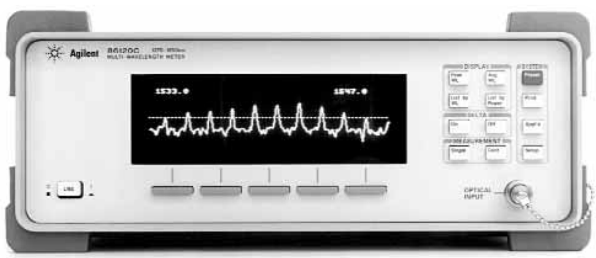
WDM Transmission Systems

Combining measurement performance with reliability, the Agilent multi-wavelength meters allow easy and accurate verification of optical carrier performance in transmission systems by measuring, wavelength, power and optical signal-to-noise ratios during design and manufacturing test. The 86122A multi-wavelength meter is optimized for measuring ultra-dense channel spacing with an absolute wavelength accuracy of up to ±0.2 ppm (±0.3 pm referenced to 1550 nm). With a resolution of <5 GHz, it is an ideal solution for the design and manufacturing of next-generation optical networks.



The Agilent 86122A displaying signal-to-noise ratios

With a rugged and portable package, the 86120B and 86120C multi-wavelength meters are ideal for optical network commissioning and monitoring applications. With the 86120C resolution of <10 GHz (<20 GHz for the 86120B) and absolute wavelength accuracy of ±2 ppm or ±3 pm at 1550 nm (±3 ppm, ±5 pm at 1550 nm for the 86120B), you can confidently verify system performance of DWDM systems with channels spaced at <50 GHz.



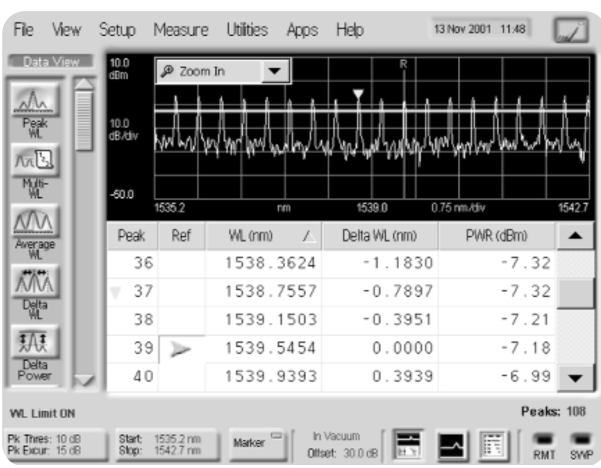
The Agilent 86120B/C and 86122A can simultaneously resolve and measure the individual optical carrier wavelengths and powers to confirm channel spacing, drift, crosstalk, and optical signal-tonoise ratios.

Sources

The superior wavelength and amplitude measurement capabilities of the Agilent 86120B, 86120C and 86122A multi-wavelength meters enable maximum performance of your components. You can measure DFB, FP or multiple DFB laser wavelengths and amplitudes during burn-in, environmental evaluation, final test and incoming inspection. Calculate center wavelengths of broader linewidth sources, such as LED's or Bragg-Gratings filtered ASE responses, using the user-selectable broadband algorithm.

Relative Wavelength and Amplitude Measurements

The Agilent 86120B, 86120C, and 86122A allow you to optimize systems or components for wavelength stability and channel spacing. You can compare individual optical carrier wavelengths and powers to those of a user-selected reference, and monitor dynamic changes.



In Delta Mode, the Agilent 86122A displays relative wavelengths and powers

Built-in Data Logging

12 Designed with the R&D engineer in mind, the 86122A multiwavelength meter allows you to capture changes in all system parameters over time, without having to develop external remote programs. Using the data-logging mode, the 86122A records measured data at user-specified intervals with a time stamp and stores the data on the built-in hard drive of the instrument. This data can then be easily downloaded via floppy drive, GPIB, or the LAN as a comma-separated variable (.csv) file to your spreadsheet program for graphing and analysis.

Advanced Measurement Applications Allow System Verification and Monitoring

The Agilent 86120B/C and 86122A multi-wavelength meters augment your productivity by processing the measurement data to automatically and directly give you system performance results, such as:

Drift

The Drift routine allows you to monitor, as a function of time or other dynamic conditions, changes in wavelength and amplitude of your optical signal or signals while simultaneously logging wavelength and amplitude:

- Current values — to give you the real-time status of your laser sources
- Maximum and minimum values — so you can record the limits reached during the measurement
- Total drift — so that you can measure the total variation of your signals during testing

Optical Signal-To-Noise Ratio

Verify transmission system performance with the Optical Signal- toNoise Ratio routine, which easily allows you to determine all the signal-to-noise ratios in your system with:

- Noise measured halfway between channels – for quick verification
- Noise measured at user-defined wavelengths – for maximum flexibility
- Noise normalized to a 0.1 nm bandwidth – for easy comparison

Fabry-Perot Laser Characterization (available on 86120C and 86122A)

This measurement routine allows you to characterize your FabryPerot laser source quickly, easily, and accurately. You can obtain immediate results of:

- Total power
- Full-width at half maximum
- Mean wavelength
- Mode spacing

Coherence Length (available on 86120B only)

The Agilent 86120B automatically allows accurate measurements of the coherence length of Fabry-Perot laser sources typically used in CD-ROM drives or datacom transmission systems:

- Measurement range from 1 to 200 mm
- Accuracy within 5%
- Display laser coherence length and cavity optical length

Instrument Drivers

Instrument drivers compatible with LabView, Visual Basic, C++, and LabWindows are available for the Agilent 86120B, 86120C, and 86122A multi-wavelength meters. These drivers enable remote program development by offering building blocks that allow you to customize your measurements.

Specifications

The technical specifications apply to all functions over the temperature range 0 to 55°C and relative humidity <95%, unless otherwise noted. All specifications apply after the instrument's temperature has been stabilized for 15 minutes in Normal Update mode, unless otherwise noted. Specifications describe the instrument's warranted performance. Supplementary performance characteristics provide information about non-warranted instrument performance in the form of nominal values, and are printed in *italic* typeface.

		86120B	**86120C**	**86122A**
Maximum Number of Laser Lines Input		100	200	1000
Wavelength	Range	700 – 1650 nm (182 to 428 THz)	1270 – 1650 nm (182 to 236 THz)	1270 – 1650 nm (182 to 236 THz)
	Absolute Accuracy	±3 ppm (±0.005 nm at 1550 nm, ±0.004 nm at 1310 nm) for laser lines separated by ≥30 GHz	±2 ppm (±0.003 nm at 1550 nm and 1310 nm) for laser lines separated by ≥15 GHz	±0.5 ppm (±0.75 pm at 1550 nm and ±0.65 pm at 1310 nm); ±0.2 ppm1 (±0.3 pm at 1550 nm and 1310 nm) for laser lines separated by ≥10 GHz
	Minimum Resolvable Separation (equal power lines input)	*20 GHz (0.16 nm at 1550 nm, 0.11 nm at 1300 nm)*[2]	*10 GHz (0.08 nm at 1550 nm, 0.06 nm at 1300 nm)*[3]	*5 GHz (0.04 nm at 1550 nm; 0.03 nm at 1310 nm)*[4]
	Display Resolution	0.001 nm, normal update mode; 0.01 nm, fast update mode	0.001 nm	0.0001 nm
	Units	nm (vacuum or standard air), cm^{-1}, THz	nm (vacuum or standard air), cm^{-1}, THz	nm (vacuum or standard air), cm^{-1}, THz
Power	Absolute Accuracy	±0.5 dB (at ±30 nm from 780, 1310, and 1550 nm)	±0.5 dB (at ±30 nm from 1310 and 1550 nm)	±0.5 dB (at ±30 nm from 1310 and1550 nm)
	Flatness, 30 nm from any wavelength	*±0.2 dB, 1200 – 1600 nm ±0.5 dB, 700 – 1650 nm*	*±0.2 dB, 1270 – 1600 nm ±0.5 dB, 1270 – 1650 nm*	*±0.2 dB, 1270 – 1600 nm ±0.5 dB, 1270 – 1650 nm*
	Linearity	±0.3 dB, 1200 – 1600 nm,	±0.3 dB, 1270 – 1600 nm,	±0.3 dB, 1270 – 1600 nm,
	Polarization Dependence	*±0.5 dB, 1200 – 1600 nm ±1.0 dB, 700 – 1650 nm*	*±0.5 dB, 1270 – 1600 nm ±1.0 dB, 1600 – 1650 nm*	*±0.5 dB, 1270 – 1600 nm ±1.0 dB, 1600 – 1650 nm*
	Units	dBm, mW, µW	dBm, mW, µW	dBm, mW, µW
Sensitivity[5]	Single Line Input	–40 dBm, 1200 – 1600 nm	–40 dBm, 1270 – 1600 nm –30 dBm, 1600 – 1650 nm	–40 dBm, 1270 – 1600 nm –30 dBm, 1600 – 1650 nm
	Multiple Lines Input	*30 dB below total input power, but not less than single line input sensitivity, 700 – 1650 nm*	*30 dB below total input power, but not less than single line input sensitivity, 1270 – 1650 nm*	*30 dB below total input power, but not less than single line input sensitivity, 1270 – 1650 nm*
Input Power	Maximum Displayed Level (sum of all lines input)	+10 dBm	+10 dBm	+10 dBm
	Maximum Safe Input Level (sum of all lines input)	+18 dBm	+18 dBm	+18 dBm
Built-in Automatic Measurement Applications				
	Signal-to-Noise Ratio (0.1 nm noise bandwidth), lines above –25 dBm	*>35 dB, channel spacing ≥200 GHz >27 dB, channel spacing ≥100 GHz*	*>35 dB, channel spacing ≥100 GHz >27 dB, channel spacing ≥50 GHz*	*>35 dB, channel spacing ≥100 GHz >27 dB, channel spacing ≥50 GHz*
	Signal-to-Noise Ratio of Modulated Lasers (with averaging) (0.1 nm noise bandwidth), lines above –25 dBm, 100 averages	*>35 dB, channel spacing ≥200 GHz >27 dB, channel spacing ≥100 GHz*	*>35 dB, channel spacing ≥100 GHz >27 dB, channel spacing ≥50 GHz*	*>35 dB, channel spacing ≥100 GHz >27 dB, channel spacing ≥50 GHz*
	Drift	Max, Min, Max-Min wavelengths and powers over time		
Laser Classification		FDA Laser Class I according to 21 CFR 1040.10; IEC Laser Class 1 according to IEC 60825		
Dimensions		140 mm H x 340 mm W x 465 mm D (5.5 in x 13.4 in x 18.3 in)		133 mm x 425 mm x 520 mm (5.2 in x 16.7 in x 20.5 in)
Weight		9 kg (19 lb)		14.5 kg (32 lb)

1 Specify 86122A-002 option.
2 For lines separated by less than 30 GHz, wavelength accuracy is reduced.
3 For lines separated by less than 15 GHz, wavelength accuracy is reduced.
4 For lines separated by less than 10 GHz, wavelength accuracy is reduced.
5 Contact Agilent Technologies for availability of special instruments with higher sensitivity.

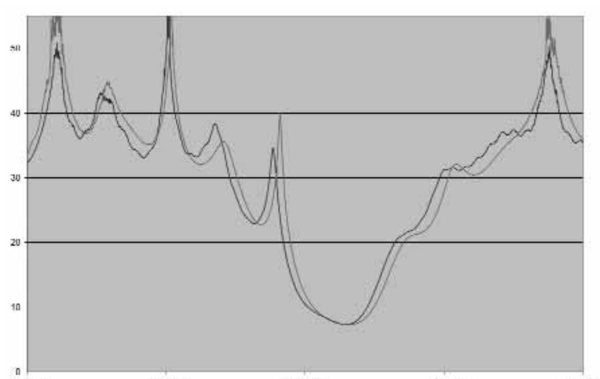
- **Precise manual and remote adjustments of polarization state**
- **Nine Save/Recall registers of SOP**
- **Continuous auto scanning, tuning the SOP across the entire Poincare sphere**

Developing and manufacturing competitive, high-value components and systems for today's optical industries requires precise attention to polarization sensitivity. The Agilent 8169A Polarization Controllers can help by saving time, money and effort when measuring and working with polarization sensitive devices.

Polarization sensitive devices include EDFAs, single-mode fiber, polarization maintaining fiber, isolators, switches, lasers, couplers, modulators, interferometers, retardation plates and polarizers. Device performance will be affected by polarization-dependent efficiency, loss, gain and polarization mode dispersion. These polarization phenomena enhance or degrade performance depending on the application area, be it communications, sensors, optical computing or material analysis.

An Important Part of a Measurement System

A polarization controller is an important building block of an optical test system because it enables the creation of all possible states of polarization. The polarized signal stimulates the test device while the measurement system receiver monitors the test device's responses to changing polarization. Sometimes polarization must be adjusted without changing the optical power. At other times, polarization must be precisely synthesized to one state of polarization (SOP) and then adjusted to another SOP according to a predetermined path.



Characterizing polarization effect of passive optical component

The Agilent 8169A Polarization Controller

The Agilent 8169A provides polarization synthesis relative to a built-in linear polarizer. The quarter-wave plate and half-wave plate are individually adjusted to create all possible states of polarization. Predeterministic algorithms within the Agilent 8169A enable the transition path from one state of polarization on the Poincare sphere to another to be specified along orthogonal great circles. These features are important because device response data can be correlated to specific states of polarization input to the test device. PDL measurement of DWDM components using the Mueller method is one of the main applications. The Mueller method stimulates the test path with four precicely known states. Precise measurement of the corresponding output intensities allows calculation of the upper row of the Mueller matrix, from which PDL is in turn calculated. This method is fast, and ideal for swept wavelength testing of PDL.

Specifications

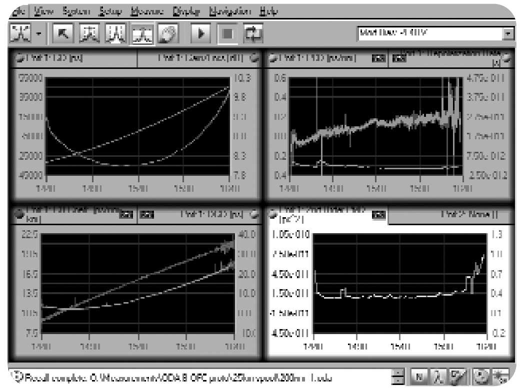
Specifications describe the instruments' warranted performance over the 0° C to +55° C temperature range after a one-hour warm-up period. Characteristics provide information about non-warranted instrument performance. Specifications are given in normal type. Characteristics are stated in *italicized* type. Spliced fiber pigtail interfaces are assumed for all cases except where stated otherwise.

Description	**Agilent 8169A**
Operating Wavelength Range	1400 to 1640 nm
Insertion Loss[2,3]	<1.5 dB
Variation over 1 full rotation	<±0.03 dB3
Variation over complete wavelength range	<±0.1 dB
Polarization Extinction Ratio[4]	>45 dB (1530 to 1560 nm)
Characteristic	>40 dB (1470 to 1570 nm)
	>30 dB (1400 to 1640 nm)
Polarization Adjustment	
Resolution[4]	0.18° (360°/2048 encoder positions)
Fast axis alignment accuracy at home position[5,6]	±0.2°
Angular adjustment accuracy: minimum step size	±0.09°
greater than minimum step size[5]	<±0.5°
Settling time (characteristic)	*<200 ms*
Memory Save/Recall registers	9
Angular repeatability after Save/Recall[5,6]	±0.09°
Number of scan rate settings	2
Maximum rotation rate[6]	360°/sec
Maximum Operating Input Power Limitation	+23 dBm
Operating Port Return Loss (characteristic)	
Total reflection – Individual reflections	*>60 dB*
Power Requirements	48 to 60 Hz 100/120/220/240 Vrms 45 VA max
Weight	9 kg (20 lb)
Dimensions (H x W x D)	10 x 42.6 x 44.5 cm 3.9 x 16.8 x 17.5 in

Agilent 86038B Photonic Dispersion and Loss Analyzer

www.agilent.com/find/lightwave

- **Fastest measurement speed for high throughput in manufacturing test**
- **Highest CD and PMD accuracy and resolution for manufacturing and R&D**
- **Specified operation over 1260 to 1640 nm (O-L band)**
- **2nd-order PMD, GD-ripple and other analysis functions**
- **Expandable for enhanced PDL accuracy and multiport use**
- **Industry-standard measurements with the modulation phase shift method**



Agilent 8169A Block Diagram

An Innovative Solution for Loss and Dispersion Measurements

High transmission data rates in optical communication networks are achieved with components and fibers ensured to have appropriate loss and dispersion properties. The challenge is to deliver this assurance in an accurate and cost-effective way. The new Agilent 86038B can simultaneously measure insertion loss (IL), polarization dependent loss (PDL), chromatic dispersion (CD), and polarization mode dispersion (PMD) by performing the industry standard modulation phase shift method that allows characterization of optical components and fibers in a single connection. By integrating Agilent's superior tunable laser source (TLS) and performance network analyzer (PNA), the Agilent 86038B is optimized for high wavelength accuracy and resolution with low-noise phase measurement.

Reduce Time to Market for 10 and 40 Gb/s

The new Agilent 86038B provides reliable accuracy and extensive analysis tools, giving deeper insight into device characteristics, faster, which will result in reduced time to market. The time-consuming task of polarization-resolved spectral measurement is solved by implementing swept-wavelength measurements, characterizing group delay (GD) and attenuation spectra at a pre-determined set of polarization states, and using matrix analysis to calculate differential group delay (DGD), PMD and PDL. Higher-level analysis for 2nd-order PMD is also provided. For example, the measurement time for a 200 nm wavelength range is 20 seconds, enabling high throughput at a lower cost.

Increase Throughput and Reduce Cost of Test

The Modularity of the system design using the modular TLS and 4-slot Lightwave Mainframe System allows adding and replacing optical modules for flexible adaption to customer-specific test needs, allowing more projects to be accepted and completed. For example, options for switched multiport measurement and enhanced IL/PDL accuracy can be added. And the wavelength range can be selected with the appropriate TLS model, anywhere in the unprecedented range from 1260 – 1640 nm. The Agilent 86038B has an easy-to-operate user interface to meet the needs of both R&D and manufacturing environments. With the push of a button, measurements can be acquired. The standard data interfaces are provided to allow data analysis, documentation and reporting. The instrument is fully remote controllable and can easily be integrated into an existing test setup.

Group Delay and Differential Group Delay Measurement

Relative Group Delay Repeatability	
<0 dB to –10 dB level	± 20 fs
<–10 dB to –20 dB level (characteristic)	± 150 fs
<–20 dB to–30 dB level (characteristic)	± 500 fs
<–30 dB to –40 dB level (characteristic)	± 5 ps
Relative Group Delay Uncertainty (<0 dB to –10 dB level)	± 50 fs
Differential Group Delay Repeatability	± 50 fs
Differential Group Delay Uncertainty (<0 dB to –10 dB level)	± 90 fs
PMD Uncertainty	± 0.03 ps + 7%
2nd-order uncertainty (typ)	PCD based on DGD uncertainty
Group Delay Time Resolution	1 fs
Modulation Frequency Range	5 MHz to 2.5 GHz
Group Delay Loss Range	50 dB

Measurements performed at the same temperature as the normalization temperature ± 0.5C. Performance measured using a 2.2 meter thermally isolated SMF patch cord.
Modulation frequency = 2 GHz. IFBW = 70 Hz, 1 nm wavelength step size. Repeatability is defined as the worst (plus or minus) standard deviation over the TLS wavelength range from 10 sweeps.

Length Measurement

Length Uncertainty (typ)	± 0.2mm +5x10-6L for L<56km.

Amplitude Measurement

Polarization Dependent Loss Accuracy	± 0.15typ (0.03 dB with Option #400)
System dynamic range (characteristic)	50 dB
Gain Loss Uncertainty	± 0.1 dB typ. (0.02 dB with Option #400)

Wavelength Measurement

Wavelength Range	
with Agilent 81600B-200 Tunable Laser Source	1440 nm to 1640 nm
with Agilent 81600B-160 or 81640B	1495 nm to 1640 nm
with Agilent 81600B-150	1450 nm to 1590 nm
with Agilent 81600B-140	1370 nm to 1495 nm
with Agilent 81600B-130	1260 nm to 1375 nm
with Agilent 81640A	1510 nm to 1640 nm
Minimum Wavelength Step Size	0.1 pm
Absolute Wavelength Accuracy [a,b]	
Stepped mode with Agilent 86122A (typ.)	± 1 pm
Swept mode without Agilent 86122A and with 81600B or 81640B	<5pm
Stepped mode without Agilent 86122A and with 81640A	± 15 pm
Relative Wavelength Accuracy [a,c]	
Stepped mode without Agilent 86122A and with 81600B or 81640B	± 5 pm
Stepped mode without Agilent 86122A and with 81600B or 81640B (characteristic)	± 2 pm
Stepped mode without Agilent 86122A and with 81640A	± 7 pm
Stepped mode with Agilent 86122A and with 81640A (characteristic)	± 3 pm

[a] Valid for one month and within a ±4.4 K temperature range after automatic wavelength zeroing. Measured with wavelength meter based on wavelength in vacuum.
[b] For details, refer to tunable laser's absolute wavelength accuracy specification.
[c] For details, refer to tunable laser's relative wavelength accuracy specification.

