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Find the *dBm Optics 2004* at our website: ***Click HERE***

Model 2004
Component Spectrum Analyzer™ (CSA)

Fast, Accurate PDL/IL/ORL across Wavelength

The 2004 Component Spectrum Analyzer™ will characterize loss, polarization dependency and return loss quickly, accurately and repeatable—all at an affordable cost. dBm Optics' technology supports unprecedented optical repeatability, accuracy, and speed. A device can be characterized over a 100 nm span at 1 pm resolution with 1 pm and 0.015 dB accuracy in less than 1 second.

Repeatable Loss Measurements

Loss measurements usually require a reference measurement—then a measurement of the loss. The 2004 eliminates the need for the reference measurement entirely by using a proprietary real-time reference. The 2004 is constantly monitoring the input power to the device and calculating the loss based on the power out of the device. In addition to speeding the measurement and eliminating the reference errors, the 2004 also eliminates the effect of variation in the source power between the reference and the loss measurement. The result: the most accurate loss measurements available anywhere.

Fast, Accurate Polarization Dependency Measurements

The PDL meter function of the 2004 performs fast and accurate measurement of the polarization dependency of the device using either all-state or matrix method. The matrix method will characterizing 100,000 points of PDL in ~1 second.

Simultaneous Return Loss Measurements

High dynamic range allows the 2004 to characterize return loss to levels approaching -70 dB. This measurement is performed simultaneously with the loss and polarization measurements, with no added time required.

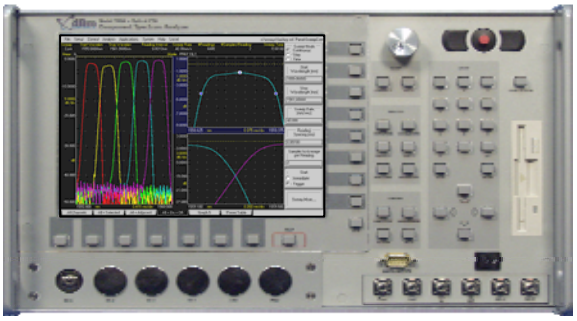
PDBW and PDCW

The 2004 will measure both PDBW and PDCW—polarization dependency of the center wavelength and bandwidth of a filter, very quickly.