Optical Fiber Chromatic Dispersion Measurement

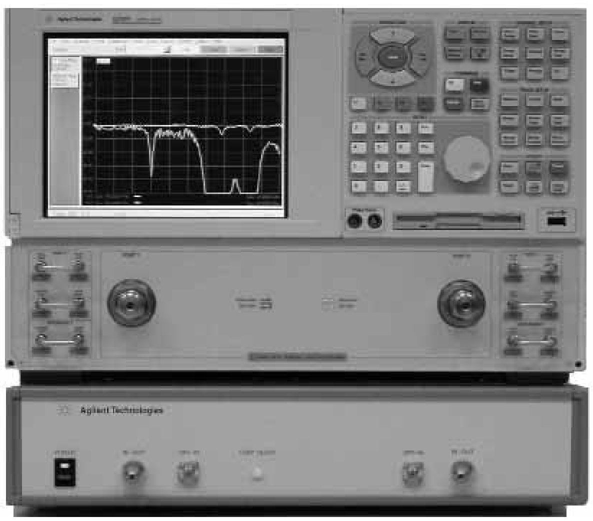
CD accuracy	0.1ps/nm +0.3%CD
Zero Dispersion Wavelength Accuracy (characteristic) [a]	± 150 pm
Zero Dispersion Wavelength Repeatability (characteristic) [a]	± 9 pm
Accuracy of dispersion slope at the zero dispersion wavelength (characteristic) [a]	± 25 fs/nm2
Repeatability of dispersion slope at the zero dispersion wavelength (characteristic) [a]	± 3 fs/nm2

[a] Derived from GD specification.

General Information

Assembled Dimensions: (H x W x D)	55.5cm x 43.5cm x 55.5cm
Net Weight	Standard system: 54 kg

- **Calibrated frequency-response measurements of fiber-optical components.**
- **Standard support of 3GHz, 8.5GHz and 20 GHz measurement bandwidth depends on Network Analyzer**
- **1310 nm and/or 1550 nm operation in SMF and 850nm in MMF**
- **Enable differential measurement with support of 4-port PNA-L**
- **Integration of customer supplied network analyzer**



N4373A Lightwave Component Analyzer

Electro-Optical Components Solution

For the development and manufacturing of optical components used in lightwave transmission systems like CATV, SDH/SONET and Ethernet, it is essential to characterize the components in parameters of gain, bandwidth and frequency response. The modulation frequency range is optionally selected depending on the network analyzer model from 3GHz to 67 GHz.

Support Industry-Standard Agilent PNA/ENA

Agilent PNA/ENA series network analyzers provide fast measurement, high dynamic range and various utilities for research and development applications. Agilent PNA-L series network analyzers enable high cost-efficiency for manufacturing, especially with the 4-port network analyzer which covers differential measurement for the complementary electrical interfaces. The Agilent electrical calibration module (ECal) achieves easy, fast and highly repeatable electrical calibration.

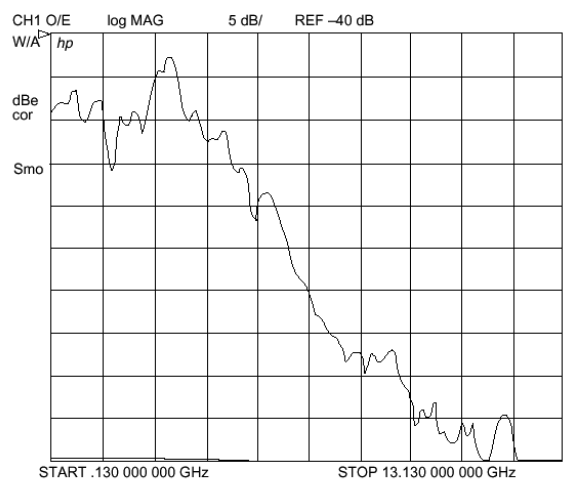
Extensive Features in Complete Solution

The Agilent N4373A Lightwave Component Analyzer includes the optical unit, which contains the laser source and the optical detector in one box. The wavelength of the laser source can be selected from 850, 1310 and/or 1550 nm. The optical detector is calibrated with a reference device traceable to NIST (National Institute of Standards and Technology), which provides high confidence in the measurements. Both the laser source and the optical detector are electrically and thermally stabilized for measurement repeatability. The user friendly interface of the Agilent network analyzer is also available on the Agilent N4373A Lightwave Component Analyzer with LCA firmware integrated in the network analyzer.

Measurement Capability

The Agilent N4373A lightwave component analyzer provides the following measurement capabilities.

- E/O, O/E components test: Test of electrical-to-optical and optical-to-electrical components such as LED, laser diodes, optical modulators, photodiodes and APDs.
- O/O components test: Test of optical-to-optical components such as optical fibers, optical splitters and optical couplers.
- E/E components test: Network analyzer's original capability, test of the electrical components such as amplifiers and electrical filters.



Typical laser frequency response

Optical Head Adapter

These adapters are to be used with Agilent optical heads only.
The connector adapters are needed to attach connecterized fibers.
Optical Head Adapters – with integral D-shape for 8162xx optical head (except 81628B – see threaded version)

81001FA	FC/PC, FC/APC
81001KA	SC
81001LA	LA/F3000
81001PA	E2000
81001MA	MU
81000ZA	Blank Adapter

Optical Head Adapters – with threaded version for 81628B optical heads

81000FA	FC/PC, FC/APC
81000KA	SC
81003LA	LA/F3000
81000PA	E2000
81000VA	ST
81003TD	MTP (for female connectors only)

Connector Adapter for Optical Heads

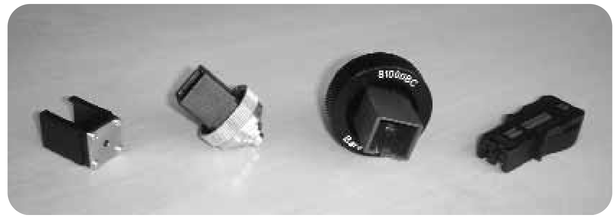
81624DD	D-shaped adapter to be used with the Agilent 8162xx optical heads. Adapter to interface, 8100xx connector

Optical Connector Interface

Used with Agilent lightwave instruments and modules. Not to be used with optical heads. These flexible connector interfaces can be exchanged by the user and allow easy cleaning of instrument front-end interfaces. Optical Connector Interface – for straight and angled, physical and non-physical contact. All connectors are available for straight and angled connection, unless otherwise noted.

81000FI	FC/PC
81000NI	FC/APC
81000KI	SC
81000LI	LC/F3000 (PC)
81002LI	LC/F3000 (APC)
81000HI	E2000 (PC)
81000PI	E2000 (APC)
81000MI	MU (PC)
81002MI	MU (APC)
81000VI	ST

Bare Fiber Adapters and Interfaces



81000BC	Bare Fiber Connectivity Set for 81623B, 81624B and 81626B (1x head Adapter, 1x 0-400 µm holder, 1x 400-900 µm holder, 1x gauge)
81000BI	Bare Fiber Connectivity Set for 81630B and 81634B (1x sensor adapter, 1x 0-400 µm holder, 1x 400-900 µm holder, 1x gauge)
81004BH	Bare Fiber Holder Set (10x 0-400 µm holder)
81009BH	Bare Fiber Holder Set (10x 400-900 µm holder)

Lenses

Used with the Agilent optical heads in combination with an optical head adapter.

81050BL	Lens, effective focal length of lens = 6.2mm, NAmax = 0.37, wavelength range 900 to 1700 nm, for multi-mode fibers with NA ≤0.3
81010BL	Lens, effective focal length of lens = 2.9mm, NAmax = 0.19, wavelength range 900 to 1700 nm, for single-mode fibers with NA ≤0.13

Universal Through Adapter

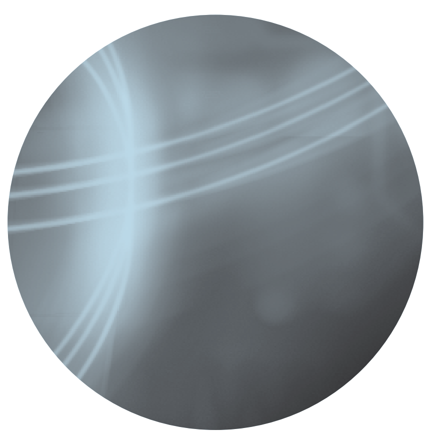
In combination with an Agilent 81000xI connector interface, this adapter allows you to mate an HMS-10 connector to another HMS-10, FC/PC/SPC, APC, DIN, ST, E-2000, or SC connector. It can also be used to mate an Agilent 81000BR reference reflector to a connector under test. The Agilent 81000UM is a through adapter only. It can not be used at the fiber interfaces of the modules. 81000UM Universal Through Adapter

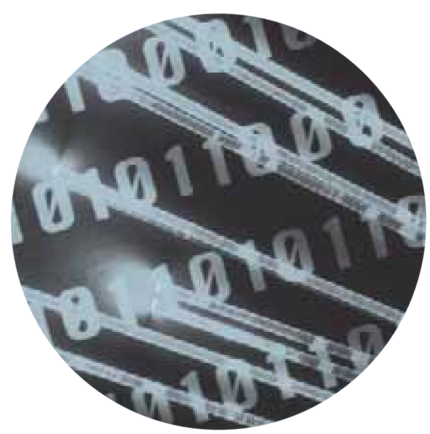
Reference Reflector

A gold-plated HMS-10 connector for use in measuring return loss of optical connectors. It allows you to establish a precise reference for reflection measurements. Return loss is 0.18dB ± 0.1dB (96% ± 2%)

81000BR	Reference Reflector

High Quality Characterization – Done quickly



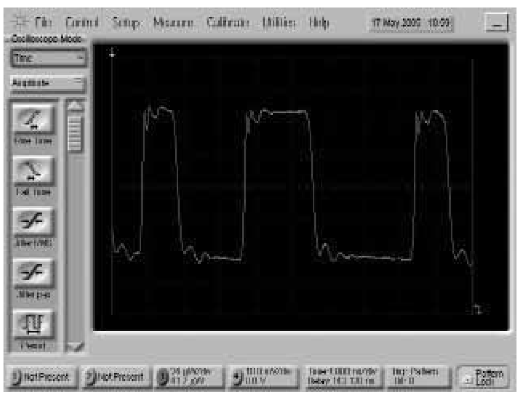


Application Overview

For any high-speed communications signals, the channel and basic signal characteristics must be assessed for compliance with standards and interoperability with other devices in the system path. Viewing these signals on a wide bandwidth oscilloscope simplifies the task and frees designers, to optimize their design and get products to market quicker. Agilent offers a wide range of high quality measurements within one mainframe, the 86100C DCA-J Infiniium oscilloscope, which characterizes four types of signals described here.

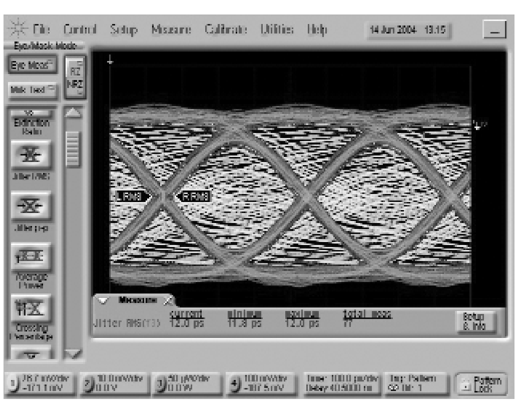
Waveform Measurements

Viewing the individual bits of a digital communications signal allows a simple analysis of the waveform quality including parameters such as rise and fall times, pulsewidth and overshoot. The DCA-J allows the user to capture and analyze a complete single-valued record, up to 2^23 bits long, of the transmitted pattern waveform.



Digital communication single-valued waveform

Today's high bite rate systems combined with increasing use of pre-emphasis and equalization techniques, used to compensate for the impairments of inter-symbol interference, make it more important than ever to characterize accurately and completely the quality of the transmission signal. With the advanced waveform analysis package on the 86100C DCA-J, the effects of equalization on closed eyes can be measured and understood. The on-board equalizer tool can auto detect the tap values of a linear feed-forward equalizer and open up a closed eye for characterization. The industry standard mathematical scripting tool, MATLAB, has also been integrated into the DCA-J for advanced filtering and signal processing of the waveform.

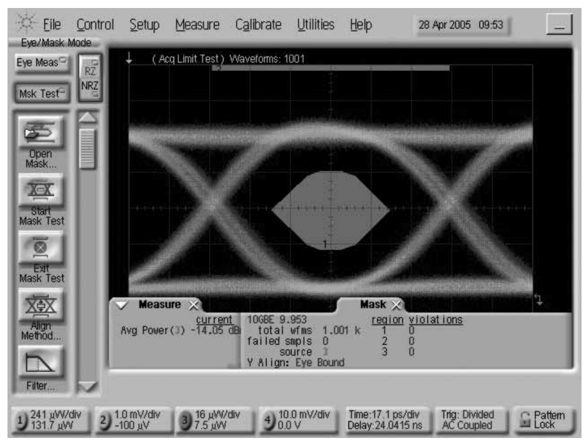


Open up a closed eye with the onboard equalization tool

Eye Diagrams and Clock Recovery

Eye tests are one of the most common methods to characterize the quality of a signal and feature in several industry standards such as SONET, SDH, Fibre Channel and Gigabit Ethernet. The eye is examined for mask margin, extinction ratio and overall quality compared to an expected eye.

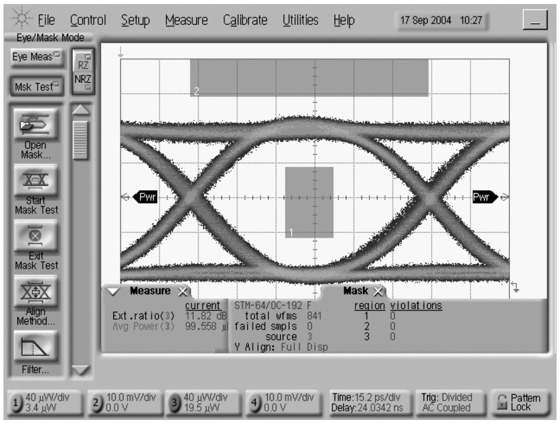
Histograms are a statistically valid means to determine the '0' and '1' levels. Masks are mapped to the '0' and '1' levels; they are described by polygons that vary between standards and are recalled from the mainframe memory as needed. Mask margin is an efficient method to verify the shape of the eye as shown in Figure cc. The quality of the eye measurement is further enhanced by the use of the applicable filter for the rate. These filters are normally described by a fourth order Bessel-Thomson low-pass response with -3dB at 75% of the bit rate and are available for all common rates in Agilent optical receivers for compliance measurements. The unfiltered eye can also be viewed to determine other design parameters to be enhanced.



Eye diagram and mask with filter applied

As the power level of the optical signal is decreased, the width of the eye increases with noise and the eye comes closer to the mask. The 86100C mainframe offers a quick means to assess the variation with several parameters, including power. Smaller signals can be characterized accurately with an amplified module such as the 86105C optical receiver that covers all the common wavelengths and data rates in modern communications systems.

Extinction ratio tells the designer how well the optical transmitter is separating the '0' and '1' levels, which are again established by the histograms. Filters are specified in the standards for these measurements and must always be used. Optical receivers have a small deviation from the nominal filter value specified in the standard, creating a small deviation in the measured value. Agilent optical receivers have the ability to adjust for the known value of extinction ratio correction factor, which can improve significantly the yield of a lot of devices. The correction factors for the 86105C are built into the module and are turned on or off quickly as required. The figure above shows a combination view of extinction ratio and mask margin for a different rate and filter.



Typical extinction ratio and mask measurements

Typically an external timing reference is used to synchronize the oscilloscope to the test signal. In cases where a trigger signal is not available, clock recovery modules are available to derive a timing reference directly from the waveform to be measured. The Agilent 8349XA series of clock recovery modules are available for electrical, multimode optical, and single-mode optical input signals. All 8349XA modules have excellent jitter performance to ensure accurate measurements. Each clock recovery module is designed to synchronize to a variety of common transmission rates. The 83496A can derive triggering from optical and electrical signals at any rate from 50 Mb/s to 13.5 Gb/s.

The Agilent clock recovery modules have adjustable loop bandwidth settings. Loop bandwidth is very important in determining the accuracy of your waveform when measuring jitter, as well as testing for compliance. When using recovered clocks for triggering, the amount of jitter observed will depend on the loop bandwidth. As the loop bandwidth increases, more jitter is "tracked out" by the clock recovery resulting in less observed jitter.

- Narrow loop bandwidth provides a "jitter free" system clock to observe all the jitter.
- Wide loop bandwidth in some applications is specified in the standards for compliance testing. Wide loop bandwidth settings mimic the performance of communications system receivers. The 83496A has a continuously adjustable loop bandwidth from as low as 15 kHz to as high as 10 MHz. It can also be configured as a golden PLL for standards compliance testing.

Jitter

The extremely wide bandwidth of equivalent-time sampling oscilloscopes makes them the tool of choice for precision analysis of very high-speed waveforms. Historically, low sampling rates have limited their ability to perform in-depth jitter analysis. A revolutionary sampling/acquisition system in the Agilent 86100C has transformed the sampling oscilloscope into a precision jitter analysis tool. Complete jitter characterization is available including:

- Jitter analysis from 50 Mb/s to over 40 Gb/s
- Ultra-high sensitivity through low intrinsic jitter ("jitter noise floor", as low as 200 femtoseconds)
- Very simple setup and measurements, typically achieved with a single button press
- Separation into random and several deterministic jitter classes
- Histogram and tabular displays of all jitter components
- Jitter analysis linked with precision waveform displays for deeper insight into signal behavior

Every high-speed communications design faces the issue of jitter. When data are jittered from their expected positions in time, receiver circuits can make mistakes in trying to interpret logic levels and bit error ratio (BER) is degraded.

As data rates increase, jitter problems tend to be magnified. For example, the bit period of a 10 Gb/s signal is only 100 picoseconds, signal impairments such as attenuation, dispersion and noise can cause the few picoseconds of timing instability that can mean the difference between achieving or failing to reach BER objectives. The problem is further aggravated by the difficulty presented in making accurate measurements of jitter. A variety of measurement approaches exist but there has been frustration within the industry around the complexity of setting up a measurement, getting repeatable results and the inconsistency of different techniques. The "equivalent time" sampling oscilloscope, with configurations having over 80 GHz of bandwidth and extremely low levels of intrinsic jitter, is the most accurate tool available for jitter measurements at high data rates.

In many communications systems and standards, specifying jitter involves determining how much jitter can be on transmitted signals. Jitter is analyzed from the approach that for a system to operate with very low BER's (one error per trillion bits being common), it must be characterized accurately at corresponding levels of precision. This is facilitated through separating the underlying mechanisms of jitter into classes that represent root causes. Specifically, jitter is broken apart into its random and deterministic components. The deterministic elements are further broken down into a variety of subclasses. With the constituent elements of jitter identified and quantified, the impact of jitter on BER is more clearly understood which then leads to straightforward system budget allocations and subsequent device/component specifications. Breaking jitter into its constituent elements allows a precision measurement of the total jitter on a signal, even to extremely low probabilities.

The first classification is between jitter that is random and that which is not. Jitter that is not random is bounded. That is, its magnitude is finite. In contrast, random jitter (RJ) is unbounded and is often described as following a Gaussian distribution with 'tails' that extend indefinitely. Random jitter mechanisms are often due to oscillator phase noise. The clock used to set data rates cannot produce a pure frequency and exhibits a random deviation from the ideal. RJ is given by the root-mean-square (RMS) value of the Gaussian distribution.

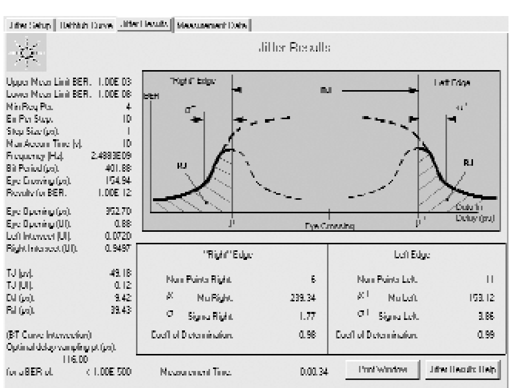
Deterministic jitter (DJ) is expressed in terms of a dual Dirac-delta model as DJ(δδ). Distinct from the peak-to-peak value of the DJ distribution, DJ(p-p) is the key parameter required of technology specifications for its utility in estimating the impact of a component on the total jitter at a low bit error ratio on a system.

Deterministic jitter can be broken into several subclasses. The first division is between that which is correlated to the data sequence or pattern and that which occurs, independent of the data. This can be referred to as correlated and uncorrelated DJ. (Note that RJ is also a class of uncorrelated jitter, but is unbounded and not deterministic). Uncorrelated DJ is most often observed as some form of periodic phase modulation of clocks used to set data rates. This DJ is uncorrelated, because its magnitude is independent of where it is observed in the pattern. Because it is periodic, it is referred to as periodic jitter (PJ). The magnitude of PJ, for example, of a single frequency of phase modulation is just the amplitude of the oscillation.

Jitter that is correlated to the data pattern can be broken into three categories: Inter-symbol interference, duty-cycle distortion, and sub-rate jitter. Measurement of these jitter sources requires that each edge in the data pattern be observed.

Inter-symbol interference (ISI) mechanisms are well known for their impact on digital communications. Reduced or insufficient bandwidth results in reduced edge-speeds. Thus, as a transition takes place from a 1 to a 0 or a 0 to a 1, the signal may not reach its intended amplitude before it is required to switch logic levels again. Obviously this will result in vertical eye closure. However, this will also result in both retarded and advanced edges relative to their ideal positions; the value of ISI determined from measuring the average position of each bit in the pattern with all uncorrelated effects removed. It is the difference between the earliest falling edge and latest falling edge, or the difference between the earliest rising edge and the latest rising edge, whichever is larger.

Duty cycle distortion (DCD) is observed when the durations of logic 1 pulses are different than the duration of logic 0 pulses. In an eye diagram the nominal eye crossing (where rising edges intersect falling edges) occurs somewhere other than the 50% amplitude point. In that jitter is typically characterized at the 50% amplitude level, rising and falling edges intersecting at a level other than the 50% amplitude implies that edges are misplaced from their ideal positions. DCD is determined from the same data set as ISI, this is the difference in the mean position of all falling edges and the mean position of all the rising edges, with uncorrelated effects removed.



Jitter family tree graphic Figure 1. Total jitter is composed of several types of jitter

ISI and DCD are part of a jitter class called data dependent jitter (DDJ) because the net jitter resulting from them varies with the data pattern. DDJ is the difference in the position of the earliest edge (rising or falling) and the latest edge (rising or falling). Thus the measurement result is dictated by the worst-case bits in the pattern, but does not include the effects of any uncorrelated jitter. Note that as DCD goes to zero, DDJ is equivalent to ISI. As ISI goes to zero, DDJ is equivalent to DCD. DDJ is not necessarily the sum of ISI and DCD. For example, the DDJ can be completely dominated by its ISI component.

Sub-rate jitter (SRJ) jitter can be viewed as a form of correlated PJ or a form of DDJ, depending on how it is manifested in the data pattern. Consider a multiplexing scheme where one leg of a data serializer is physically longer than intended. Any bit on this leg is possibly retarded compared to others on different legs.

The separation of jitter into its various subcomponents obviously helps in troubleshooting jitter problems, as the nature/type of the jitter is often a key indicator of the source. A less obvious reason is that it provides a method to assess accurately the total jitter magnitude to very low probabilities without the time required for a direct measurement. The key to the approach is to be able to segregate the RJ from all other sources. This allows a precision assessment of the distribution of the jitter. The extreme jitter magnitudes are effectively the low probability tails due to RJ. Thus determining these values is achieved once the RMS RJ is known, in addition to knowing how the deterministic elements interact with the RJ.

Total jitter (TJ) is interpreted as the total effective eye diagram closure in the time axis at a specified BER level expressed in time or unit intervals. The probability that an edge will be misplaced beyond the TJ value is less than the user-defined probability threshold. Thus if the user defined closure threshold is 10^{-9}, and the TJ value provided by the 86100C is 50 ps, the likelihood that an edge will be more than 25 ps late or 25 ps early is less than 1 in 10^{9}. If for the same signal the threshold is set to a lower probability, such as 10^{-12}, the reported jitter value will increase significantly, as a much wider population of the distribution function is included in the assessment of TJ.

Time Domain Reflectometry and Transmission
Most optical devices have high-speed electrical inputs and outputs, and these must be considered when designing and verifying the overall device. Solutions using Time Domain Reflectometry (TDR) and Time Domain Transmission (TDT) are quick and telling of the path and device electrical performance. Most industry standards call for the characterization of impedance and S-parameters, which are easily accommodated with Agilent's 86100C DCA-J Infiniium oscilloscope, 54754A Differential TDR Module and 86100C-202 enhanced impedance and S-parameter software.

Most new circuit designs are differential to improve crosstalk and interference performance. Circuits need to be characterized in single-ended, differential mode and common mode. Typical displayed results are shown in Figure 1.

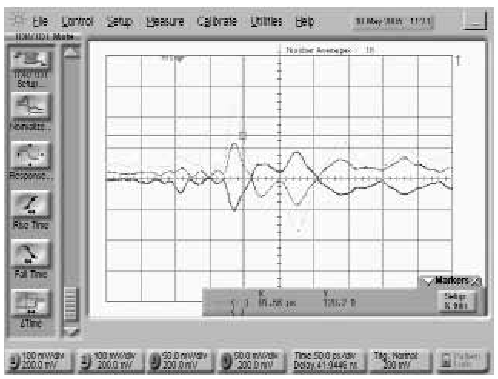


Figure 1: Single-ended and differential impedance

The TDR module sends a fast edge along the transmission line, then analyzes the reflected signal and displays voltage or impedance versus distance. The 86100C-202 software converts the time-domain results into the frequency domain to display return loss, VSWR or reflection coefficient versus frequency as shown in Figure 2. Any selected portion of the trace can also be assessed for the excess inductance or capacitance, allowing the designer to estimate the amount of required compensation in that region.

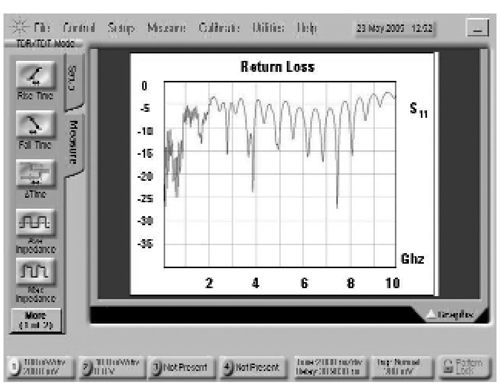


Figure 2: Return loss versus frequency

Many high speed circuits and interconnects are fabricated using inexpensive FR-4 or similar materials, which have high loss. The loss needs to be understood for the effect on the waveform, jitter and eye diagram. Similarly, the incident pulse is sent through the transmission line and the resulting signal is analyzed by another receiver channel in the same or adjacent module. This pulse is displayed in the time domain and also converted to the frequency domain, which is the insertion loss versus frequency as shown in Figure 3.

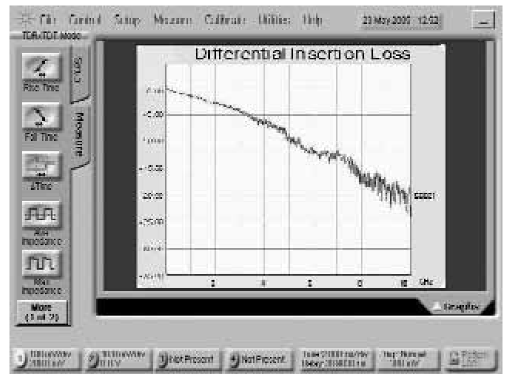


Figure 3: Differential insertion loss

Adjacent and large discontinuities from connectors, via fields and transitions, often mask subsequent discontinuities and the reported value of impedance and return loss may not be accurate. The 86100C-202 software corrects for these impedance mismatches and shows an accurate representation of impedance versus distance as shown in Figure 4. These insights allow the designer to adjust properly the design in the appropriate locations of the circuit path.

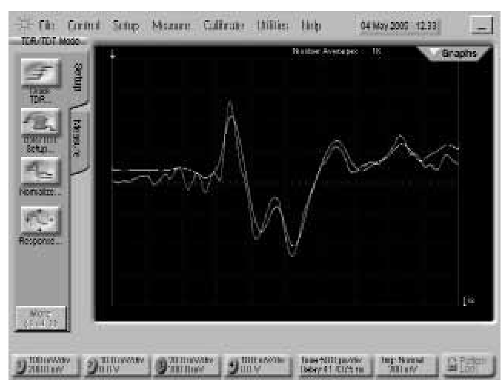


Figure 4: Corrected impedance profile (green trace)

The Smart Way to Measure – Quality Stimulus Solution
Delivering the confidence you demand to ensure signal integrity in today's and the next speed class devices.

Signals break through one performance barrier after another. As electrical signals start competing with laser-generated ones, it is no longer necessary to convert to optical to reach high speeds.

Agilent Technologies offers the most comprehensive portfolio of digital stimulus solutions to generate current and emerging digital waveforms and data signals.

The high-speed instruments of this portfolio are:
- 81133/4A 3.35 GHz pulse pattern generator
- 81141A 7 GHz serial pulse data generator.

Agilent 81133/4A 3.35 GHz Pulse Pattern Generator – At a glance

Digital communication single-valued waveform

Ultimate timing accuracy and signal performance
- Unrivaled performance - the solution is the perfect clock, pulse, data, pattern and PRBS source for all application up to 3.3.5 GHz
- Control over the signal quality at speeds from 15 MHz up to 3.35 GHz
- Cross-over point adjustments and jitter insertion using the delay control input
- High quality signal and low intrinsic jitter enable you to perform quick and reliable measurements with accurate and repeatable results
- 12 Mbit pattern memory per channel enables testing of today's high-speed interfaces like PCI Express or Serial ATA.

Application information
- PCI Express receiver testing
- Multi level testing
- System clock and system trigger
- Stress test
- Fully buffered DIMM
- Fibre Channel
- Pulsed R/F measurements

High speed, High Fidelity
When timing is crucial and high performance is required, the Agilent 81133A and 81134A provide the fast rise times and low jitter that are required for in depth analyzes and performance characterizations of your devices.

With their unrivaled performance they are the perfect clock, pulse, data pattern and PRBS sources for all applications up to 3.35 GHz. Sample applications comprise cross-over point adjustments and jitter insertion using the delay control input. Their high quality signals and low intrinsic jitter enable you to perform quick and reliable measurements with accurate and repeatable results. The jitter-insertion capability enables jitter tolerance tests. Target application of the 81133A and 81134A include physical layer characterization, signal integrity and jitter tests. In addition the 81134A is Agilent's recommended solution for PCI Express and Serial ATA compliance tests.

81133A and 81134A Performance Overview:
- 1 channel (81133A) or 2 channels (81134A)
- 50 mV up to 2 Vpp amplitude (into 50 Ohm)
- Programmable termination voltage
- Transition times <90 ps (adjustable between 70 ps – 120 ps typ.)
- 15 MHz to 3.35 GHz repetition rate
- Total jitter typically less than 2 ps RMS jitter
- 12 Mbit pattern memory per channel
- PC-based pattern management software
- 1.5 ps typ. clock jitter
- Differential outputs
- Complex data patterns e.g. for PCI Express, SATA
- Pseudo Random Binary Sequence (PRBS) generation
- Delay modulation: –250 ps to 250 ps (up to 500 ps total jitter)
- Modulation frequency: 0 – 200 MHz
- Additional variable crossover between 30% – 70% typ.
- NRZ/RZ/R1 signal formats over the full frequency range

Complementary Products:
54855A Infiniium oscilloscope and DSO 80000/86100C DCA-J

Agilent 81141A 7 GHz Serial Pulse Data Generator – At a Glance

Versatile, highest quality pulse and data signals
- Data formats RZ, R1 and NRZ with flexible parameters for high quality waveforms and eye diagram measurements
- Pattern and sequence capabilities for protocol like data
- Linear delay modulation up to 1 GHz for jitter tolerance testing
- Up to 7 GHz Frequency to address next generation speed classes for serial bus standards
- Electrical signals start competing with laser-generated ones, it is no longer necessary to convert to optical to reach ultra-high-speeds.

Applications:
- High speed serial Buses e.g. PCI Express I,II, S-ATA II,III, Fibre Channel
- Application in education and research laboratories e.g. control of particle accelerators
- Ultra Wide Band Radio
- System Clock and System Trigger
- Stress Test

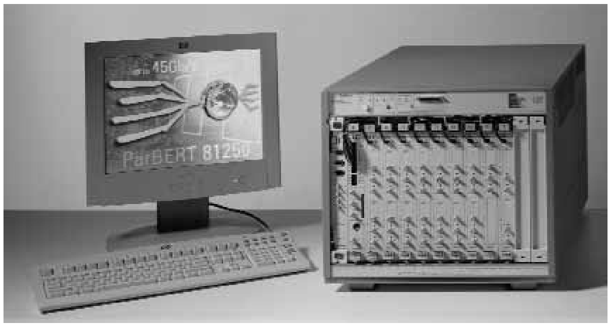
High-speed and high-quality signals for developing reliable, next generation products
Achieving high-quality characterization and reliable measurements needs superior signal quality. The new 7 GHz Pulse Data Generator provides what is needed to conduct physical layer tests, e.g. precision low jitter signals or full control of data streams for stress tests. Its linear delay modulation is essential for jitter tolerance measurements.

The 81141A combines multiple data formats like RZ, R1 and NRZ with sequencing, trigger capability and high-speed frequency. It enables the development of the next generations of high-speed buses.
Small amplitudes with flexible and accurate crossover-points allow sensitivity tests, the RZ format is mandatory for bandwidth tests.

81141A Performance Overview:
- Frequency: 150 MHz to 7 GHz
- Output Channels: Single channel data and clock differential or single ended
- Triggering: Trigger In and Trigger Out
- Subrate clock for easy generation of reference clock
- Sequencing: 4 levels possible
- Data formats RZ, R1, NRZ
- Transition times (20/80) < 20 ps
- Additional variable crossover between 20 % and 80 %
- Jitter (clock mode) 1 ps typical
- Jitter (data mode) 9 ps pp typical
- Jitter modulation bandwidth up to 1 GHz
- Data output amplitude /resolution 0.1V to 1.8 V with a 5 mV resolution
- Output voltage window –2V to 3 V
- PRBS generation from 2 5 –1 to 2 31 - 1
- Memory 32Mbit
- PC based pattern management software

Complementary Products:
54655A Infiniium oscilloscope and DSO 80000/86100C DCA-J

High Quality Characterization – Done Quickly
ParBERT 81250 Parallel Bit Error Ratio Tester



- **Modular, flexible and scalable design to fit testing needs, varying from a few Mb/s up to 45 Gb/s**
- **Generate complex sequences & analyze data in real-time**
- **Up to 64 parallel input and output channels at rates up to 13.5 Gb/s**
- **Addresses: MUX, FEC, CEI, AMB, PON, PCIe, SAN, GbE, SONET/SDH**

The ParBERT 81250 parallel bit error ratio tester provides extremely fast parallel BER testing for high-speed digital communication ports, components, chips or modules. Application examples are:

- MUX/DeMUX testing up to OC-768
- FEC device testing
- Multiple transmitter/receiver testing; PON
- Characterization of computing ports; SAN, FC, GbE, AMB
- Characterization of communication ports; SONET/SDH
- True differential input and output; SFI-4, SFI-5, Xaui

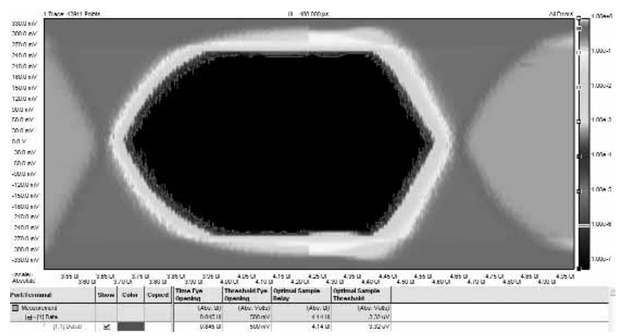
The ParBERT 81250 is a modular, flexible and scalable Platform, with a very comprehensive software and measurement suite, designed to fit your application needs. The system generates complete pattern sequences based on pseudo random word sequences (PRWS), user-defined and standard PRBS up to 2^31-1 on parallel lines. Dependent on the data module's speed class, the user pattern length is from 2 Mb up to 128 Mb. This enables fast BER measurements, as bits are compared in real-time. The BER can be viewed while a measurement is running.

The ParBERT Analyzers can synchronize automatically on the incoming data stream. Based on the BER measurement the ParBERT 81250 offers independently programmable timing and level parameters on every channel. It can generate and analyze single-ended and differential signals – including true differential signals, to test devices based on logic technologies such as LVDS, ECL and PECL.

The 3.35 Gb/s and 13.5 Gb/s ParBERT generator modules offer a delay control input for jitter injection for receiver Input stress testing. The new 13.5 Gb/s ParBERT generator and analyzer modules are the latest enhancement to the powerful ParBERT platform. With enhanced jitter generation and analysis capabilities and their broad frequency range, the new modules are the ideal solution for testing 10 Gb/s devices like OC-192 devices. The new 13.5 Gb/s ParBERT modules are working with the new E4809A clock module only.