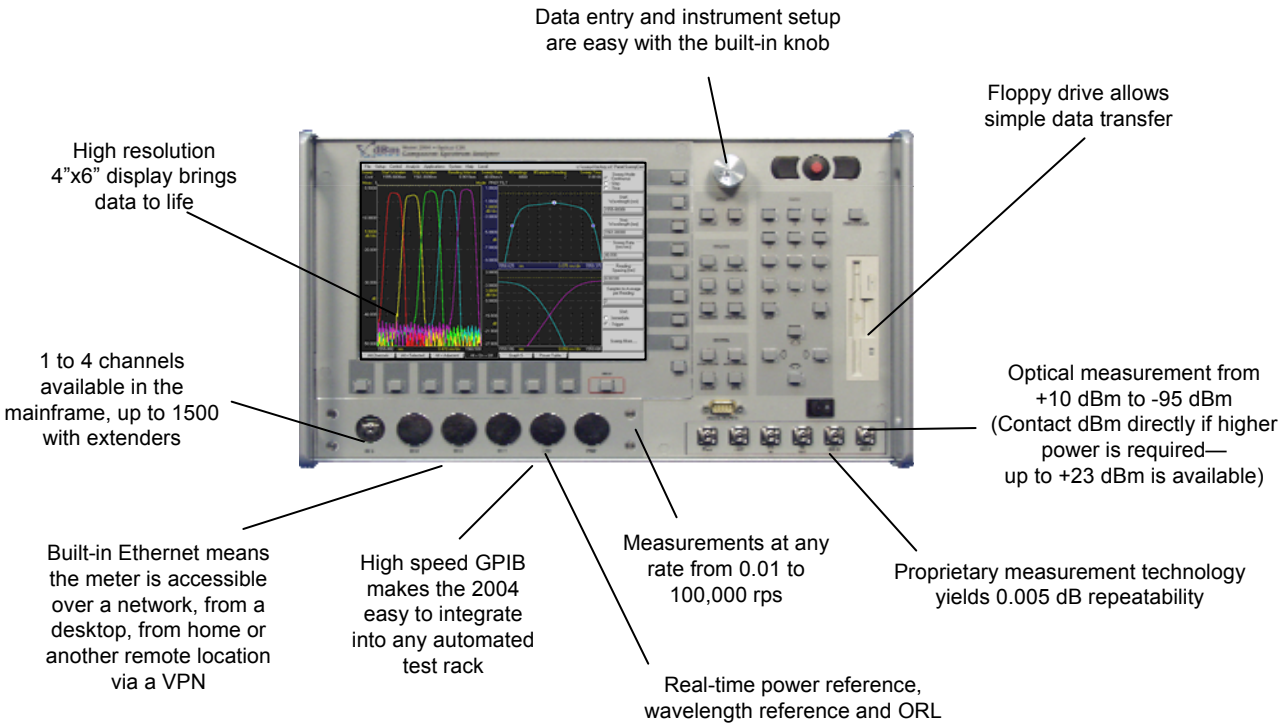
Summary

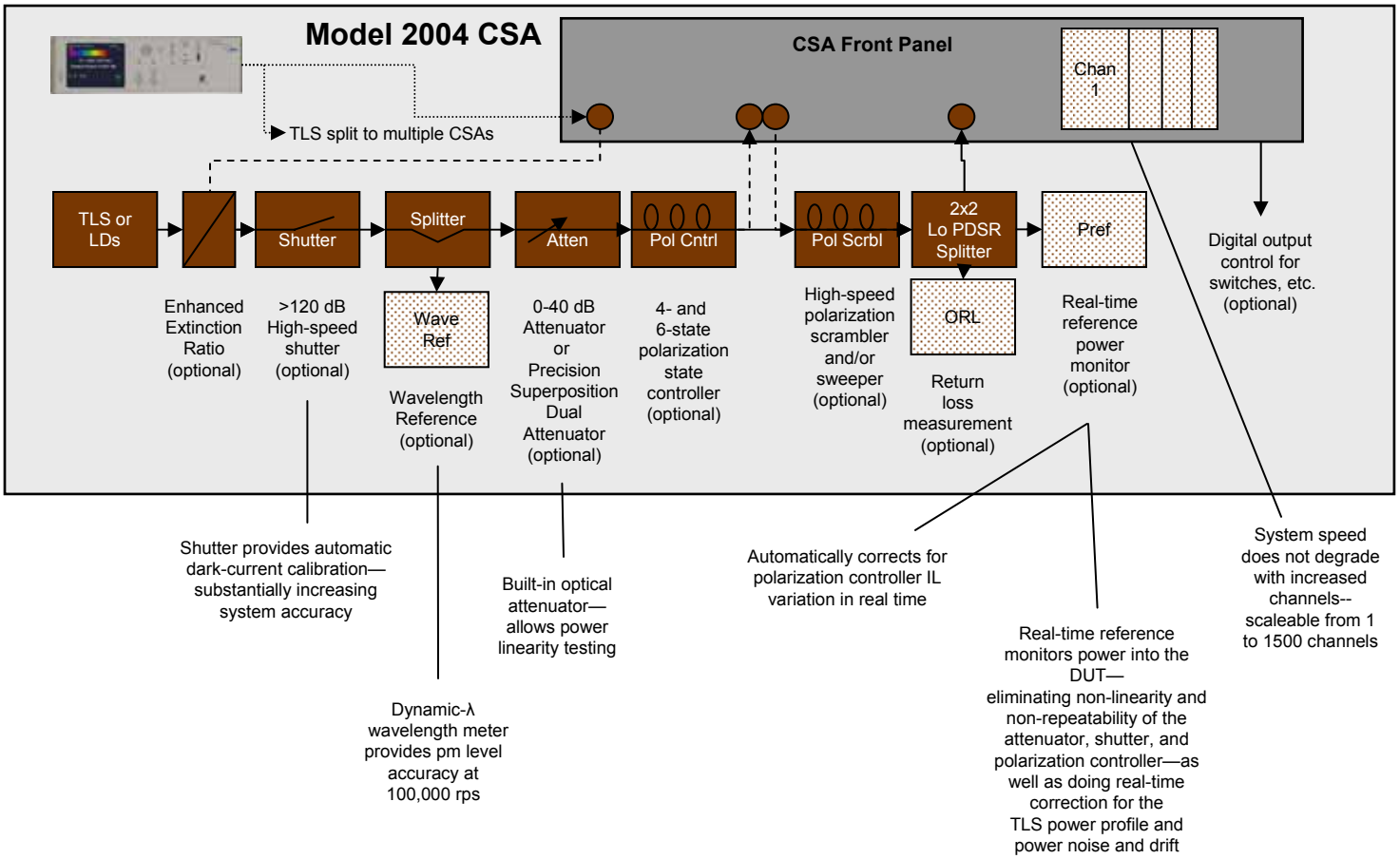
- IL and ORL simultaneously measured in less than 1 second over a 100 nm band
- IL, ORL and PDL simultaneously measured in less than 8.5 seconds over a 100 nm band
- >65 dB dynamic range at full speed; >100 dB total dynamic range
- Low PDL error and high repeatability
- <0.0015 dB polarization dependency
- <0.005 dB repeatability
- Real time referencing reduces test time and increases accuracy
- <1 pm wavelength accuracy with built-in wavelength meter
- Built-in or external TLS or fixed wavelength sources
- Built-in or external polarization controller
- 100,000 readings per second for fast testing and to capture dynamic performance
- PDL, ORL, PWCW and PDBW simultaneously at high speed
- Communicate over GPIB or Ethernet
- 2-year warranty