ParBERT offers a measurement suite:

- BER measurement (one-/zero errors, accumulated errors...)
- Fast eye mask measurement (mask test with pass/fail)
- DUT output timing measurement (RJ, DJ, TJ, phase margin)
- Spectral decomposition of jitter (spectral jitter analysis)
- DUT output level measurement (high/low level, amplitude, Q-factor)
- Eye opening (3-dimensional eye analysis voltage-time-BER)



Data Modules

	E4832A	E4861A	E4861B
Maximum Data Rate	675 Mb/s	2.7 Gb/s	3.35 Gb/s
Front End Slots per Module	4	2	2
Memory Depth per Channel	2 Mb	8 Mb	Up to 16 Mb
Segments PRBS, PRWS	User defined patterns and PRBS 2^n-1, n=7,9,10,11,15,23,31		
Auto-Synchronisation	On PRBS and memory based data by: – Bit synchronization with or without automatic phase alignment – Automatic delay alignment around the start sampling delay		
Usable Front Ends	E4838A E4835A	E4862A E4863A E4864A E4865A	E4862B E4863B

Data Generator Front Ends

	E4838A	E4864A	E4862A	E4862B
Maximum Data Rate	675 Mb/s	1.65 Gb/s	2.7 Gb/s	3.35 Gb/s
Outputs	1, differential or single-ended	1, differential or single-ended	1, differential or single-ended	1, differential or single-ended
Data Format	RZ, R1, NRZ, DNRZ	NRZ, DNRZ clock: duty cycle 50% + 10% typ.	NRZ, DNRZ clock: duty cycle 50% + 10% typ.	NRZ, DNRZ, RZ, R1
Transition Times	0.5 ns – 4.5 ns (0.35 ns typ.) @ ECL (10% – 90%)	90 ps typ. @ ECL, LVDS (110 ps typ. @ Vpp max) (20% – 80%)	90 ps typ. @ ECL, LVDS (110 ps typ. @ Vpp max) (20% – 80%)	<75 ps (60 ps typ.) (20% – 80%)
Amplitude/Resolution	<0.1 to 3.5 V_{pp}/10 mV	0.05 to 1.8 V_{pp}/10 mV	0.05 to 1.8 V_{pp}/10 mV	0.05 to 1.8 Vpp/10 mV

Data Analyzer Front Ends

	E4835A	E4865A	E4863A	E4863B
Maximum Data Rate	675 Mb/s	1.65 Gb/s	2.7 Gb/s	3.35 Gb/s
Inputs	2, differential or single-ended	1, differential or single-ended	1, differential or single-ended	1, differential or single-ended
Impedance	50Ω single-ended 100Ω differential	50Ω single-ended 100Ω differential	50Ω single-ended 100Ω differential	50Ω single-ended 100Ω differential
Input Threshold	–2.0 to +4.5 V	–2.0 to +3.0 V	–2.0 to +3.0 V	–2.0 to +3.0 V

Data Generator Module

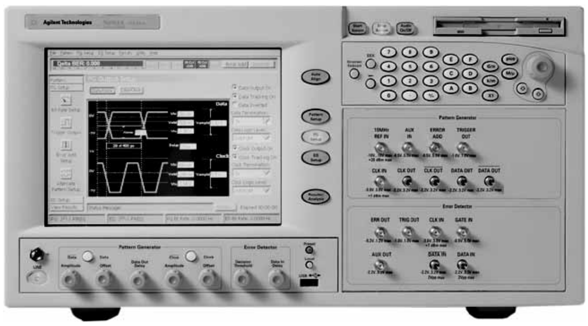
	N4874A	N4872A	E4810A Optical Generator	E4868B 45 Gb/s MUX Module
Maximum Data Rate	7 Gb/s	13.5 Gb/s	3.35 Gb/s	43.2 Gb/s (with E4861A + E4862A) 45 Gb/s (with E4861B + E4862B)
Outputs	1, differential or single-ended	1, differential or single-ended	Optical 830 – 860 nm (850 nm typ.)	differential
Data Format	NRZ, DNRZ	NRZ, DNRZ	NRZ, DNRZ	NRZ
Transition Times	<25 ps (10% – 90%)	<25 ps (10% – 90%)	<100 ps (20% – 80%)	9 ps typ. (20% – 80%)
Amplitude/Resolution	0.1 to 1.8 Vpp/5 mV	0.1 to 1.8 Vpp/5 mV	–	0.5 to 2.0 V single ended/10 mV
Average Output Power Level	–	–	>–3 dBm	–
Extinction Ratio Range/ Resolution/Accuracy	–	–	5 to 10 dB/0.5 dB/±1 dB	–
Memory Depth per Channel	Up to 64 Mb	Up to 64 Mb	Up to 16 Mb	128 Mb
Segments PRBS, PRWS	User defined patterns and PRBS 2^n-1, n=7, 10, 11, 15, 23, 31 (HW based)	User defined patterns and PRBS 2^n-1, n=7, 10, 11, 15, 23, 31 (HW based)	User defined patterns and PRBS 2^n-1, n=7, 10, 11, 15, 23, 31	User defined patterns and PRBS 2^n-1, n=7, 10, 11, 15, 23, 31 (pure PRBS)
Auto-Synchronisation	On PRBS and memory based data by: – Bit synchronization with or without automatic phase alignment – Automatic delay alignment around the start sampling delay			–

Data Analyzer Module

	N4875A	N4873A	E4811A Optical Analyzer	E4869B DEMUX Module
Maximum Data Rate	7 Gb/s CDR at 1/2/4 Gb/s	13.5 Gb/s CDR at 1/2/4/10 Gb/s	3.35 Gb/s	43.2 Gb/s (with E4861A + E4863A) 45 Gb/s (with E4861B + E4863B)
Inputs	1, differential or single-ended	1, differential or single-ended	Optical 750 – 1650 nm calibrated at 850 nm	differential
Impedance	50Ω single-ended 100Ω differential	50Ω single-ended 100Ω differential	–	50Ω
Input Threshold	–2.0 to +3.0 V	–2.0 to +3.0 V	–	±400 mV
Sensitivity	50 mV	50 mV	–9 dBm (lowest average power for mask test)	50 mV

Clock Module

	E4805B	E4808A	E4809A
Frequency Range	1 kHz to 2.7 GHz	170 kHz to 10.8 GHz	20.8 MHz to 13.5 GHz
Resolution	1 Hz	1 Hz	1 Hz
Accuracy	±50 ppm with internal PLL reference	±50 ppm with internal PLL reference	±50 ppm with internal PLL reference
Clock Jitter	<10 ps rms (5 ps typ.)	<10 ps rms (5 ps typ.)	~2 ps rms
Compatible Data Modules	E4832A/E4861A	E4832A/E4861A/E4861B/ E4868B/E4869B/E4810A/ E4811A	E4832A/E4861B/E4810A/ E4811A/N4872A/N4873A/ N4874A/N4875A



- **Excellent price/performance ratio**
- **Variable Frequency up to 3.6 Gb/s or 12.5 Gb/s**
- **<25 ps transition time**
- **<50 mV pp input sensitivity**
- **Fast eye mask measurement for pass/fail testing (Option 101)**
- **Differential data generation and analysis capability (Option 101)**
- **Integrated clock data recovery (Option 102)**
- **Small form factor saves bench or rack space**
- **LAN, USB, GPIB for remote control**
- **Compatibility with existing remote commands, e.g. Agilent 71612, 86130A series and N4900 Series**
- **Color touch screen, Windows XP**
- **Applications: manufacturing test, Telecom transceivers such as SONET/SDH, 10 GbE, XFP, PON-OLT's and hi-speed serial computer buses**

The serial BERT N4906B is a general-purpose bit error ratio tester, designed for high-speed digital communication components and systems. It is ideal for cost-effective manufacturing and telecom device testing. It offers a 3.6 Gb/s or 12.5 Gb/s pattern generator and error detector with excellent price/performance ratio.

Transition times <25 ps allow precise measurements.

The analyzer can be configured with CDR to test clock-less interfaces and with true differential inputs to test LVDS and other differential interfaces. The compact size of the N4906B saves rack space; LAN, USB and GPIB interfaces allow smooth integration into automated test environments. For bench users the N4906B serial BERT offers an intuitive user interface with state-of-the-art Windows-XP based touch-screen.

Measurements

BER
Fast Eye Mask Measurement with pass/fail (Option 101)

Pattern Generator

Operation Range	9.5 Gb/s to 12.5 Gb/s (Option 012)
	150 Mb/s to 12.5 Gb/s (Option 102)
	150 Mb/s to 3.6 Gb/s (Option 003)
Data Output	1, differential or single-ended
Output Amplitude	0.10 V to 1.8 V in 5 mV steps
Jitter	9 ps pp typical
Transition Time	<25 ps (10% to 90% and ECL levels)
Cross Point Adjust	20% – 80%

Error Detector

Operation Range	9.5 Gb/s to 12.5 Gb/s
	150 Mb/s to 12.5 Gb/s (Option 102)
Data Input	1, single-ended or differential (Option 101 or 003)
Delay Adjust	1.5 ns
Clock Data Recovery	1.058 to 1.6 Gb/s, loop bandwidth 1 MHz typ.
(Option 102)	2.115 to 3.2 Gb/s: loop bandwidth 2 MHz typ.
	4.23 to 6.4 Gb/s: loop bandwidth 4 MHz typ.
	9.9 to 10.9 Gb/s: loop bandwidth 8 MHz typ.
Sensitivity	<50 mV

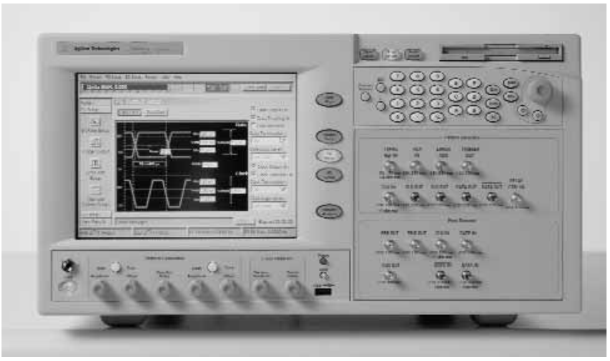
Pattern

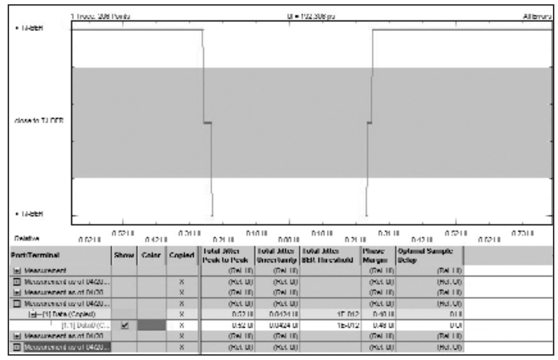
PRBS 2n–1, n=7, 10, 11, 15, 23, 31
User-definable memory: 32MB

High Quality Characterization – Done Quickly

Serial High-Performance BERT 13.5 Gb/s (N4901B) and 7 Gb/s (N4902B)

www.agilent.com\find\N4900





Fast Total Jitter with Results

- **Operating from 150 Mb/s up to 13.5 Gb/s (N4901B) or 7 Gb/s (N4902B)**
- **Superior ease-of-use concept with an intuitive user interface**
- **Excellent pulse performance**
- **Differential data generation and analysis capability**
- **Enhanced jitter capabilities**
- **Integrated clock data recovery**
- **Applications: CEI, SATA, XFP, Fibre Channel, Gb Ethernet, SONET/SDH**

Serial high-performance BERT 13.5 Gb/s & 7 Gb/s are frequency agile and easy-to-use serial bit error ratio test solutions with a very comprehensive measurement suite.

The serial high-performance BERT 13.5 Gb/s and 7 Gb/s are the ideal solutions for R&D and manufacturing engineers in the computation and communication industry, who are designing, characterizing and testing components, chips and modules for up to 13.5 Gb/s covering OC-192, 10 GbE, backplane, Common Electrical Interfaces (CEI) and all kinds of high-speed communication ports. The measurement suite contains all one- and two-dimensional sweeps to provide insight to the eye opening including RJ/DJ separation and jitter spectrum. The error location capture allows the identification of error locations in a pattern. The analyzer capabilities are enhanced by true differential data inputs and integrated clock data recovery.

Jitter tolerance testing is allowed thru the delay control Input on the serial high-performance BERT, which can be stimulated with externally modulated clocks.

The serial high-performance BERT addresses today's state-of-the-art voltage levels (e.g. LVDS, ECL, PECL,...) In order to ensure long-term protection of capital invested, the N4902B serial high-performance BERT 7 Gb/s is upgradeable to the N4901B serial high-performance BERT 13.5 Gb/s.

For automated measurements the serial high-performance BERT is remotely programmable via GPIB, LAN or USB. For bench use it offers an intuitive color touch screen based on Windows XP.

Measurement Suite

BERT scan, "bathtub" curve includes RJ, DJ
Output level (includes Q factor)
Eye contour (two-dimensional)
Fast eye mask
Spectral jitter
Error location capture
Fast total jitter measurement

Pattern Generator

Operation Range	Internal clock: 620 Mb/s – 13.5 Gb/s (N4901B) or 7 Gb/s (N4902B) External clock: 150 Mb/s – 13.5 Gb/s (N4901B) or 7 Gb/s (N4902B)
Data Output	1, differential or single-ended
Output Amplitude	0.1 Vpp – 2.0 Vpp
Jitter	<9 ps pp
Transition Time	<25 ps (10% to 90% and ECL levels)
Cross Point Adjust	20% – 80%
Delay Control Input	200 ps @ 7 Gb/s

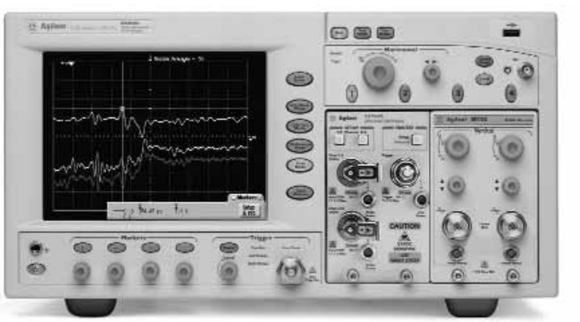
Error Detection

Operation Range	Internal clock: 620 Mb/s – 13.5 Gb/s (N4901B) or 7 Gb/s (N4902A) External clock: 150 Mb/s – 13.5 Gb/s (N4901B) or 7 Gb/s (N4902A)
Data Input	1, differential or single-ended
Delay Adjust	1.5 ns
Clock Data Recovery	1.058 to 1.6 Gb/s, bandwidth 1MHz typ. 2.115 to 3.2 Gb/s: bandwidth 2 MHz typ. 4.23 to 6.4 Gb/s: bandwidth 4 MHz typ. 9.9 to 10.9 Gb/s: bandwidth 8 MHz typ. (N4901B only)
Sensitivity	<50 mV

Pattern

PRBS	2n-1, n=7, 10, 11, 15, 23, 31
User-definable memory	32 Mbit

- **The DCA-J builds on its reputation as the industry's leading wide-bandwidth oscilloscope, adding to its powerful capabilities. You now have four instruments in one.**
- **A digital communications analyzer with automated eye measurements**
- **A full-function time domain reflectometer (TDR) for impedance analysis**
- **A full-function oscilloscope with bandwidth in excess of 80 GHz**
- **An innovative jitter analyzer for electrical and optical signals**



86100C Infiniium DCA-J Wide Bandwidth Oscilloscope with Jitter Analysis

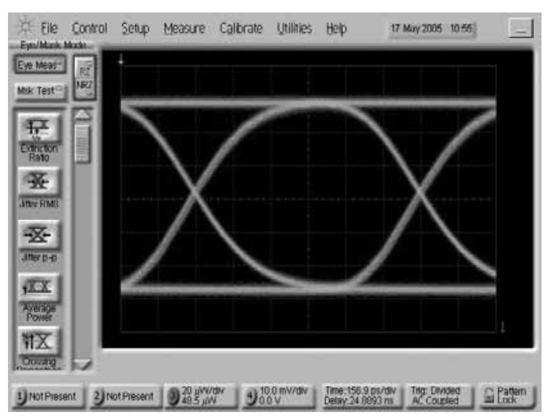
The most comprehensive multi-function analyzer for high speed electrical and optical signals. The 86100C DCA-J combines extremely high accuracy and precise repeatability with significant ease of use to greatly simplify characterizing signals from 50 MHz to 80 GHz. The 86100C DCA-J is configurable to meet your needs and supports a wide range of modules for testing. Select modules to get the specific bandwidth, filtering, and sensitivity you need.

The 86100C digital communications analyzer with jitter analysis (DCA-J), offers breakthrough speed, accuracy and affordability for detailed jitter subcomponent analysis. Digital designers can combine the mainframe and modules into four key instruments with state of the art performance. The DCA-J can accurately separate jitter into its subcomponents such as random jitter, deterministic jitter, data dependent jitter, periodic jitter, inter-symbol interference and duty cycle distortion, at rates from 50 Mb/s to 40 Gb/s and higher, all with the touch of one button. For design and test engineers working on new and emerging standards such as CEI, XFP, XFI, UXPi, Fibre Channel, Gigabit Ethernet, PCI Express and Serial ATA, the DCA-J is the tool of choice.

- Jitter mode - powerful jitter separation into subcomponents, all with the push of one button: Total Jitter (TJ), Random Jitter (RJ), Deterministic Jitter (DJ), Data Dependent Jitter (DDJ), Duty Cycle Distortion (DCD), Inter-Symbol Interference (ISI), Periodic Jitter (PJ), and Sub-Rate Jitter (SRJ).
- DCA-J has the lowest intrinsic jitter of any jitter enterprise solution. This delivers the best sensitivity for jitter measurements.
- For ultra high performance device characterization, Jitter Mode using the 86107A precision timebase module delivers even lower intrinsic jitter. This enables characterization and specification of extremely low level jitter performance.
- Eyeline Plus - Isolate specific bit sequences; create averaged eye diagrams.
- Pattern Lock - Internally generated pattern trigger - now you just need to supply clock to capture pulse trains.
- Open operating system - Windows® XP Pro allows external applications to be installed.
- Electrical bandwidths to over 80 GHz ensure the most accurate waveforms for signals from 50 Mb/s to 40 Gb/s and beyond.

The DCA-J takes jitter analysis to a new level of simplicity and accuracy.

- Displays that save you time: the DCA-J provides revealing histograms and intuitive graphical views by providing an easy and simple table of jitter subcomponents.
- Easy setup, easy triggering: with the DCA-J, a simple physical setup combined with a user interface that never lets you get lost, makes getting simple, accurate jitter measurements easy
- Eyeline mode – see your problem sequences: It's easy to move between eye diagrams that overlay all possible bit sequences to single valued waveforms that show individual bit sequences. You can see exactly which sequences are causing mask violations. No need for a pattern trigger – connect your signal and in most cases the DCA-J detects pattern length and bit rate without being told. You have an immediate display to work from.
- Jitter mode – one button gateway to understanding jitter: Jitter can be a complex subject and sometimes it can seem your test equipment is making it even more complicated. Building on the intuitiveness of eye diagrams, the DCA-J shows you the behavior of your device in the jitter domain but always tracks back to the eye diagram. Results are in familiar formats.



Digital Communications Analyzer

86100C DCA-J Mainframe Specifications

Time interval accuracy[2]	1 ps + 1.0% of time reading[3] 8 ps + 0.1% of time reading
Time interval accuracy – jitter mode operation[4]	*1 ps*
Time interval accuracy – with 86107A precision timebase	< 200 fs
Vertical System (channels)	
Number of channels	4 (simultaneous acquisition)
Vertical resolution	14 bit A/D converter (up to 15 bits with averaging)
Record length	16 to 4096 samples – increments of 1

[2] Dual marker measurement performed at a temperature within +/-5°C of horizontal calibration temperature
[3] Delay settings: _ time is in the range (26 + N* 4 ns) +/- 1.9 ns, where N=0,1,2...17.
[4] Characteristic performance. Test configuration: PRBS of length 27 – 1 bits, Data and Clock 10 Gb/s.

	Standard (direct trigger)	**Option 001 (enhanced trigger)**
Trigger Modes		
Internal trigger[1]	Free Run	
External direct trigger[2]		
Limited bandwidth[3]	DC to 100 MHz	
Full bandwidth	DC to 3.2 GHz	
External Divided Trigger	N/A	
Pattern Lock	N/A	
Jitter		
Characteristic	*< 1.0 ps RMS + 5°10E-5 of delay setting*[4]	*1.2 ps RMS for time delays less than 100ns*[6]
Maximum	1.5 ps RMS + 5°10E-5 of delay setting[4]	1.7 ps RMS for time delays less than 100ns[6]
Trigger sensitivity	200 m Vpp (sinusoidal input or 200 ps minimum pulse width)	200 m Vpp sinusoidal input: 50 MHz to 8 GHz 400 m Vpp sinusoidal input: 8 GHz to 13 GHz *600 m Vpp sinusoidal input: 13 GHz to 15 GHz*
Trigger configuration		
Trigger level adjustment	-1 V to +V	AC coupled
Edge select	Positive or negative	N/A
Hysteresis[5]	Normal or high sensitivity	N/A
Trigger gating		
Gating input levels (TTL compatible)	Disable: 0 to 0.6V Enable: 3.5 to 5V Pulse width> 500 ns, period > 1us	
Gating delay	Disable 27 ns + trigger period + Max time displayed Enable: 100 ns	
Trigger impedance		
Nominal impedance	50	
Reflection	10% for 100 ps rise time	
Connector type	3.5 mm (male)	
Maximum trigger signal	2 V peak-to-peak	

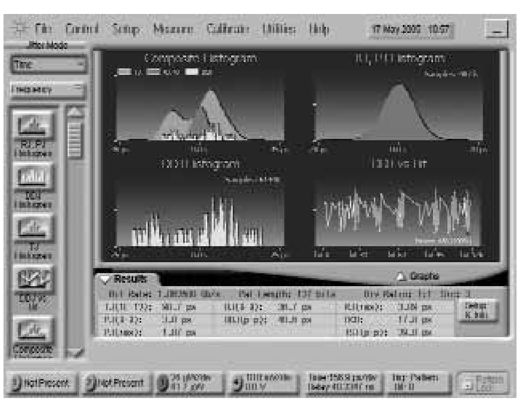
[1] The free run trigger mode internally generates an asynchrionious trigger that allows viewing the sampled signal ampitude without an external trigger signal but provides no timing information. Free run is useful in troubleshooting external trigger problems.
[2] The sampled input signal timing is recreated by using an externally supplied trigger signal that is synchronous with the sampled signal input.
[3] The DC to 100MHz mode is used to minimize the effect of high frequency signals or noise on a low frequency trigger signal.
[4] Measured at 2.5 GHz with the triggered level adjusted for optimum trigger.
[5] High Sensitivity Hysteresis Mode improves the high frequency trigger sensitivity but is not recommended when using noisy, low frequency signals that may result in false triggers without normal hysteresis enabled.
[6] Slow rate 2V/ns

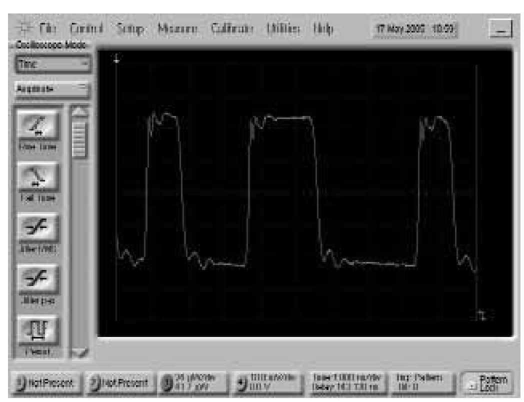
86100 family plug-in module matrix

The 86100 has a large family of plug-in modules designed for a broad range of data rates for optical and elecrical waveforms. The 86100 can hold up to two modules for a total of four measurement channels.

	Module	Option	No. of optical channels	No. of electrical channels	Wavelength range (µm)	Unfiltered optical bandwidth (Ghz)	Electical bandwidth (GHz)	Fiber input (µm)	Mask test sensitivity (dBm)	Filtered data rates																			
										155 Mb/s	622 Mb/s	1063 Mb/s	1250 Mb/s	2125 Mb/s	2488/2500 Mb/s	2.666 Gb/s	2.72 Gb/s	3.125 Gb/s	3.1875 Gb/s	3.32 Gb/s	4.25 Gb/s	8.500 Gb/s	9.953 Gb/s	10.3125 Gb/s	10.51875 Gb/s	10.664 Gb/s	10.709 Gb/s	11.095 Gb/s	11.317 GB/s
Optical/electrical	86101A	201	1	1	750-860	2.85	20	62.5	-17	●	●																		
		202	1	1	750-860	2.85	20	62.5	-17			●	●																
	86102U	201	1	1	750-860	15	20	62.5	7.5				●		●														
		202	1	1	750-860	15	20	62.5	-7.5						●			●											
		203	1	1	750-860	15	20	62.5	-7.5									●						●					
	86103A	201	1	1	1000-1600	2.85	20	62.5	-20	●	●																		
		202	1	1	1000-1600	2.85	20	62.5	-20			●	●																
	86105B	101	1	1	1000-1600	15	20	9	-12														●	●	●	●	●		
		102	1	1	1000-1600	15	20	9	-12	●	●				●	●							●	●	●	●	●		
		103	1	1	1000-1600	15	20	9	-12			●	●	●	●								●	●	●	●	●		
	86105C	100*	1	1	750-1650	8.5	20	62.5	-20	●	●	●	●	●	●	●		●			●	●							
		200	1	1	750-1650	8.5	20	62.5	-16														●	●	●	●	●	●	●
		300*	1	1	750-1650	8.5	20	62.5	-16	●	●	●	●	●	●	●		●			●	●	●	●	●	●	●	●	●
	86106B		1	1	1000-1600	28	40	9	-7														●	●	●				
		410	1	1	1000-1600	28	40	9	-7														●	●	●	●	●		
	86116A		1	1	1000-1600	53	63	9	N/A																				
	86116B		1	1	1480-1620	65	80	9	N/A																				
Dual electrical	54754A		0	2		N/A	18																						
	86112A		0	2		N/A	20																						
	86117A		0	2		N/A	50																						
	86118A		0	2		N/A	70																						

* Pick any 4 rates (155 Mb/s to 4.25 Gb/s)





High Quality Characterization – Done Quickly
83496A Multi-Rate Optical/Electrical Clock Recovery Module

- **Continuous unbanded tuning from 50 Mb/s to 13.5 Gb/s (and any rate in between) provides ultimate flexibility and value in one plug-in module.**
- **More than 300 femtoseconds rms jitter results in negligible residual jitter of the output clock and accurate measurements of very low levels of signal jitter.**
- **Tunable loop bandwidth from 30 kHz to 6 MHz allows configuration as a Golden PLL with optimal loop bandwidth for industry-standard compliance testing.**

Multi-Rate Tool Increases Measurement Accuracy and Performance Margins in Compliance Testing

The 83496A multi-rate optical/electrical clock recovery module for the 86100 Infiniium digital communications analyzer series performs clock extraction for waveform analysis with continuous, unbanded tuning from 50 Mb/s to 13.5 Gb/s, ultra-low residual jitter and Golden PLL (phase locked loop) operation. The 83496A represents a significant technology breakthrough in test instrumentation. It provides the first true hardware Golden PLL triggering system because the loop bandwidth can be tuned to the precise value that is called out in the standard for any data rate within its operating range. Optical and electrical component and system designers, in high-speed digital communications, can achieve, now, higher measurement accuracy and increased performance margins in industry-standard compliance testing.

Application Information

In today's computing and communications equipment, although processors are fast, communication links struggle to keep pace. The trend is toward higher speed buses, moving from parallel to serial technologies such as PCI-Express, Serial ATA, and Infiniband. In communications equipment, parallel backplanes are a bottleneck, so new high-speed serial links means that jitter can have a significant contribution towards overall system performance and bit error ratios. It is critical to test it quickly and accurately, and more importantly, to test compliance across all the new high speed serial link standards.

So where does clock recovery fit in? Since the goal of a standard is to ensure that devices will work in real world systems, they specify tests that mimic real world situations. The 83496A represents a significant technology breakthrough in test instrumentation. It provides the first true hardware Golden PLL triggering system because the loop bandwidth can be tuned to the precise value that is called out in the standard for any data rate within its operating range.

The 83496A is available in either of two configurations: Option 100 for electrical applications and Option 101 for optical applications.

The 83496A clock recovery module provides ideal performance for waveform analysis with the 86100C DCA-J. It can derive a clock from NRZ signals with rates as low as 50 Mb/s, as high as 13.5 Gb/s, and any rate between, providing the ultimate in flexibility and value. At under 300 femtoseconds rms, the residual jitter of the output clock is virtually negligible, allowing accurate measurements of very low levels of signal jitter.

Software / User Interface

A well-designed clock recovery circuit can significantly enhance the accuracy of eye-mask and jitter analysis. It can be a fundamental element of many jitter and eye-mask test strategies.

The 83496A has a tunable loop bandwidth. This critical feature allows the module to be configured as a Golden PLL with the optimal loop bandwidth for whatever standard/data rate is being tested. Test systems can now be designed according to the exact specifications of industry standards. Measurement precision is enhanced and test margins can be significantly increased. Using hardware from Agilent precision signal sources and patented technology from Agilent Laboratories, the 83496A raises clock recovery performance from “off-the-shelf” to a high-quality instrumentation grade level.

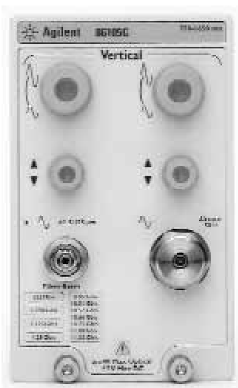
Performance Overview

Operating range	50 Mb/s to 7.1 Gb/s
With option 200	50 Mb/s to 13.5 Gb/s
Residual jitter (jitter free input)	< 300 fs rms
Loop BW	50 kHz or 2 MHz
With option 300	30 kHz to 6 MHz1 or fixed ratio of data rate/N
Wavelength range (Option 101)	780 to 1330 nm MMF (62.5 um) 1250 to 1620 nm SMF (9 um)

[1] Loop BW tuning range varies with data rate

83496A Multi-Rate Optical/Electrical Clock Recovery Module

- **Optical bandwidth to 9 GHz and electrical bandwidth to 20 GHz**
- **Wavelength range from 750 - 1650 nm and sensitivity as low as –21 dBM**
- **Industry's best intrinsic jitter when used with the 86107A Precision Time-base Reference module, making it easy to measure high performance designs where instrument jitter might otherwise hide real device performance**



86105C High Sensitivity, Broad Wavelength Multi-Rate Optical Module

Test the widest range of telecom and datacom wavelengths and transmission rates in the industry with the 86105C multi-rate compliance filter module. Wide-wavelength, multi-rate tool provides critical solution in single, plug-in module.

In the midst of proliferating data rates, the 86105C covers datacom/enterprise standards such as 10 Gb Ethernet and 10 G Fibre Channel, which run at 10.3125 Gb/s and 10.51875 Gb/s respectively. Switching and routing systems are required to interface some of these technologies (specifically the IEEE 802.3 Ethernet standards and SONET) at varying rates. Therefore, the ability to test and characterize performance across a wide range of technologies and data rates is essential in the R&D and manufacturing environments. Multi-port and multi-rate system/component designers and manufacturers can take advantage of both the wide filter coverage and outstanding sensitivity of the 86105C. Optical component and equipment manufacturers can use a single plug-in module to perform waveform characterization and test transmitter compliance, on an unprecedented number of networking technologies.

The 86105C offers unprecedented wavelength and optical filter coverage for SONET/SDH and datacom/enterprise technologies up to 11.3 Gb/s. With this industry-first capability, optical component and equipment manufacturers can perform waveform characterization and test transmitter compliance on multiple networking technologies with a single plug-in module, increasing ROA.

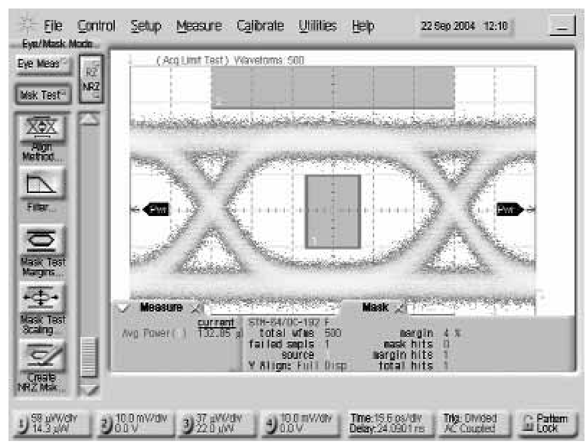
Sensitivity as low as –21 dBm. This enables customers to simulate real network power levels when qualifying critical network components and equipment.

It can be used with all A, B, and C versions of the DCA – This will allow existing customers to upgrade easily to the newest capabilities, whilst protecting their investments in Agilent test equipment.

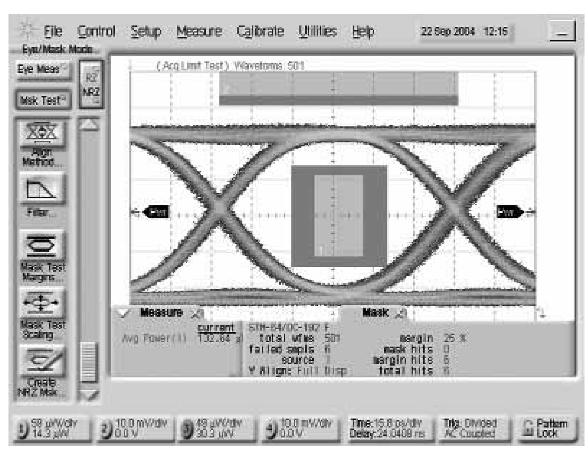
This module makes possible the characterization of optical transmission performance of all SONET, Ethernet, and Fibre Channel technologies, from 155 Mb/s through 11.3 Gb/s. In addition, new Infiniium DCA-J 86100C software now provides industry-leading jitter characterization.

Performance Overview:

Bandwidth	9 GHz optical and 20 GHz electrical
Wavelength	750-1650 nm
Sensitivity (typical)	–21 to –16 dBm based on rate and wavelength
RMS noise (typical)	0.8 to 2.5 µW
Fiber input	62.5 µm accepts single mode or multi-mode



Eye and mask for 10.709 Gb/s using typical optical module



Improved mask margin using 86105C

- **Complete S-parameters obtained quickly, selecting up to four parameters to view and compare against design and verification limits**
- **Complete channel verification done simply - Analyze transmitters, channels, and equalizers all with one instrument**

Complete Channel Verification – Done Simply, Done Accurately.
For R&D and manufacturing test engineers working on high-speed electrical communications, 86100C-202 Enhanced impedance and S-parameter software enable unparalleled measurement capability by providing comprehensive signal integrity measurements with accurate, one-button convenience, without requiring hardware upgrades for the 86100C mainframes or purchasing a vector network analyzer.

Application Information
The demand for greater transfer of voice, data and video over networks and the increasing demand by users for higher productivity have dramatically increased the need for higher speed signals. These signals place a greater burden on the physical channel and have stimulated the need for use of differential channels. New and existing industry standards such as PCI Express, Serial ATA, USB and IPC increasingly call for the use of S-parameters and impedance measurements to ensure complete system verification and interoperability. Once time domain is captured, users of Agilent's 86100C-202 enhanced impedance and S-parameter software can request the S-parameters of the chosen channel – quickly, simply, and accurately.

86100C-202 gives customers the ability to characterize, fully, their channel. We offer the cleanest edge and provide very accurate impedance measurements, when used with the Picosecond Pulse Labs 4020 accelerator (www.Picosecond.com). Our solutions also work seamlessly with our physical layer test solutions software (www.agilent.com/find/plts).

Complete S-Parameters obtained quickly
Complete S-parameters obtained quickly enables customer verification to defined standards, quicker and less expensive than network analyzers, and not available with other TDR solutions

Corrected impedance profiling
Enables customer to determine where the largest discontinuities are.

Normalization
Provides accurate characterization of only the DUT, removing effects of cabling and fixturing

Calibration kit
Provides convenient and accurate means to calibrate the test solution

Min/Max Average
Provides quick assessment of greatest impedance discontinuities and the nominal value of the channel

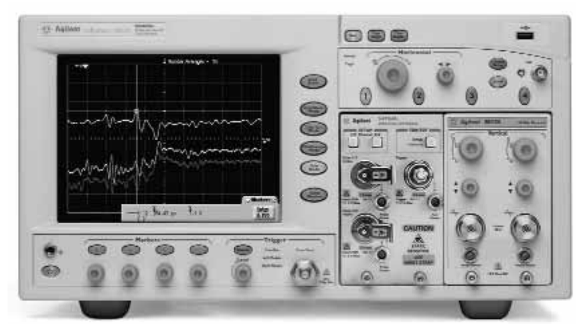
Input Protection
Greatly reduces downtime at test station

Software / User Interface
The 86100C-202 software capability will add:
- S-parameter measurements, which are called out in new high-speed serial standards, for both single-ended and differential circuits
- Corrected impedance profile, which enables customers to obtain an accurate impedance measurement of discontinuities well into the device
- Ability to measure minimum, maximum and average of displayed impedance profile

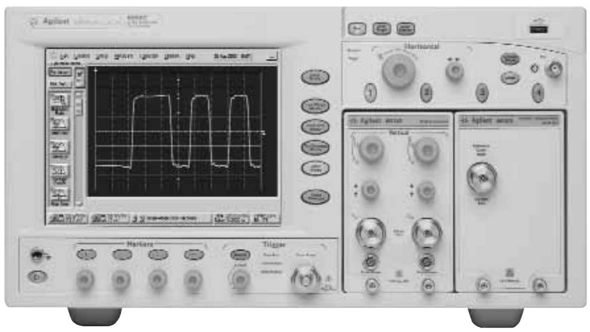
When performing S-parameter and corrected impedance profile measurements, the user installs the 86100C-202 and one or two 54754A TDR modules into the 86100C mainframe. The user performs module calibration, then configures the measurements for their particular DUT configuration and completes normalization using the calibration kit. The user takes the desired impedance or transmission characteristics for their device and the software presents the appropriate S-parameter measurements (out of 32 available parameters).

Performance Overview

Step Rise Time	< 30 ps
Step Flatness	< +5/-3% up to 1 ns < 1% beyond 1 ns



86100C DCA-J with S-Parameter and Time Domain Characterization



86100C with Enhanced Jitter and Waveform Analysis Software

Enhanced Jitter Analysis Software (Option 200) and Advanced Waveform Analysis Software (Option 201) for the 86100C DCA-J
As data rates increase in both electrical and optical applications, jitter presents an ever increasing measurement challenge. Decomposition of jitter into its constituent components is becoming more critical. It provides critical insight for jitter budgeting and performance optimization in device and system designs. Many emerging standards require jitter decomposition for compliance. Traditionally, techniques for separation of jitter have been complex and often difficult to configure. Availability of instruments for separation of jitter becomes very limited as data rates increase. The 86100C DCA-J provides simple, one button setup and execution of advanced waveform analysis.

- Option 200 for the 86100C Infiniium DCA-J offers enhanced jitter analysis capabilities. Extremely wide bandwidth, low intrinsic jitter, and advanced analysis algorithms yield the highest accuracy in jitter measurements.
- Option 201 for the 86100C Infiniium digital communication analyzer offers advanced waveform analysis for breakthrough insight, industry leading performance, and intuitive signal analysis tools.

As bit rates increase, channel effects cause significant eye closure. Many new devices and systems utilize equalization and pre/de-emphasis to compensate for channel effects.

Option 200 includes:
- Decomposition of jitter into Total Jitter (TJ), Random Jitter (RJ), Deterministic Jitter (DJ), Periodic Jitter (PJ), Data Dependent Jitter (DDJ), Duty Cycle Distortion (DCD), and Jitter induced by Inter-symbol Interference (ISI).
- Various graphical and tabular displays of jitter data
- Export of jitter data to convenient delimited text format
- Save / recall of jitter database
- Jitter frequency spectrum
- Isolation and analysis of Sub-Rate Jitter (SRJ), that is, periodic jitter that is at an integer sub-rate of the bit-rate.
- Bathtub curve display
- Adjustable total jitter probability

Jitter Decomposition
Jitter Mode decomposes jitter into its constituent components and presents jitter data in various insightful displays. Jitter Mode operates at all data rates the 86100C supports, removing the traditional data rate limitations from complex jitter analysis. The 86100C brings several key attributes to jitter analysis:
- Very low intrinsic jitter (both random and deterministic) translates to a very low jitter noise floor which provides unmatched jitter measurement sensitivity.
- Wide bandwidth measurement channels deliver very low intrinsic data dependent jitter and allow analysis of jitter on all data rates to 40 Gb/s and beyond.
- Pattern-Lock triggering technology provides sampling efficiency that makes jitter measurements very fast.

Option 201 advanced waveform analysis will provide key tools to enable design and test of devices and systems that must deal with difficult channel effects:
- Capture of long single valued waveforms. Pattern-Lock triggering and the waveform append capability of Option 201 enable very accurate pulse train data sets up to 256 mega-samples in length.
- Equalization. The DCA-J can take a long single valued waveform and route it through a linear equalizer algorithm (default or user defined) and display the resultant equalized waveform in real time. The user can simultaneously view the input (distorted) and output (equalized) waveforms.
- Interface to MATLAB® analysis capability.

Understand the effects of equalization on closed eyes
At today's high bit rates, advanced techniques must be used to maintain very low bit error ratio (BER) performance. Pre-emphasis on the transmission side and equalization on the receiving side are common ways to counteract the impairments of inter-symbol interference (ISI) on circuit boards.

Want to know what type of equalization works best for your design?
The new on-board equalization tool allows you to evaluate the effectiveness of different equalizer schemes. Traditional eye measurements such as eye amplitude and rise-time can be measured on both the input signal and the equalized signal.

Analyze complete waveforms
The advanced waveform analysis software on the DCA-J allows you to capture and analyze a complete single-valued record of a transmitted pattern waveform – up to 223 bits long. Pattern waveforms provide key measurement data for design modeling and for optimizing equalizer design.

Jitter analysis functionality is segmented into two software package options. Option 200 is the enhanced jitter analysis software, and Option 201 is the advanced waveform analysis software.

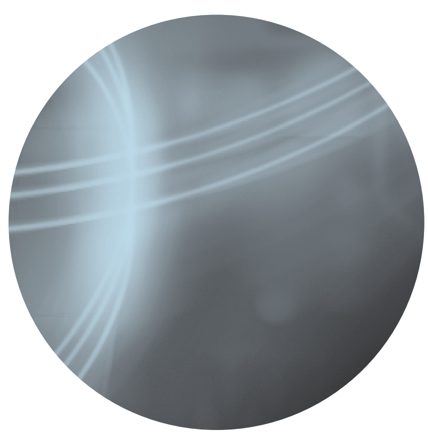
Measurements with Options 200 and 201
Measurements (Option 200 - Jitter Analysis)
Total Jitter (TJ), Random Jitter (RJ), Deterministic Jitter (DJ), Periodic Jitter (PJ), Data Dependent Jitter (DDJ), Duty Cycle Distortion (DCD), Inter-symbol Interference (ISI), Sub-Rate Jitter (SRJ)

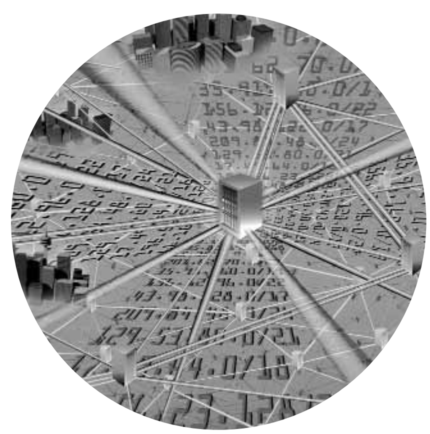
Data Displays (Option 200 - Jitter Analysis)
TJ histogram, RJ/PJ histogram, DDJ histogram, Composite histogram, DDJ versus Bit position, Bathtub curve, SRJ analysis

Measurements (Option 201 - Advanced Waveform Analysis)
Pattern waveform

Data Displays (Option 201 - Advanced Waveform Analysis)
Equalized waveform

Accelerating Triple Play Service Deployment





Core Network Trends
Investment in core routers is on the rise. According to Dell 'Oro Research, the market for high-end 10G routers was $260 million in the second quarter of 2004, increasing by 13% quarter over quarter, with Cisco, Juniper and Avici all posting strong revenue increases in the 10 Gbps routers segment. These positive signs of growth indicate that Carriers are not being complacent with their current core network infrastructure and are being very proactive for the next generation of IP/MPLS. A recent Infonetics report identified a strong trend to migrate to IP/MPLS, with 90% of service provider respondents planning to increase expenditures for network-based IP services, and 81% for IP/MPLS networks.