Fast, Accurate
Passive Component Test System



Overview



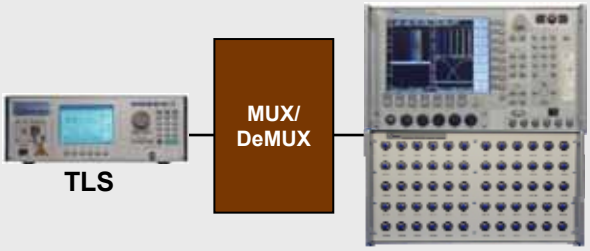


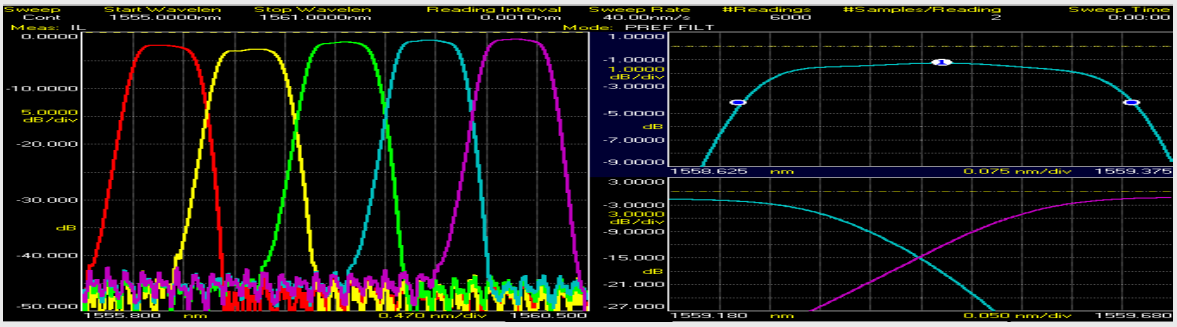
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A Wide Range of Applications

Multiplexer Test

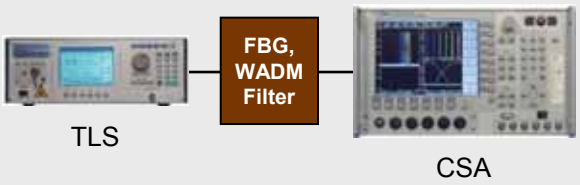
Devices	
✓ **Multiplexers** ✓ **DeMultiplexers**	➢ Eliminate typical speed-for-resolution compromises ➢ Split a TLS to many test benches with the Component Spectrum Analyzer's (CSA) low-power measurement ➢ Fast • Good wavelength resolution • Characterize deep wells at high speed ➢ Automated PDL-vs.-wavelength measurement

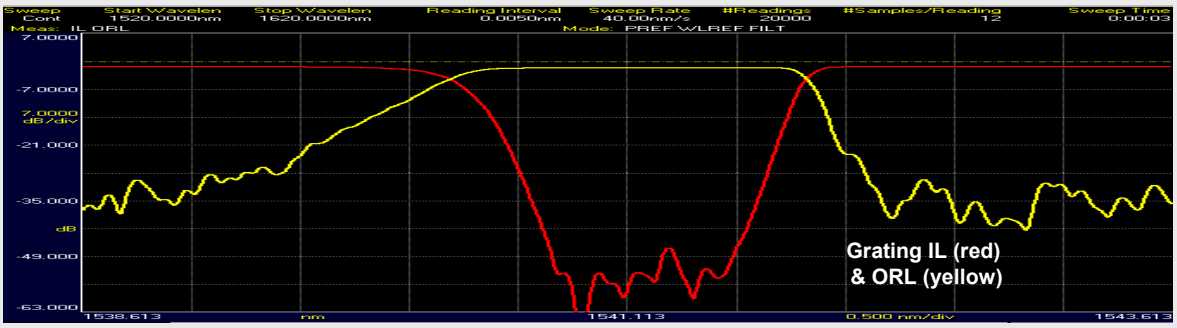




Filter & Grating Test

Devices	
✓ **Fiber Bragg Gratings** ✓ **WADM's & ROADM's** ✓ **FTTH WDMs, triplexers** ✓ **Etalons** ✓ **Filters** ✓ **Interleavers**	➢ Very fast characterization even with very deep (over 60 dB) wells ➢ Low noise allows TLS signal to be split to many benches without loss of test performance ➢ Built-in Dynamic Wavelength meter provides <1 pm or <1.8 pm accuracy with readings at 100,000 updates/sec