It appears the time is finally here for a new upgrade cycle that can equip the core with the scalability and reliability required to deliver voice, video and data services, on demand, over a converged network infrastructure.

Network Equipment Manufacturers have introduced a new breed of core routers that promise to meet service provider scalability and reliability expectations. The price tag for a next generation core routing system can easily reach into the tens of millions. With such a significant capital outlay, carriers want to make sure they are getting the best return on their investment. Infonetics reported that 'price-to-performance ratio' and 'product reliability' are the leading criteria considered by service providers when choosing a router and switch manufacturer. However, measuring router performance and reliability these days presents a considerable challenge itself. Qualification cycles for next generation routers are rumored to take upwards of a year.

Measuring Router Performance
Router performance, at least within the core, is most often associated with, and quantified by, scalability. When surveyed, service providers identified scalability as a key determining performance factor when making router purchases. The objective of scalability testing is to expose the limits or boundaries of a device or a network. It is crucial that network architects fully understand scalability thresholds prior to deploying any equipment.
There are many aspects of router scalability to consider. We will focus on key scalability metrics being weighed by service providers today including:

- Port scalability
- Traffic scalability

Quantifying and interpreting scalability can be challenging since there are no standard industry guidelines for what constitutes exceptional, or even acceptable, scalability. However, one would expect that a core router should be capable of meeting traffic and network growth expectations well into the future. For example, the recent test methodology created by EANTC for testing OC-192 and OC-768 routers employed traffic and protocol projections five years into the future.

Port Scalability
Measuring port scalability can be achieved by simply quantifying the physical number of ports that a router can support. This quantity is readily available (or can be calculated) from the available technical specifications of any routing system, and thus requires no further testing or validation. The Cisco Carrier Routing System, for example, reportedly scales to over 1,152 physical OC-768 ports, in a multi-chassis configuration. The Juniper TX Matrix reportedly supports up to 128 physical interface cards (PICs), and the Avici TSR reportedly scales to 40 ports of OC-192 POS or 10GbE. Although a physical port can also support a number of logical ports, ATM, Ethernet and Frame Relay interfaces supporting logical ports are more predominant at the network edge than in the network core, so logical port scalability will not be discussed in this paper.

Typical interfaces supported on next generation core routers today include:

- OC-48c/STM-16c Packet over SONET/SDH
- OC-192c/STM-64c Packet over SONET/SDH
- 10 Gigabit Ethernet

Cisco announced the industry's first OC-768c POS interface on their CRS-1 in 2004 while Avici and Juniper have announced plans to deliver this interface on their core routers in 2005.

Traffic Scalability
The sum of traffic from data, voice and video service offerings and other sources converging over core networks is expected to increase core IP/MPLS traffic at a rate exceeding 100 percent per year for the next three to five years. Infonetics research shows that "all types of data traffic grow between 2002 and 2004, but IP and IP/MPLS growth is by far the strongest, growing on average 119%, 118%, and 84% year over year, in 2002, 2003, and 2004 respectively."

The aggregate traffic capacity of a core router is a function of the physical number of interfaces supported on the routing system. Without counting ingress and egress traffic separately, the Cisco Carrier Routing System reportedly scales to support up to 46Tbit/s in a multi-chassis configuration. Juniper Networks' TX Matrix can be used to combine up to four of the vendor's existing T640 core routers to reportedly support up to 1.28 Tbit/s of traffic (3 billion packets per second). The Avici TSR reportedly scales from 155 Megabits to over 5 Terabits.

Traffic capacity claims made within marketing documents and technical datasheets presume that every interface on the router is capable of forwarding traffic at wire-rate, with zero packet loss and minimal delay. The specified or theoretical traffic capacity of a routing system should be verified through testing, since actual forwarding performance of the router can vary depending on the traffic parameters and network conditions it's facing at any given time. The number of ports, individual traffic flows, and distribution of packet lengths and traffic types across each flow can have varying demands on the router's memory and processing power and ability to forward traffic at wire/rate. Likewise, control plane conditions - such as the number of routing table entries, distribution of network prefix lengths amongst these entries, and stability of the routing table itself can impact forwarding performance.

Test Methodology
Capital expenditure for core network upgrades is on the rise. Router vendors have announced the next generation of core routing equipment that claim to deliver unprecedented levels of scalability and reliability. With significant capital outlay and the ability to deliver revenue-generating IP services at stake, service providers must be much more proactive and diligent in their qualification and evaluation of core routing devices.

It is imperative that service providers fully understand the limitations of each network device prior to deployment. The sheer scale and complexity of today's core router makes verifying performance claims a daunting but critical task.

Scalability testing is just one component of router qualification, and must be supplemented by the functional validation of system features and components, as well as interoperability testing with other vendor equipment. With a drive to deploy time-sensitive and mission-critical IP services across the network core, measuring router reliability and stability is becoming an increasingly important.

Partnering with an experienced test equipment vendor can greatly facilitate the router qualification process. A router tester should be scalable and flexible enough to quickly perform all types of router performance, functional, interoperability and reliability testing. A test vendor with industry-proven experience and test leadership can provide the test methodologies and automated tools to help expedite complex test configurations and shorten the time it takes to comprehensively qualify a next generation core router.

Agilent's "Journal of Internet Test Methodologies" is an industry standard reference tool detailing comprehensive test plans for verifying the functionality and performance of next generation multi-service devices and networks.

For more information and detailed test methodologies for testing next generation core router performance please visit www.agilent.com/comms/thejournal

Agilent N2X Solution
The Agilent N2X solution is the industry's first to combine leading-edge data services testing with carrier-grade infrastructure testing and emulation. The N2X solution comprehensively verifies the ultimate performance, scalability and resiliency of carrier grade services under realistic network operating conditions. Including the ability to stress both the network data and control planes, the Agilent N2X offers unparalleled test realism and scalability to verify the ultimate performance of carrier routers.

- Industry's leading multi-protocol emulation and traffic generation environment
- Extensive interface range (from Sonet/SDH, 10/100 Ethernet to OC-768c)
- Patented real-time measurements
- Powered through a versatile GUI
- Fully featured API

Scalability: Test extreme network conditions
The scalable performance of underlying carrier-grade devices is critical in the network's ability to efficiently deliver the new wave and density of services reliably and consistently. Only Agilent N2X, with the industry's highest layer 2/3 traffic and protocol scalability can test the ultimate performance of the device's ability to deliver network services.

- Industry's highest stream scalability through the generation and measurement of over 32,000 unique streams representing 32,000 customer service levels (QoS) per port simultaneously
- Industry's highest port density to cost-effectively stress the devices and networks
- Most Comprehensive network services coverage including Layer 2/3 MPLS VPNs, Multicast, VPLS and IPv6 based services

Versatility: Test without boundaries
Agilent N2X simplifies scalable performance testing through unique ease-of-use features, which simplify and accelerate complex test scenario configurations. This not only reduces the time required to learn how to use the tool, but also provides users with the versatility to test without boundaries and get the most of their testing time.

- Versatile and interactive user interface
- Flexible PDU Builder to build any type of encapsulation easily
- Topology builder to quickly create complex multi-protocol network topologies
- Comprehensive API and QuickTest library for complete automation and repeatability

Innovation: Industry leading solutions
N2X builds upon Agilent's long established reputation of innovation through continuous industry leadership in carrier routing test methodologies and test capabilities. Agilent N2X has spearheaded the definition of test methodologies and procedures to evaluate cutting edge services such as Layer 2/3 MPLS VPNs and multicast. Furthermore, Agilent N2X has enabled network services innovation through the delivery of industry-first solutions for VPLS, GMPLS and 40G.

- **Simultaneous multiple services testing - Metro Ethernet, MPLS L2/3 VPNs, Triple-play services and multicast**
- **Test a variety of network infrastructure implementations across the edge/access thru metro transport and core**
- **Test hybrid network devices – core/edge routers, enterprise switches, edge aggregation and MSPPs.**
- **Emulate the scale and complexity of converging network infrastructures**
- **Isolate problems anywhere in the network**

The Agilent N2X multi-service tester is the first test solution to combine leading edge services testing with carrier grade infrastructure testing and emulation. The N2X solution set allows network equipment manufacturers and service providers to test, more comprehensively, new services end-to-end, resulting in higher quality of service and lower operating costs.

Today's communication networks for voice and data are converging onto a single infrastructure designed to both reduce cost and enable new services. These networks are based on multifunction networking elements that are significantly more complicated to test. Furthermore, the proliferation of new services is increasing the diversity of deployed network architectures.

What distinguishes the Agilent N2X is its ability to test leading edge services such as Metro Ethernet, MPLS L2/3 VPNs, triple-play services and multicast over the latest converging infrastructures such as MPLS, IPv6 and Next Generation SONET/SDH.

The N2X system consists of a system controller and multiple chassis containing purpose built test cards for specific test requirements. The system controller provides a graphical user interface to drive applications running on the test cards.

System Controller
A number of system controllers are available depending upon your performance requirements. The controller provides an easy-to use Windows environment.

N2X Chassis
Daisy chain,easily, up to 60 N2X chassis to create the industry's highest density of test ports. The highly compact 4-slot chassis and 2-slot portable chassis are available for both the development environment and in-field use. Hot-swappable test cards can be moved between chassis without affecting other test sessions.

N2X Test Cards
The N2X product architecture is based on programmable measurement test cards that offer best-in-class performance over a wide range of interfaces from 10/100 Ethernet through to OC-768c. High density and flexible N2X test cards are optimized for specific test needs of next generation transport, carrier routing and enterprise networks and devices.

E7912-80012 N2X 2-slot Chassis Hard Transit Case
E7900-80012 N2X 4-slot Chassis Hard Transit Case
E7900-64207 N2X Chassis-to-Chassis Cable
E7900-64208 N2X Rack-to-Rack Cable

- **Broad range of protocol bricks - simulate millions of real users**
- **Client and server emulation - one system, one user interface**
- **Powerful "Test Plan", design and management environment**
- **Stateful traffic over integrated IPSec, PPPoE, DHCP, 802.1x and VLANs**
- **Transaction variability and real-time control - no need for scripts**
- **Stackable modules with optional IPsec & IPsecv6 hardware acceleration**
- **Integrated IPv6 for testing next-generation devices**
- **VoIP, video and data emulation on the same interface**

The Agilent NetworkTester is the industry's most powerful test solution for performance testing of connection-aware and content-aware (Layer 4-7) devices and networks.

NetworkTester offers Internet-scale, multi-protocol, multi-port client/server traffic emulation capabilities, delivering unprecedented realism, flexibility and control for your most complex test challenges.

Whether you are an equipment manufacturer, public network operator, or private enterprise network manager, you'll find NetworkTester applicable to a diverse set of network performance test problems.

Key product application areas include network security and content networking. Typical devices-under-test include firewalls; intrusion detection and prevention systems; IPsec VPN concentrators; triple play and VoIP-aware systems; content switches; SSL accelerators; load balancers and virus and spam email filters. NetworkTester is specifically designed to test integrated devices, where point test solutions fall short. Equipment manufacturers use NetworkTester to load and stress test new products with Internet-scale traffic throughout the development lifecycle. Development costs and cycle times are reduced by finding complex traffic-related problems in the lab before deployment.

Public network operators and private enterprise network managers find NetworkTester an invaluable addition to their test labs. NetworkTester is applied, before equipment purchases, to verify vendor-reported networking capacity and performance and to ensure that security devices will not become a network bottleneck or a single point of failure. After equipment deployment, NetworkTester is utilized to perform off-line testing of new network configurations prior to exposure to live customer traffic.

Customer labs that have developed their own wall-of-PCs proprietary test solutions find that a migration to the NetworkTester reduces the total costs of solution ownership. Proprietary solutions take significant valuable resources to develop, maintain, upgrade and extend over time. NetworkTester makes the wall-of-PCs approach obsolete. Agilent NetworkTester delivers realistic Internet-scale traffic testing to your lab.

The NetworkTester system consists of a number of stackable Ethernet traffic modules, a system controller, a system management Ethernet switch, the NetPressure software application and optional software licenses for applications such as IPsec, IPv6 and VoIP.

Traffic Modules
Each traffic module has two test ports to connect NetworkTester to the System Under Test (SUT), as well as one management port. Multiple modules can be stacked to increase system performance. Electrical and optical Ethernet traffic modules are available, with and without IPsec hardware acceleration.

System Controller
The system controller runs the NetPressure software application. A number of system controllers are available to match your performance requirements.

Management Switch
The 10/100 Mb/s Ethernet system management switch interconnects the Ethernet management ports of the traffic modules and the system controller.

NetPressure Software Application
The powerful and flexible NetPressure application is licensed per traffic module. A license is included with each traffic module purchase.

IPsec Software License
The IPsec software license fully integrates emulation of IPsec into the NetPressure application, enabling rapid configuration of IPsec and powerful testing of stateful traffic over IPsec tunnels.

IPv6 Software License
The IPv6 software license adds integrated IPv6 emulation into the NetPressure application, enabling testing of next-generation devices that support both IPv4 and IPv6.

VoIP Software License
The VoIP software license adds integrated VoIP emulation into the NetPressure application, enabling testing of devices such as application-aware firewalls, session border controllers and integrated security devices that support VoIP.

Causes of PMD

Effects like chromatic dispersion, polarization dependent loss, polarization mode dispersion and also non-linear effects are a result of the refractive index not being constant in one way or the other. While for chromatic dispersion it is the wavelength dependency of the refractive index, it is the refractive index dependence on the signal power that causes non-linear effects. For polarization mode dispersion the cause is a small difference in refractive index for a particular pair of orthogonal polarization states, a property called birefringence. This means that the speed of light depends on the path it takes along the fiber. The cause of the birefringence is illustrated in Figure 1. In contrast to an ideal fiber (left cross-section in Figure 1), a real fiber can exhibit several kinds of imperfections. From right to left, strain, impurities in the fiber and fiber asymmetry are shown.

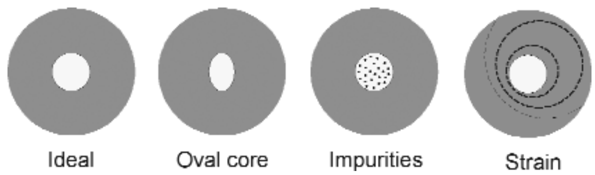


Figure 1: Cross-sections of optical fibers illustrating causes of birefringence

The imperfections are partly inherent to the manufacturing process of the fiber, from cabling of the fibers and are partly caused by environmental conditions and the quality of fiber deployment. The asymmetries in shape of the fibers are nearly constant over time causing a constant PMD. Strain in fibers can vary with time due to temperature changes and even show a diurnal (day/night) fluctuation of strain and so vary the PMD. Vibrations can cause a dynamic change in strain and so PMD for fibers that are deployed near railway tracks and aerial fibers can exhibit a change in strain due to movement caused by wind. All these effects contribute to the PMD not being constant over time, so that the maximum PMD that might occur can only be predicted as will be explained later. When discussing polarization mode dispersion, it is important to understand that the real cause of signal degradation is the differential group delay (DGD), also called the instantaneous PMD and that the term PMD, is really the mean value of DGD over wavelength and over time.

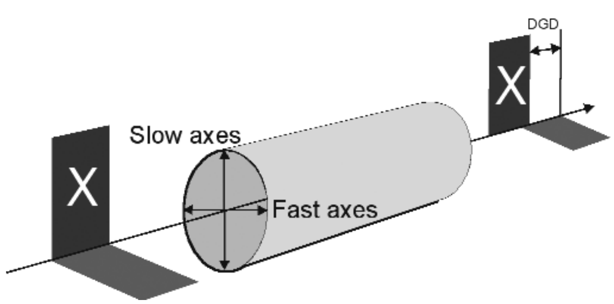


Figure 2: Fiber element with slow and fast axes and DGD of fast and slow light pulse

When light is coupled into a fiber, it takes different paths travelling through the fiber. As shown in Figure 2, the differential group delay is the difference in time that the components of the light pulse need to travel along the fiber depending on the different paths it takes. The part of the light pulse indicated in blue (marked with X) travels the slow axis in the fiber. The part of the light pulse indicated in red travels the fast axis of the fiber. At the end of the fiber there is a difference in travel time for the two different parts of the light pulse, the differential group delay. Because of the statistical nature of PMD, PMD is not linearly proportional to the fiber length but to its square root. This means that a 4 times longer fiber exhibits only twice the PMD and the PMD coefficient is given in ps/√km.

In Figure 3, probabilities are shown for the differential group delays when the mean DGD (i.e. PMD) is 10 ps. The probability that the mean DGD (PMD) of 10 ps (10 ps ± 0.5 ps) actually occurs at a particular moment in time for a particular wavelength is about 10 %. There are also lower DGD values than the 10 ps mean DGD that might occur with a certain probability and there are higher DGD values than the 10 ps mean DGD that might occur with a certain probability. In conjunction to the ITU-T G.691 recommendation, as an example let us assume that the maximum link-DGD a receiver in a certain 10Gbit/s system can tolerate is 30 ps. Let us also assume that system failure[1] due to the DGD being higher than 30 ps must be less than 0.004 %. Then the red area in the inset of Figure 5 represents the probability for the DGD being higher than 30 ps (i.e. about 0.004 %). The resulting PMD that the fiber-link must not exceed is then 10 ps.

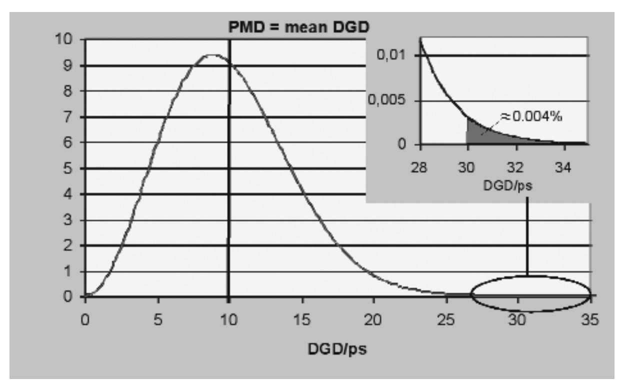


Figure 3: Probability density of DGD values for a PMD of 10 ps

System Impairments and PMD Limits

Every transmission system has its distinct tolerance with respect to the differential group delay (corresponding to PMD). In order to get an idea of to what extent today's fibers can impact system performance, PMD-limits for different bit-rates[2] are listed in Table 1, assuming that as a rule of thumb the PMD value in ps should not exceed 10% of the bit-period.

			Maximum link lengths		
Bit Rate	SDH/SONET	Maximum PMD	0,08 ps/√km	0,2 ps/√km	1 ps/√km
2.5 Gbit/s	STM-16/OC-48	40 ps	250,000 km	40,000 km	1,600 km
10 Gbit/s	STM-64/OC-192	10 ps	15,000 km	2,500 km	100 km
40 Gbit/s	STM-256/OC-768	2,5 ps	1,000 km	160 km	6 km

Table 1: Tolerable PMD for different bit-rates

PMD Measurement Methods

Reliable and accurate PMD measurements require a dual-ended measurement using a PMD-tester light-source and a PMD-tester receiver. Different test equipment exists for measuring PMD and DGD in the field, using standardized methods to determine the PMD/DGD.

- The Fixed Analyzer Method
- The Interferometric Method
- The Jones Matrix Eigenanalysis Method

The fixed analyzer method consists of a broad-band light source and a polarizer on the one end and an analyzer (same as the polarizer on the source side) and an optical spectrum analyzer on the other end. The light of the broad-band source, such as an LED, is polarized and is connected to the fiber under test. The PMD of the fiber causes the polarization to change as a function of the wavelength. As the polarization of the light changes with wavelength, this polarization change is detected as a power fluctuation with wavelength, recorded by the optical spectrum analyzer.

The number of occurrences of high power and low power need to be counted and multiplied by a constant that is known from the literature[3]. From this the PMD is estimated. The limitations of the fixed analyzer method are caused by the resolution of the optical spectrum analyzer, which influences the maximum measurable PMD, the bandwidth of the light-source which influences the minimum measurable PMD and the dynamic range of the measurement which limits measurement accuracy in general.

A high-end implementation of the fixed analyzer method is possible. The broad-band light source is replaced by a tuneable laser and the receiver is based on a polarimeter. This way the power fluctuation with wavelength is recorded for three different polarizations. The PMD is estimated in the same way as done with the low-accuracy implementation. Advantages of the high-end implementation of the fixed analyzer method are that the three measurements can be averaged giving a higher accuracy for the PMD result[4] and that there is nearly no limitation for measuring high PMD values due to the high resolution, i.e. small bandwidth of the laser source. Also more optical power is available at each wavelength, providing high dynamic range. Both implementations only measure the total PMD but give no information on the DGD versus wavelength.

Another way of measuring the PMD is using the interferometric method. As in the low-accuracy implementation of the fixed analyzer method, a polarized broad-band light source is used at one fiber end. At the receiver side the light passes a Michelson interferometer before it hits the detector. To obtain the PMD from the interferogram, it is fit to a mathematical model. Most commonly it is fit with a Gaussian curve. From the standard deviation (width) of the fitted curve the PMD can be obtained. The interferogram of many fibers is not however strictly Gaussian, introducing a measurement error. Discussions about the accuracy of the interferometric measurement for the field are ongoing. As with the fixed analyzer method, the interferometric method does not give any information on the DGD but only the PMD.

For both methods, the fixed analyzer as well as the interferometric method, the 2nd-order PMD is only estimated by multiplying the first-order PMD with a factor.

The third method that standards quote as the most accurate common technique is the Jones Matrix Eigenanalysis method (JME).
It is the only field method that directly measures the DGD as a function of wavelength and so measures the PMD directly by calculating its average. The method can be applied to short and long fibers regardless of the degree of mode coupling.

Like all field-test instruments the JME field DGD/PMD test instrument N3909A consists of a PMD-test light source and a PMD-test receiver. The light source of the JME instrument consists of a high-end tunable laser source with polarization management components. The polarization management is used to set the different input polarizations that are used for the measurement. The receiver consists of a polarimeter. This is a sophisticated receiver that splits the received signal into polarization components and analyzes them simultaneously. The analysis is based upon the measurement of the transmission matrix of the fiber at a series of wavelengths. To obtain the transmission matrix of the fiber, the instrument needs to compute the relationship between three output and three input states of polarization at each wavelength. From the matrix values at pairs of adjacent wavelengths, the DGD is obtained. The PMD is then given by simply averaging the obtained DGD values. Because the complete transmission behaviour of the fiber is measured, 2nd-order PMD in addition to the PMD can be obtained. An added measurement is to also provide loss values over wavelength. Today's JME equipment measures 100,000 data points per seconds making the method field suitable and extremely robust against fiber movement.

1 System failure relates to a path penalty of 1 dB for receivers with signal dependent noise.
2 Bit-rates refer to single channel bit rates.
3 $PMD = [k \cdot Ne \cdot \lambda_1 \cdot \lambda_2]/[2 \cdot c \cdot (\lambda_2 - \lambda_1)]$. K: mode coupling factor, Ne: number of extrema, λ_1, λ_2:start and stop wavelength respectively, c: speed of light.
4 With the low-accuracy fixed analyzer implementation it is also possible to obtain and average measurement results for different polarizations by rotating the analyzer.

Fiber optic networking applications, such as Gigabit Ethernet, the emerging 10 Gigabit Ethernet and Storage Area Networks (SANs) are focusing much of the industry's attention on the need to properly evaluate fiber optic installations. Today there is no simple standards-based test method to assure that the installed cabling can support new fiber optic applications.

It is therefore important to use a tester such as the WireScope™ 350 that can produce pass/fail results for networking applications in addition to pass/fail results for generic cabling standards. Considering how complicated fiber optic network test limits get, having a tester that "knows" these standards is a practical necessity.

TIA 568B.3 and ISO 11801 specifications include generic loss limits based on wavelength and fiber type. Tables 1 and 2 show the loss limits for fiber cables, connectors and splices currently specified in the draft TIA 568B.3 document being developed by the TIA TR42.8 committee.

Optical fiber cable type	**Wavelength (nm)**	**Maximum attenuation (dB/km)**
50/125 μm	850	3.5
	1300	1.5
62.5/125 μm	850	3.5
	1300	1.5
Singlemode inside plant cable	1310	1.0
	1550	1.0
Singlemode outside plant cable	1310	0.5
	1550	0.5

Table 1: TIA 568B.3 Fiber optic cable loss limits

	Attenuation (dB)
Splice	0.3
Connection, TIA	0.75
Connection, ISO	0.5

Table 2: TIA-568B.3 Connector and splice loss limits

A field tester can evaluate the measured fiber losses against the generic limits shown in tables 1 and 2, provided the test technician specifies the length of fiber and the number of connectors or splices[1].

However, testing to these generic limits does not guarantee that the applications will work. It is important to select a field tester that can automatically produce pass/fail limits for different networks.

[1] TIA 568B.3 [3] document references TIA-526-14 for field measurement methodology over multi-mode fiber and it references TIA-256-7 for measurement over singlemode fiber.

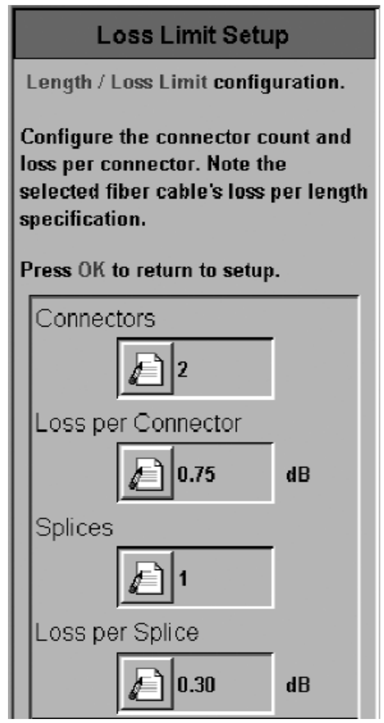


Figure 1: WireScope™ 350 set-up screen for specifying the loss budget per TIA and ISO standards.

The losses in the connectors and splices are added to the cable loss to come up with the overall loss limit. The cable loss is based on the loss per unit length, times the cable length.

Clearly, such a limit has little to do with the requirements of any networking applications.

Test limits for networking applications are typically specified in the IEEE, ANSI and other standards defining these applications. Today, we have 7 different sets of length and loss limits specified by the IEEE for the existing variants of gigabit Ethernet (table 3).

Gigabit Ethernet	Type of Fiber	Wavelength (nm)	Fiber Core Size (microns)	Modal Bandwidth (MHz • km)	Maximum Distance (m)	Attenuation (dB)
1000Base-SX	MMF	850	50	400	500	3.37
				500	550	3.56
			62.5	160	220	2.38
				200	275	2.60
1000Base-LX	MMF	1310	50	400,500	550	2.35
			62.5	500	550	2.35
	SMF	1310	10		5,000	4.57

Table 3: Maximum length and attenuation specifications for different versions of Gigabit Ethernet over various types of fiber optic media

The new 802.3ae 10 Gb/s Ethernet standard will likely require at least as many different sets of limits which will add considerably to field testing complexity. With so many different network test requirements, it is virtually impossible to use an old-fashioned stand-alone loss meter to guarantee proper operation of the fiber optic networks.

The loss and length limits for different networks are a function of cable type and transceiver operating wavelength. Because of the vast number of different applications and in many cases several different sets of limits for each application, the field tester should automatically keep track of the application test limits (figure 2). The test report should document the pass/fail result for each network and the pass/fail result with respect to generic TIA or ISO limits (figure 3).

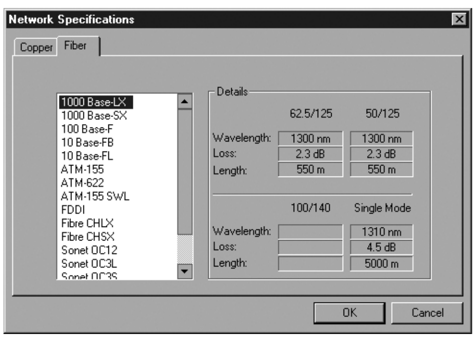


Figure 2: An example of fiber optic network test limits programmed into a field tester.

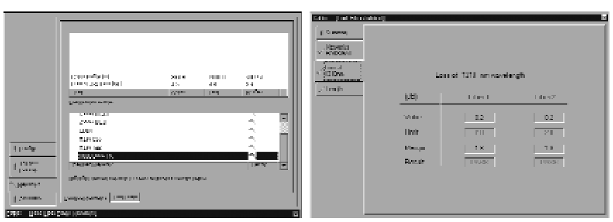


Figure 3: A sample test report displaying application-specific pass/fail results for each fiber optic network (left) in addition to the generic TIA and ISO pass/fail results for cable loss (right).

Accelerating Triple Play Service Deployment
E6000C Mini-OTDR Family

www.agilent.com/comms/otdr

- **High dynamic range –45dB**
- **Fiber break locator to quickly find breaks and bends**
- **Locate and characterize splice and connector losses**
- **Multifiber testing for fast high-count cable qualification**
- **Perform power and loss measurement with the built-in light source and the power meter module**
- **Graphical representation of measurement results in event tables, showing loss and reflection, and pass/fail results**
- **Visual fault finder to check patch cords for light leakage**
- **New cost-effective FTTx OTDR for fiber-to-the-home or short distance fiber links**

The Mini-OTDR is designed to provide you with the fastest tool available for installing and commissioning multiple fiber links and locating faults for fiber maintenance. This is accomplished through high measurement performance and an award winning simple user interface.

The Agilent Mini OTDR family offers you the most advanced technology for portable equipment: measurements that are simultaneously fast, reliable and accurate, best trace resolution from the connector to the end of the link, 8 hours of battery operation and just 2.9 kg. It makes your work easier before you even switch it on.

Agilent's new E6020B FTTx OTDR is a cost-effective, easy to use solution for the installation and maintenance of access fiber networks, ideally suited to serve the needs of technicians who deploy fiber-to-the-home or short distance fiber links, such as enterprise networks or links to wireless base stations.

Built-in Applications

- OTDR expert mode
- Multi-fiber test
- Pass fail test and event table
- Optical return loss and end to end loss
- Traffic detection
- Fiber break locator
- OTDR wizard and auto-text for novice operators

Specifications

Minimum Sample Space	4 cm
Pulse Width	10 ns to 20 µs
Event Dead Zone	3 m
Attenuation Dead Zone	10/12/14 m at 1310/1550/1625 nm

Single Mode OTDR Modules

Wavelength	Deadzone	30 dB	35 dB	40 dB	43 dB	45 dB
1310/1550 nm	3 m	E6004A	E6003A	E6003B		E6008B
1310/1550 nm	1.5 m				E6003C	
1550/1625 nm	3 m				E6012A	
1310/1550/1625 nm	3 m			E6013A		

Multimode OTDR Modules

Wavelength	Deadzone	23 dB	35 dB
850/1300 nm	3 m		E6005A
850/1300 nm	3 m	E6009A	

Power Meter Submodule E6006A

Wavelength	Power Range
800 – 1650 nm	–70 dBm to +10 dBm

Visual Fault Locator Submodule E6007A

Wavelength	Distance Range
Red Visible Light	up to 5 km (635 nm)

Accessories

E6080A Spare NiMH battery pack
E6081A Mini-Keyboard
E6082A Hard transit case
E6092A OTDR Toolkit III Plus trace analysis & acceptance test documentation software
N3980A CompactFlash™ card 192 MB
E6000-13601 OTDR Support CD

Ordering Information

E6000C Mini-OTDR Mainframe
  E6000C-003 Color Screen VGA – LCD
  E6000C-006 B/W Screen VGA – LCD
E6003A 1310/1550 nm Standard Performance Single Mode Module
E6003B 1310/1550 nm High Performance Single Mode Module
E6003C 1310/1550 nm Very High Performance Single Mode Module
E6004A 1310/1550 nm Economy Single Mode Module
E6005A 850/1300 nm High Performance Multimode Module
E6006A Optical Power Meter Submodule
E6007A Visual Fault Finder Submodule
E6008B 1310/1550 nm Ultra High Performance Single Mode Module
E6009A 850/1300 nm Economy Multimode Module
E6012A 1550/1625 nm Ultra High Performance Single Mode Module
E6013A 1310/1550/1625 nm Very High Performance Single Mode Module
E6020B FTTx OTDR with Color Display and Visual Fault Finder Submodule
  E6020B-011 1310 nm Single-mode OTDR Module, 30 dB
  E6020B-012 1310 nm/1550 nm Single-mode OTDR Module, 30 dB
  E6020B-013 1310/1550 nm Single-mode OTDR Module, 30 dB and 850 nm/1300 nm Multimode OTDR Module, 23 dB

Note: the submodules E6006A and E6007A can not be inserted to the E6013A OTDR module.

- **Large, brilliant 10.4” color TFT display 800 x 600 pixels**
- **Only 3.3 kg (including battery pack)**
- **5 hours of continuous measurement, <3 hours charging time**
- **OTDR mode**
- **Multi fiber test**
- **Automated OTDR measurements using 1 x 12 Optical Switch**
- **Accumulated optical return loss**
- **Accumulated end-to-end loss**
- **Loop Back fiber testing mode**
- **Build-in continuous wave source (CW)**
- **Pass/Fail Test**

The Agilent N3900A modular network tester is a portable, lightweight, rugged test platform for the installation, commissioning and maintenance of optical networks. Developed from customer feedback from installation and maintenance (I&M) technicians worldwide, its modular design delivers the measurements you need when you need them. Snap-on measurement modules meet your test requirements for today’s communications networks; the modular platform protects your investment, and lets you grow into your future measurement needs.

The modular network tester can hold up to three modules to perform OTDR measurements, chromatic dispersion, polarization mode dispersion or optical spectrum analysis, or a 1 x 12 optical switch module. A video microscope camera can be connected to ensure clean, fast and safe connector inspection as the connector surface picture can be analyzed on the 10.4” display. From the carrying case to the handles and tilt-stand, from the pop-up connector to your choice of interface, attention to detail and to your feedback provide the perfect fit for the way you work.

Each OTDR engine has built-in RISC processing power for fast and accurate trace acquisition. For long haul links, use Agilent N3910AL (1310 & 1550 nm) and N3911AL (1550 & 1625 nm). For metro links, use Agilent N3914AL (1310, 1550 & 1625 nm).

The Agilent N3909A is a field PMD analyzer based on the “golden standard” Jones Matrix Eigenanalysis method. It helps to maximize revenues through fiber plant capacity and repeater distance optimization by minimizing the effects of PMD using the most robust PMD measurement available. The measurement result includes the DGD distribution over the transmission band and link loss over wavelength up to the L-band.

The Agilent N3916AL chromatic dispersion analyzer comes with powerful built-in measurement algorithms that provide fiber type and accurate chromatic dispersion information. Access to just one fiber end is necessary. This engine combines the CD analyzer with the capabilities of a 4-Wavelength OTDR, measuring fiber loss test and chromatic dispersion in one go. For easy dispersion compensation planning, measurements are expressed in dispersion values and dispersion slope ratios as a function of the wavelength.

The Agilent N3935A optical spectrum analyzer engine is designed for use in systems with channel spacing down to 25 GHz. It covers the S, C, L bands and beyond. It is capable of resolving up to 256 simultaneous channels. Built-in test routines and applications include a channel planning tool, real time and averaged spectral analysis, automatic detection of missing and/or unexpected channels and pass/fail test for all parameters (OSNR, power, channel frequency and drift, total power).

The Universal Serial Bus (USB) video microscope camera N3988A is used for the inspection of fiber optic connectors such as those on patch cords or patch panels. The video microscope is connected via a single USB port, and comes complete with a set of exchangeable connector tips to fit all the common connector interfaces. It makes the examination of connectors for debris, scratches and defects extremely easy by displaying the magnified image on the brilliant 10.4” screen of the modular network tester or on a PC, away from any laser hazards to the eye.

Specifications

Single Mode OTDR Modules

Wavelength	**40 dB**	**43 dB**	**45 dB**
1310/1550 nm	N3910AM		N3910AL
1550/1625 nm		N3911AL	
1310/1550/1625 nm		N3914AL	
1310/1480/1550/1625 nm	N3916AL		

Minimum Sample Spacing	4 cm
Pulse Width	selectable, from 10 ns to 20 µs
Event Dead Zone	3 m (for all single mode modules)
Attenuation Dead Zone	10 m @ 1310 nm/12 m @ 1550 nm, 14 m @ 1625 nm
Linearity	±0.03 dB (1km – 100 km)

Chromatic Dispersion Analyzer Agilent N3916AL

Zero Dispersion Wavelength Repeatability	±0.6 nm
Dispersion Coefficient Accuracy	±0.5 ps/nm/km
Repeatability	±0.05 ps/nm/km
Dispersion Range	±2500 ps/nm
Wavelength Range	1250 nm to 1700 nm

Polarization Mode Dispersion Analyzer Agilent N3909A

Wavelength Range	1525 nm to 1620 nm
Wavelength Resolution	50 pm
DGD Range	0 ps to 150 ps
PMD Range	0 ps to 50 ps
PMD Accuracy	±(0.03 ps + 2% of PMD)
Link Loss Accuracy	±0.4 dB

Optical Spectrum Analyzer Engine Agilent N3935A

Dynamic Range	45 dBc @ 100 GHz and 40 dBc @ 50 GHz
Resolution Bandwidth (FWHM)	<100 pm
Scanning Resolution	0.005 nm
PDL	±0.05 dB
Wavelength Accuracy	±40 pm
Power Noise Level	–70 dBm

Accessories

N3980A	CompactFlash™ Card 192 MB
N3985A	Battery Li-Ion
N3993A	Hard Carrying Case for Modular Network Tester, modules and accessories
E6081A	Mini-Keyboard
E6092A	OTDR Toolkit III Plus trace analysis & acceptance test documentation software

Key Literature

5988-5065EN	Agilent N3900A Modular Network Tester, Brochure
5988-8190EN	Agilent N3900A Modular Network Tester, Technical Specifications
5988-5069EN	Agilent N3988A USB Video Microscope Camera
5988-5068EN	Agilent N3940A Optical Switch Module

Ordering Information

N3900A	Agilent Modular Network Tester Mainframe
N3910AM	OTDR Test Engine 1310/1550 nm 40/39 dB
N3910AL	OTDR Test Engine 1310/1550 nm 45/43 dB
N3911AL	OTDR Test Engine 1550/1625 nm 43/39 dB
N3914AL	OTDR Test Engine 1310/1550/1625 nm 43/41/38 dB
N3909A	Polarization Mode Dispersion Test Solution, includes N3909AR Polarization Mode Dispersion Receiver Module, 81944A Compact Tunable Laser Source, 8163B Lightwave Multimeter
N3916AL	CD/OTDR Test Engine 1310/1480/1550/1625 nm 43/40/41/38 dB
N3935A	Optical Spectrum Analyzer Test Engine
N3940AA	1 x 12 Optical Switch Module
N3988A	USB Video Microscope Camera

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- **Certifies compliance of installed LAN cabling to TIA Category 6 and ISO Class E standards**
- **Accuracy beyond TIA and ISO level III requirements traceable to laboratory reference standards**
- **Tests fiber optic cabling via optional Fiber Smart Probes**
- **Expandable test result storage on removable Compact Flash™ memory cards**
- **Included ScopeData Pro software produces professional quality graphical test reports**
- **Easy to use color touch screen interface minimizes training requirements**
- **Talkset support improves coordination within testing teams**

One Answer to All Cable and Fiber Testing Needs

The Agilent WireScope™ 350 cable tester provides high performance permanent link and channel test probes for UTP, STP, ScTP or coax copper cabling. The Fiber SmartProbes provide certification testing of both multimode and single mode fiber cables while also providing low cost optical power meter and light source functionalities.

Superior Measurement Performance with eACT Technology

The WireScope™ 350 is based on frequency domain testing, the same principle used by the world's most accurate network analyzers. Its unmatched hardware accuracy is further augmented by state of the art software algorithms including a novel patent pending eACT algorithm to automatically cancel the interface and adapter effects from the test results. This automatic and dynamic compensation assures superior repeatability and accuracy with continuous usage of the instrument.

Color User Interface

A bright color touch screen simplifies navigation through menus and improves comprehension of test result data, resulting in faster operation and reduced training times. Setup instruction screens assist the operator when configuring test options, minimizing the chances of inadvertently testing to the wrong limits. All settings can be defined on a PC and downloaded in a single operation, speeding the process of configuring multiple WireScope™ 350 sets for the same job site testing requirements.