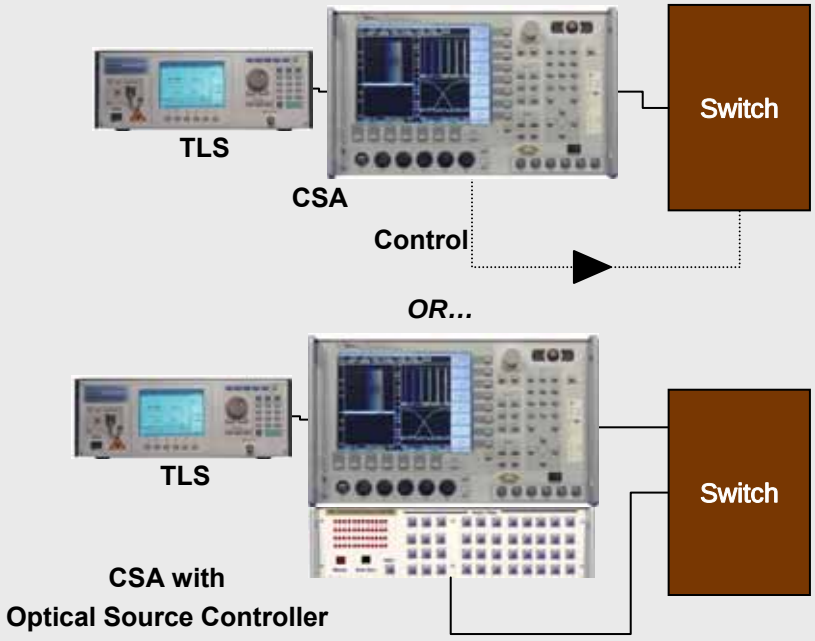


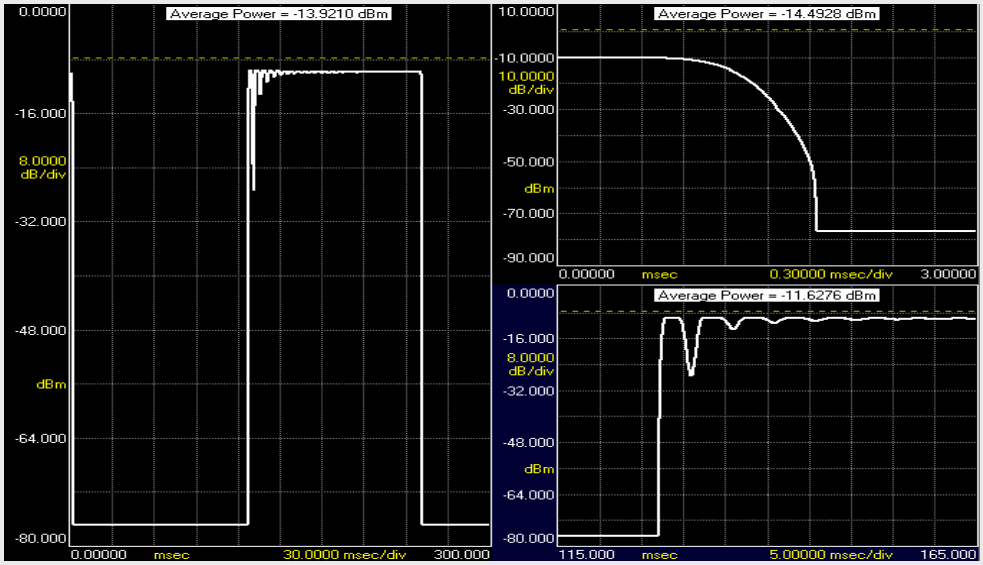


A Wide Range of Applications

Optical Switch Test

- Catch switch dynamics with 10 μsec measurements--fully characterize switch transitions
- Wide dynamic range provides resolution to characterize very low cross-talk levels
- Control the switch with built-in digital output



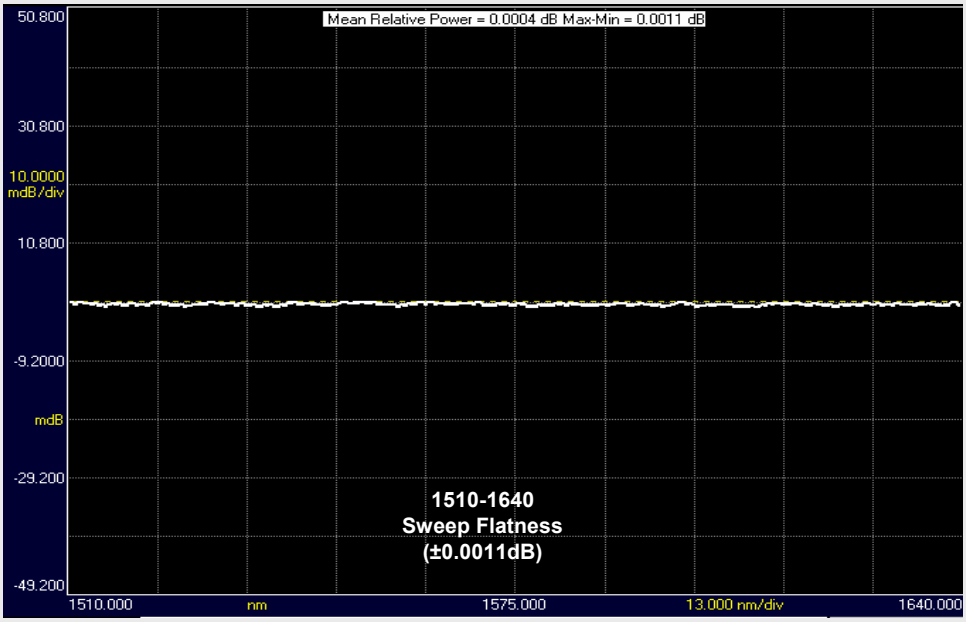


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A Wide Range of Applications

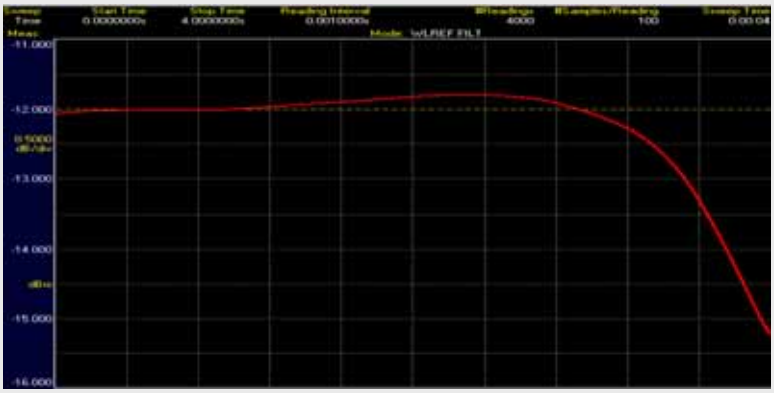
Broadband Passives Test

Devices	
✓**FTTH Splitters** ✓**Circulators** ✓**Isolators** ✓**Splitters** ✓**Couplers** ✓**Attenuators**	➢ Automatic sweep power reference reduces system error dramatically ➢ Easy to use--speeds test execution ➢ Automated measurements for PDL and ORL



Photodiode & Channel Monitor Test

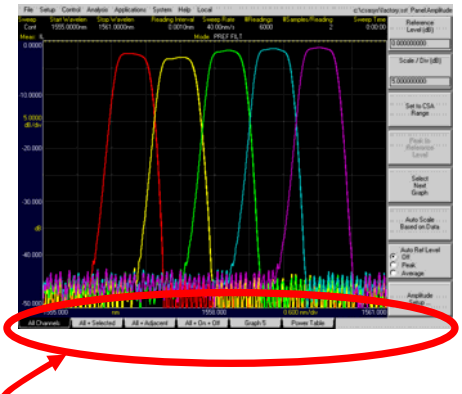
- Covers all telecom photo diode wavelengths 800-1700 nm (pumps, O+E+S+C+L-band)
- Measure directly from the photodiode, or 0-10 V from a trans-impedance amplifier
- Test embedded PD in amplifiers simultaneous with optical parametric tests
- Great absolute accuracy, measurements down to <200 fA
- Simultaneous responsivity, PDR and ORL measurement across wavelength



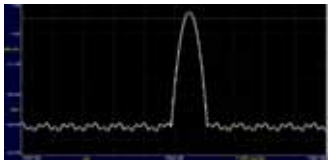
A Front Panel that Makes Your Work Easier

Multiple Alternate Displays

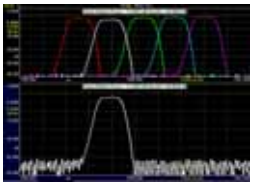
View the data as a typical power meter numeric display, a graphical display, multi-channel graphical display, or a tabular display. The 2004 Component Spectrum Analyzer™ offers a number of unique capabilities that will make a difference in the lab or on the production floor—at an affordable cost.



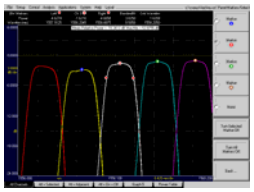
Changing display style is as simple as hitting one of the folder buttons at the bottom of the screen

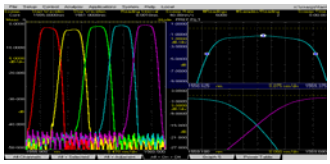


Single channel analysis



Isolate one channel of many in a multiplexer or switch





Multiple simultaneous graphs allow analysis of key details of the signal, in the context of the whole sweep or the other channels



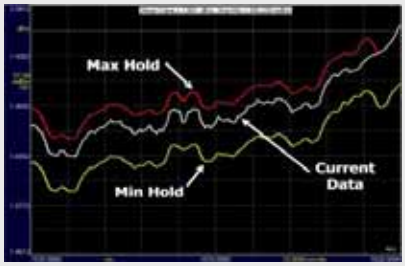
Four independent markers allow direct measurement of wavelength difference, power difference, and optical signal-to-noise

Save Trace

Save the results of a measurement or set of measurements across wavelength and display or use that data automatically in subsequent measurements by using the Save Trace capability.

Max Hold and Min-Hold Traces

Turn these traces on and get a real-time graphic update of the envelope of a measurement at each wavelength. The maximum and minimum excursions of the measurement are displayed.



Capture Max and Min Excursions

Passband Analysis Trace

Average the data in the passband of a wavelength-dependent device and plot that single value along with values in other passbands for an easy visual indication of a device's performance.

Automatic Internal Reference Across Wavelength

The 2004 will automatically perform a reference power sweep and correct all future data with this reference.

Wavelength Accuracy Trace

Characterize the linearity of a tunable laser with these built-in functions.



Automatic Referencing Eliminates Most Errors

Digital Filtering

Multiple digital filter types (including Hamming, Hanning, rectangle) can be used on each channel independently or together.

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The Technology Behind the Performance

Polarization Dependency

The same breakthrough integrating sphere technology that provides high repeatability also serve to drastically reduce the polarization dependency of the dBm Optical Power Meter. On average, each photon bounces 220 times inside our miniature integrating sphere. This ensures that the polarization of the light reaching the detector is very well randomized. This yields a polarization dependency of measurement of <0.0015 dB (1.5 mdB) typical and <0.0035 dB (3.5 mdB) guaranteed.