Professional-Quality Reports

As the complexity of cable testing standards increases, it becomes more challenging to present test result data clearly. The WireScope™ 350 solves this problem with professionally designed report layouts which include plots of test data, facilitating at-a-glance analysis of cabling quality and headroom vs. limits. The WireScope™ 350 test memory can be expanded with removable CompactFlash™ memory cards to support plot storage for all tests.

www.wirescope.com

Test Parameters
- Supported frequency range: 1-350 MHz
- Accuracy: TIA Level III accuracy

Supported Tests
- Near End Crosstalk (NEXT): results displayed in pair to pair and/or PowerSum format
- Attenuation (Insertion Loss)
- Equal Level Far End Crosstalk (ELFEXT)
- Return Loss
- Ambient Noise: plots noise versus frequency
- Wire Map: identifies miswires, shorts, opens, reversals and split pairs. Detects shield continuity.
- Cable Length: measures length of each pair and distance to faults
- Propagation Delay: reports total delay and delay skew between pairs
- Loop Resistance

Test Standards
- TIA/EIA-606-A and TIA/EIA-568-B Cat 3 through 6
- ISO/IEC 11801 Class C, D and E
- EN 50173 Class C, D and E
- Australia/NZ Class C, D and E
- TIA 606a
- UTP, STP, SCTP, COAX and Twinax cabling
- IEEE 802.3 10BASE-T, 100BASE-TX, 1000BASE-T
- IEEE 802.5 Token ring and IBM Type 1
- UTP and fiber PMD interfaces

Memory
- Type 1 CompactFlash™ memory allows for flexible test record storage.
- 128 MByte CF Card included.

Power
- Removable/Rechargeable NiMH batteries

Dual Remote
- Included as part of WireScope 350 Product Kit; provides all required testing from the far end of the cable.

User Interface
- 2.38" x 6.25" (6 x 16 centimeters) touch-sensitive color LCD display screen

Dimensions
- Size: 9” x 4.5” x 2.6” (22.8 x 11.4 x 6.6 centimeters)
- Weight: 2.6 lbs. (1.2 kilograms)

Ports
- Intelligent Test Port
- Serial Port
- Universal serial bus
- Talkset interface: 3.5 mm stereo jack

Ordering Information

N2600A-100	WireScope™ 350 Product Kit
N2600A-130	WireScope™ 350 Multimode Professional Test Kit
N2600A-150	WireScope™ 350 Multimode and Single Mode Professional Test Kit Optional Probes and Accessories
N2604A-100	Category 6 Channel Probe (set of two)
N2604A-101	Category 6 Permanent Link Probe (set of two)
N2604A-200	COAX Test Probe
N2605A-134	Removable Battery Pack
N2605A-135	Hard Carrying Case
N2605A-137	Talkset Kit
N2605A-097	USB Cable
N2584A-003	Serial Cable
N2596A	AC Power Adapter

Accelerating Triple Play Service Deployment
N2620A FrameScope™ Pro with SFP Transceivers

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- **New Voice over IP test option**
- **Autotest application performance testing**
- **Network discovery of stations and resources**
- **Remote control via any web browser**
- **10/100/1000BASE-T Copper interface**
- **1000BASE-SX/LX/ZX SFP interface**

With the FrameScope™ Pro, technicians deploying Ethernet in Metro networks now have a fast, efficient and very cost effective test solution for measuring bandwidth at line rates from 1 Mbit/s to 1 Gbit/s. FrameScope™ Pro connects via RJ45 port for copper networks and SFP (Small Form-factor Pluggable) for fiber networks.

The FrameScope™ Pro is a powerful Ethernet deployment tool capable of throughput, latency, back-to-back frames and frame loss measurements for SLA verification and performance testing. It uses a standardized point-to-point testing method defined by RFC 2544. The test results can be stored on the CompactFlash™ card or viewed and printed via the remote interface.

FrameScope™ Pro Autotest uses an innovative technique to objectively measure and benchmark the performance of network application servers, and produces detailed reports on the performance metrics. This complete toolkit for testing enterprise networks is useful
for both troubleshooting and network pre-qualification.

FrameScope™ Pro contains a complete arsenal for troubleshooting tools from Ping and Trace Route to traffic generation and statistical analysis of the traffic breakdown. With just a few clicks, FrameScope™ Pro allows you to identify 10/100/1000 Mbit/s Ethernet utilization, broadcasts, collisions and errors, or pinpoint incorrectly assigned subnet masks, misconfigured servers, and duplicate IP addresses.

Network security is about knowing who is accessing the network and what type of traffic they are generating. Using the network database, rogue stations can be found and identified.

As technology advances, FrameScope™ Pro is ready. The compute engine and operating system allow for many future enhancements and the card bus slot enables the use of PCMCIA cards for additional expansion.

The FrameScope™ Pro is capable of voice service testing in IP based networks. It provides Mean Opinion Scores (MOS) to indicate the performance of the Voice over IP service. These calculations are based on the ITU-T G.107 standard for measurement of QoS for VoIP to pinpoint potential issues that may exist on their IP voice networks.

FrameScope™ Pro VoIP, the voice over IP test version of FrameScope™ Pro, supports PPPoE which stands for Point-to-Point Protocol over Ethernet. PPPoE relies on two widely accepted standards: PPP and Ethernet. It supports PAP, CHAP (RFC 1994), MS-CHAP and MS-CHAPv2 authentication methods.

It is also capable of doing setup and control calls. It acts as an IP phone and initiates a call on demand. If used to answer incoming calls automatically, it continuously plays back pre-recorded speech/tone.

Specifications

Test Interfaces
- 10/100/1000BASE-T copper interface
- Supported SFP fiber interfaces: 1000BASE-SX, -LX, -ZX

Supported Protocols
- IP, IPX, NetBIOS

Supported Tests
- Autotest performance measurement of Email, Web, File, DNS, DHCP, WNS, Novell,
  Print, FTP, Primary DC, Secondary DC Servers, Switches and Routers
- Ping, Trace Route, and SNMP Queries verify connectivity to user-defined devices
- Statistical analysis of the network condition
- Traffic Generator up to full line rate at 10/100/1000 Mbit/s speeds
- RFC 2544 tests for throughput, latency, back-to-back frames and frame loss measurement at full 1 Gbit/s line rate
- VLAN tag and priority fields are configurable
- QoS IP TOS and DSCP settings are configurable
- IP and MAC Loopback measure precise roundtrip delay at layer 2 (MAC) or layer 3 (IP)
- Locate Switch Port & Blink Hub Port locates live network cable connections
- Network Database stores station information
- Wiremap Test to locate miswires using the Wiremap Adapter

Supported VoIP Test
- QoS test result provided as MOS based on ITU-T G.107
- PPPoE test supporting PAP, CHAP (RFC 1994), MS-CHAP and MS-CHAPv2
  authentication methods
- Set up and control voice calls
- Autoanswer of incoming voice calls

Memory
- 128 MB CompactFlash™ card included

Power
- Removable/Rechargeable Lithium Ion battery
- Battery life: 5 to 8 hours of operation

User Interface
- 2.38” x 6.25” (60 mm x 160 mm) touch-sensitive color LCD display screen

Dimensions
- Size: 9” x 4.5” x 2.6” (228 mm x 114 mm x 66 mm)
- Weight: 2.5 lbs. (1.2 kg)

Ports
- RJ45 Wiremap test port
- RJ45 10/100/1000BASE-T Ethernet port
- SFP port for 1000BASE-SX, -LX or -ZX 1 Gbit/s fiber connections
- Universal Serial Bus (USB 1.1)
- Talkset Interface: 3.5 mm stereo jack
- CardBus interface

Ordering Information

N2620A-001	FrameScope™ Pro Ethernet Kit Ethernet troubleshooting and RFC 2544 performance test
N2620A-003	FrameScope™ Pro Voice Kit Voice over IP tester with basic Ethernet troubleshooting

Software Upgrade Licenses

N2620A-030	Voice over IP test license for N2620A-001
N2620A-031	RFC 2544 test license for N2620A-003

Accessories

N2620A-050	Multimode SFP Transceiver, 1000BASE-SX, 850 nm
N2620A-051	Single Mode SFP Transceiver, 1000BASE-LX, 1200 – 1600 nm
N2614A-001	Wiremap Adapter
N2595A-096	Rechargeable Battery Pack
N2620A-080	Additional Universal AC Adapter
N2620A-060	Headset

Accelerating Triple Play Service Deployment

1735A 1,2 and 4 Gb/s Fibre Channel Multi-Application Test Module

www.agilent.com/find/fctester

- **The 1735A Combines Multiple Test Applications in One 1,2 and 4 Gb/s Fibre Channel protocol analysis module**
- **Data performance test of Fibre Channel network infrastructures with wire speed traffic generation capabilities**
- **SAN fabric stress test with error injection and exceptions generation**
- **Protocol analysis for SAN network monitoring and troubleshooting**
- **Portable solution for on-site measurements.**
- **Scalable platform for simultaneous analysis of multiple points of the SAN network.**

The Agilent 1735 Fibre Channel test system allows network equipment manufacturers, service providers and IT departments to characterize realistically the performance of local or distributed Storage Area Networks based on the Fibre Channel technology.

The 1735 test system is a comprehensive solution that provides the controlled environment necessary to test complex SANs before deployment, as well as the non-intrusive protocol analysis capabilities to monitor and troubleshoot Storage Area Networks during operation.

Reduce Equipment Needed for On-Site Measurement with the 1735A Multi-Application Module

The versatile 1735A multi-application protocol analyzer is a new-generation Fibre Channel test module that you can easily configure as either, a dual Fibre Channel protocol analyzer, or a 2-port traffic generation and performance measurement system. The same module can then be used on-site for SAN performance testing or troubleshooting.

Test SAN Networks Under Extreme Conditions

The user-controlled, multi-port Fibre Channel traffic generation, at full wire speed, helps you increase test coverage of your network infrastructure with a wide range of specific real-world traffic conditions. The continuous real-time statistics help you detect errors such as disparity errors, lost frames, misdirected frames, CRC errors and invalid data.

Device Emulation Capabilities

Each test port can be configured to mimic various Fibre Channel devices. You will minimize the number of real devices needed to test your environment, and will be able to reproduce problems that only happen with certain types of Fibre Channel devices.

Customize Your Measurements with Test Automation and Scripting Capabilities

A complete TCL programming environment helps you create and automate your specific test procedures, perform regression tests and build application specific user interfaces

The SAN tester, all-in-one window, gives you easy visibility into your system performance. The real-time GUI includes ruler-bars to change traffic conditions dynamically together with real-time statistics and histograms to observe the impact on the SAN network performance. The user interface includes a dashboard to monitor the health and status of all the test ports.

When the 1735A is used in protocol analysis mode, the traffic activity, port status and trace content are displayed simultaneously, giving you a complete overview of SAN network activity. The hierarchical trace display helps you speed your debug process by avoiding constant scrolling, and compare frames with simultaneous zooming on multiple lines. Hardware-accelerated search capabilities help you find errors within GBytes of captured data in seconds.

Physical interface	
Number of Ports	Can be configured in 4 ports as a protocol analyzer or 2 ports as a SAN tester
Line Rate	1.0625, 2.125 or 4.25 Gigabits/second (Gb/s)

Specifications	
Protocol analysis (analyzer mode)	
Analyzers	Two independent, dual port, full-duplex analyzers per module Each analyzer has its own triggering and filtering resources
Memory size	1 GByte per analyzer (2 GBytes per module)
Trigger	2 independent multilevel trigger sequencers per module with multi-way branching
Dual channel	Trigger on sequence of events in both directions (Tx and Rx)
Sequencer	8 states per sequencer
Resources	2 counter/timers (for trigger on time-outs) per sequencer
Pattern matchers	8 128-byte pattern matchers (primitives or frames) with associated local occurrence counters
Cross triggering (internal)	Cross-module arm in/out for inclusion in sequencer events coming from another analyzer
Cross triggering (external)	1 external trigger in/out per chassis
Filters	Hardware filter conditions can be defined individually for each sequence level
Error detection	Disparity, code violation, CRC error, undersize frames, oversized frames, loss of synch
Resolution	8.3 ns Timestamp resolution
Time correlation	All analyzers in the same session share the same clock to allow for time-correlated measurements Time correlation on up to 128 modules (256 analyzers)
Search	High-speed hardware assisted search
Trigger in/out	1 external trigger in/out per chassis

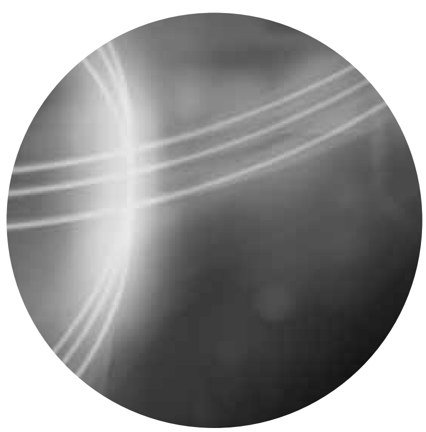
Traffic generation (SAN tester mode)	
Rate	Full line speed rate
Port type	N_port, Arbitrated loop port (including up to 126 loop devices)
Port behavior	Control of port initialization either as FCP or FICON port
Classes of service	Class 2 and Class 3 traffic
Traffic streams	256 streams per port
Oversized frame	Oversized frames traffic generation and capture
Buffer-to-buffer credit	Adjustable from 1 to 256
Error generation	Aborted frame, CRC error, oversized frame, invalid SOF, invalid EOF

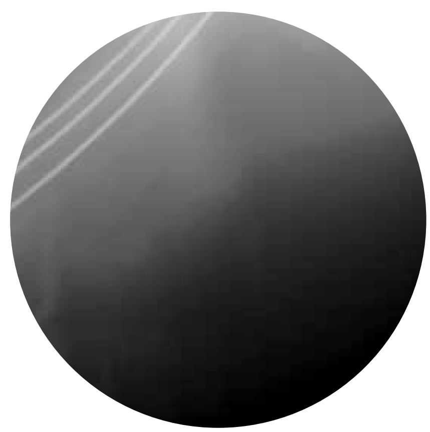
Measurements (SAN tester mode)	
Measurements	24 real-time measurements including throughput, latency, dropped frames, disparity errors, BB credit, failover recovery time
Result types	Cumulative: measurements are reported from the start of the measurement interval. Sampled: measurements are reported from the most recently completed sampling interval.

Fabric services test

- **Zone test**
- **Name server performance**
- **Name server command coverage**
- **State change notification latency**

Literature and Service





Agilent offers a variety of technical support services to keep you and your team up and running smoothly and efficiently. This will enable you to:

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Our technical support staff is knowledgeable about the products and related technologies. All the services in the technical support service family are designed to help your team make the most of your investment and to ensure that you can use your instruments to produce reliable and accurate test results throughout their life span.

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Ordering Information

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www.agilent.com/comms/education.

Description	Literature Number
Photonic Foundation Library Fast Sweep PDL: A Getting Started Guide to perform PDL measurements in Fast Sweep Mode	**5988-7325EN**
Photonic Foundation Library Enhancing Swept Loss Measurement	**5988-3622EN**
Polarization dependent loss measurement of Passive Optical Components	**5988-1232EN**
PDL Measurements Using the 8169A Polarization Controller	**5964-9937E**
Photonic Foundation Library: Creating Software for Optical Component Tests	**5988-4100EN**
Return Loss solutions with the Agilent 8161X Return Loss modules	**5988-3435EN**
State of the Art characterization of optical components for DWDM applications	**5980-1454E**
Cleaning Procedures for Lightwave Test & Measurement Equipment- Pocket Guide	**5963-3538E**
How to use VXI Plug and Play Driver with Agilent VEE,C/C++,Visual Basic,LabVIEW, and lab Windows/CVI	**5988-2790EN**
Measuring the Dependence of Optical Amplifers on Input Power Using an Attenuator	**5988-5260EN**
Variable Optical Attenuator in BER Test Applications	**5988-3159EN**
E6000C Mini-OTDR Technical Specifications	**5988-2302EN**
Mini-OTDR Technical Specifications	**5988-2302EN E6000C**
Agilent N3900A Modular Network Tester, Brochure	**5988-5065EN**
Agilent N3900A Modular Network Tester, Technical Specifications	**5988-8190EN**
Agilent N3988A USB Video Microscope Camera	**5988-5069EN**
Agilent N3940A Optical Switch Module	**5988-5068EN**
1735A 1, 2 and 4 Gb/s Fibre Channel Multi-Application Protocol Analyzer Module and Traffic Generator	**5989-1661EN**
Agilent Technologies 81133A and 81134A 3.35 GHz Pulse Pattern Generators Data Sheet	**5988-5549EN**
PCI Express RX Design Validation with 81133A/81250 Application Note	**5988-7432EN**
Agilent 81141A The 7 GHz serial Pulse Data Generator Data Sheet	**5989-3052EN**
Agilent Technologies Pulse Pattern Generators – Digital Stimulus Solutions Family Brochure	**5980-0489E**

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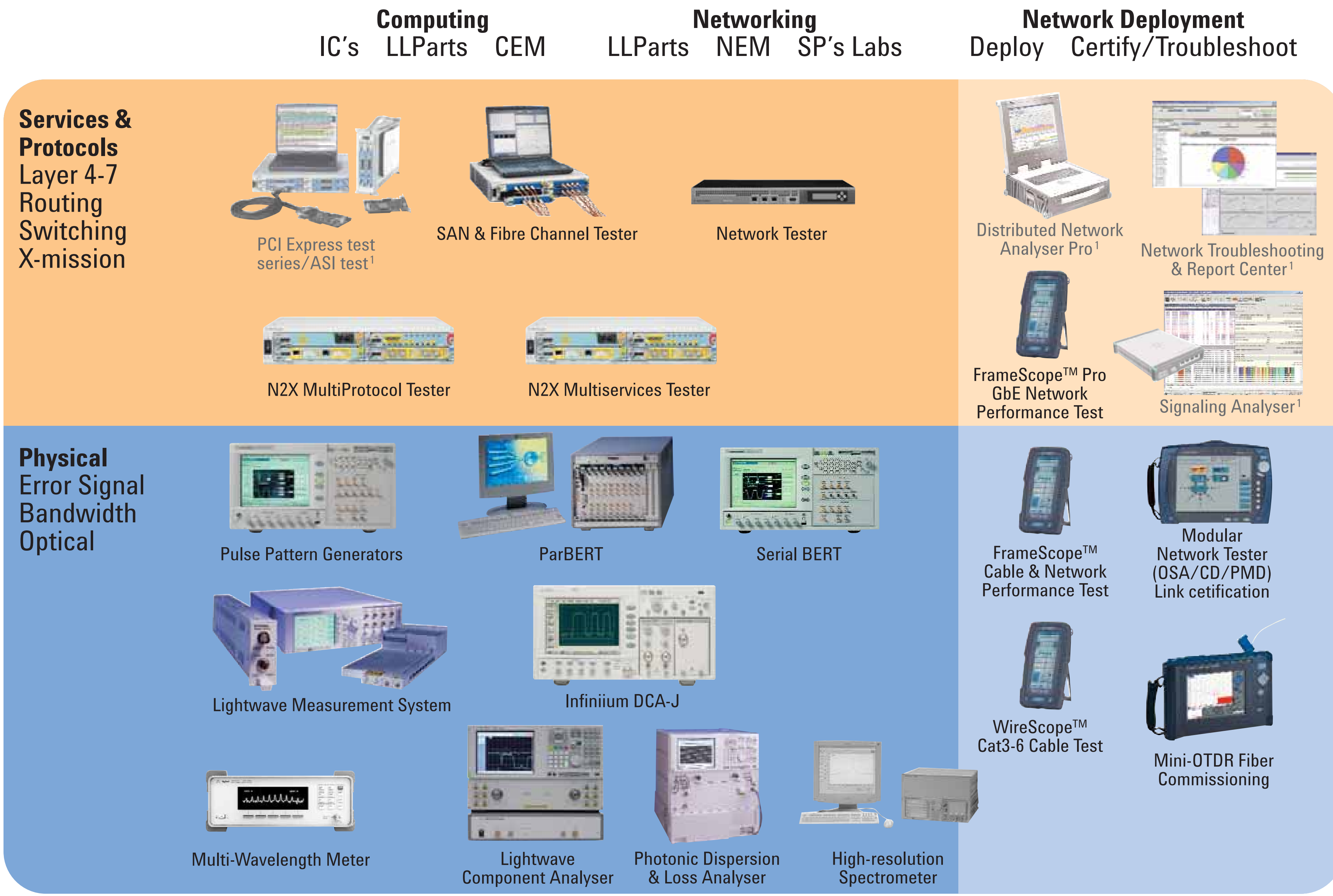
Agilent Computing & Networking Test
Product portfolio



[1] For further information contact your local Agilent sales office or visit www.agilent.com

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