Low-Level Detection

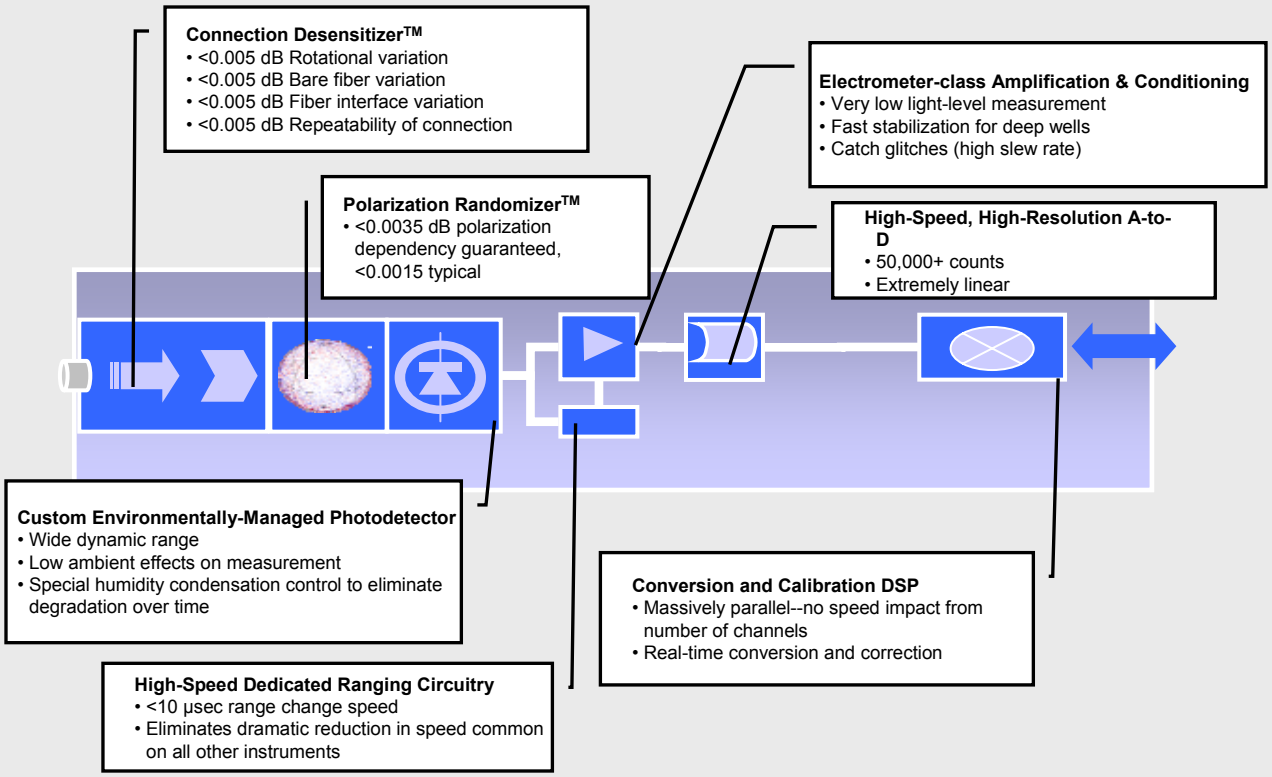
One of the core limits to making low level measurements is the dark current of the internal photodetector. The 202 uses a special low dark current detector. In addition, because dark current is sensitive to temperature, the photodiode is run at –20°C (which substantially lowers dark current). In addition, we hired the world's authority on temperature control to design our temperature control circuitry and achieved stability of approximately 0.002°C (which makes the dark current very stable over time). The cooling itself is driven with very high currents, allowing the device to stabilize quickly and adapt to environmental changes without transient errors. The –202 has a dual-stage controller which further enhances the stability.

Low-Level Amplification Without Compromising Speed

Most optical power meters use traditional current measurement techniques. This involves putting an equivalent resistance across the diode and measuring the voltage drop. The obstacle created using this technique is that a high resistance is needed for low currents which, when combined with the photodiode capacitance, creates slow measurement response. dBm Optics' measurement technology uses an electrometer approach which is more akin to charge counting. This allows us to measure much lower power (~200 fA or -95 dBm).

High Dynamic Range at Speed

The dBm Optical Power Meter is the only power meter available that can measure at 100,000 readings per second. Most power meters drop to 50 readings per second to change ranges. The dBm 2004 can auto-range across three full ranges, spanning over 67 dB, at full speed. The alternative—using a logarithmic amplifier—substantially compromises low-level measurement accuracy and linearity. (Note: For applications requiring over 65 dB of dynamic range, ask a member of our Applications Team about built-in stitched measurements which expand the dynamic range at speeds to >85 dB.)



The Technology Behind the Performance

Repeatably Capturing the Light

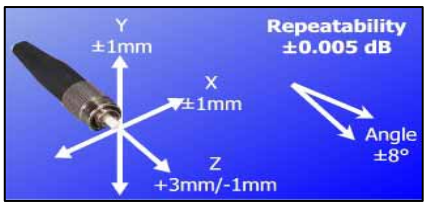
Unless all of the light from a source can consistently be captured, a repeatable measurement will not be made. The action of simply connecting and disconnecting fiber connections to a typical power meter can create large power deltas. The proprietary Connection Desensitizer™ reduces this variation by a factor of 2-20 (with reductions of 4-8 typical). This technology is based on a patented miniature integrating sphere technology. With any of the following changes, a less than ±0.005 dB variation in the measurement can be expected. This compares with typical values for other meters of ±0.05 to ±0.2 dB:

±1 mm X variation

±1 mm Y variation

+3 mm/– 1 mm Z variation (typical with a bare fiber adapter)

±8° angular variation



Integrating sphere-like input eliminates most input variation

When using a bare fiber adapter to eliminate the need to connectorize in production, there is often a large variation when the bare fiber adapter is rotated in the chuck. The Connection Desensitizer™, combined with the low-stress, non-contact proprietary bare fiber adapter, reduces the rotational variation substantially.



OMM-502 **OMM-501**

Measurement repeatability with bare fiber adapters is <0.01 dB

The low connection sensitivity results in excellent performance with a bare fiber adapter. Many production teams perform temporary connectorization in production to accommodate in-process measurements. dBm's Optical Power Meters gives users the option of using a BFA instead of taking the extra time to connectorize.

Long-Term Stability

Any optical power meter that can measure low power levels is likely using some form of a cooled detector. One problem with cooled detectors is that the window of a cooled detector is a miniature condensing surface. Atmospheric moisture condensates on the window. Although typical telecom bands are not effected much by the absorption lines of H_2O, the contamination that comes with it *is* spectral in telecom bands. This contamination is one of the reasons optical power meters need to be recalibrated regularly. Our –202 power meter virtually eliminates this problem by actively heating the photodiode enclosure (including the window). By holding the window 5°C above ambient, any condensate (and the contamination that comes along with it) is discouraged. The result is an incredibly stable measurement over long periods of time. Many of dBm Optics' customers use two-year calibration cycles (rather than one-year calibration cycles), resulting in both downtime and dollar cost savings.

High-Speed Processing

Measurement speed without the ability to retrieve the data quickly can be a big limitation. Our –202 optical power meter modules have onboard 40 Mflop DSP on each channel. This allows the channel card to do all the channel-specific processing in real time, including calibration, corrections, linearizations, referencing, and real-time user-defined math. By the time the measurement is complete, most of the processing is also complete. The high-speed main processor then formats the data for the display, for external communication over Ethernet, GPIB, or onto a USB flash memory drive.

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The Technology Behind the Performance

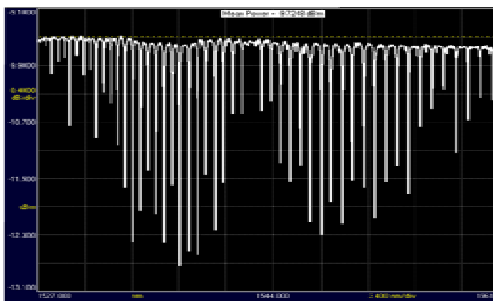
Real-time Swept Wavelength Meter

The dBm 2004 has an optional Precision Wavelength Reference that assures absolute wavelength accuracy at full speed.

Model	Accuracy
410	<1 pm (even with mode hops)
401	<5 pm; <1.8 pm (with occasional wavelength calibration)

Tunable Source Error	410 Correction	401 Correction
Initial wavelength offset	Yes, up to 200 pm	Yes, up to 200 pm
Sweep rate error	Yes	Yes
Sweep rate gross non-linearity	Yes, up to 200 pm total	Yes, up to 200 pm total
Sweep rate noise	Yes	Yes
Stiction	Yes	Yes
Mode hops	Yes, multiple	Partial

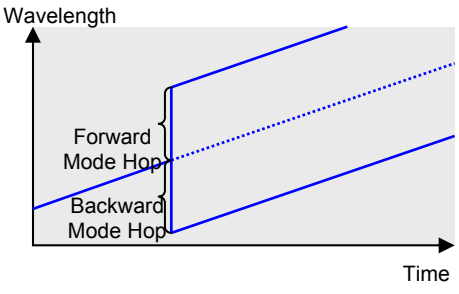
The dBm Precision Wavelength Reference uses a proprietary multiple optical path technique combined with precise environmental control and dedicated digital signal processing to recalibrate every measurement point to an absolute wavelength. This absolute wavelength is calibrated using gas cell spectroscopy.



Absolute reference gas spectroscopy is at the core of the dBm Precision Wavelength Meter, augmented with several additional corrections.

Mode-Hop Correction

The dBm –410 Precision Wavelength Reference has the patent-pending capability to both detect and correct for mode hops in the tunable laser. Most tunable lasers mode hop outside the "mode-hop-free" tuning range. Also, many lasers that are specified not to mode hop often fail to meet this critical specification. Mode hops are generally 18-35 pm "instantaneous" jumps forward or backwards in wavelength during a sweep. This is a direct error if not detected and corrected. dBm is the only company that has this patented capability. Our wavelength meter corrects the entire wavelength table for these occurrences.



Mode hops occur in virtually every tunable laser. The 410 detects and corrects them.

Correction Over Wide Wavelength Range

dBm Optics has developed a unique, comprehensive line of gas cell artifacts. Included in this range are multiple-gas cells. Our multiple-gas cells utilize isotopes that provide for non-overlapping absorption lines across wide wavelength ranges. We have designed these to optimize the partial pressures to provide similar depth of line and line width appropriate for swept measurement applications. See the Wavelength Calibration References specifications sheet for more information on single, double, and triple cells, covering wavelength ranges from 800 to 1650 nm.

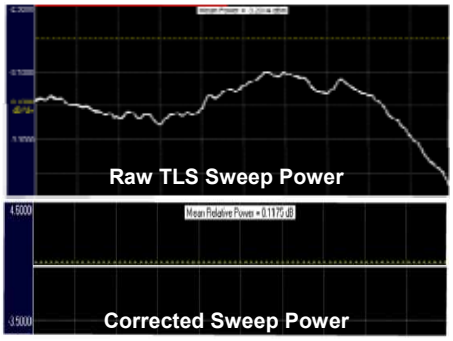
The Technology Behind the Performance

Real-Time Referencing

Real-time referencing cuts measurement time while improving accuracy and repeatability. The dBm 2004 has the ability to correct automatically and in real-time for many of the key errors often associated with measuring passive components. These errors include the power flatness of the TLS, noise from the TLS, etalons in the optical path, fiber movement upstream from the DUT, vibration induced noise, and insertion loss variation. To eliminate high-frequency noise, the 2004 aligns the channel and reference readings to ±40 ns.

Automatic Power Reference makes measurements in lock-step with each channel, thereby eliminating TLS flatness errors while reducing the effective noise in each measurement.

The 2004's automatic correction not only increases speed and reduces noise, but makes it possible to measure broadband components to unheard-of flatness. The reference measurement is made within 40 ns of the power measurement, substantially eliminating even high-speed sources of noise.

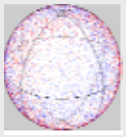


Real-time referencing eliminates many of the sources of noise and error in traditional systems

Amplitude Error Source	Real-time Reference Correction
Power line noise on TLS output	Yes
High-frequency digital noise from TLS processor	Yes
Polarization state wobble against polarizer for PDL	Yes
Wavelength dependence of TLS output power	Yes
IL variation of upstream polarization controller	Yes
IL variation of test interconnects	Yes
Vibration-induced IL variation	Yes
PDL of upstream components, such as switches, attenuators, etc.	Yes
Upstream connection variation	Yes
The last "To DUT" connection variation	No

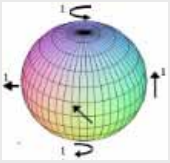
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The Technology Behind the Performance



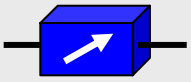
Polarization Scrambling

Add the 957I Polarization Scrambler Option to the 2004 and turn on and off high-speed polarization scrambling—turning your TLS output into a randomized polarization signal. This eliminates the effects of birefringence in your optical path.



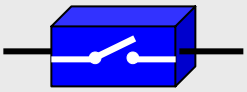
Polarization State Control

The 953I 4- or 6-state polarization controller enables deterministic control over the output state of the signal. The 953I provides 4 or 6 orthogonal states for use in polarization analysis—all in a low cost, fully integrated package. With the 953E Option, an external 8169 polarization controller can be used under direct control of the TLS.



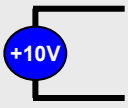
Attenuation

With either the 921 or the 922 attenuator, 0 to 20 dB or 0 to 40 dB of attenuation can be added (respectively) and controlled from either the front panel or remotely. Alternatively, add the upcoming 923 Precision Superposition Dual Attenuator and achieve attenuation linearity in excess of 0.05%. By implementing dual path attenuators with shutters, exact divide-by-two output powers can be obtained.



Output Shutter

Add a model 310 shutter for fast stabilization power control of any tunable laser. The base laser can be turned on and off, but all TLS take some time to stabilize after current is applied to the laser. Using the shutter eliminates the stabilization time after turn-on.



Companion DC Voltage and Photodiode Measurements

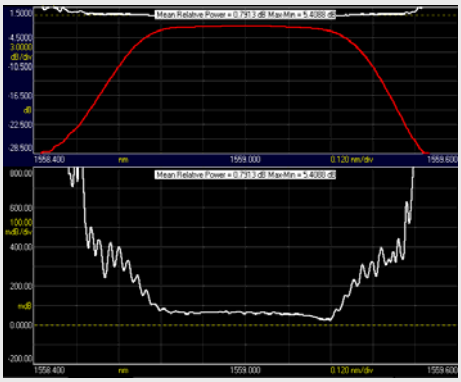
In addition to optical signals, the Component Spectrum Analyzer™ can be outfitted with either DC voltage measurements or photodiode measurements. These measurement options fit in the same bays as the optical measurement options and can be used simultaneously to characterize linked phenomena.

Built-in PDL-vs.-Wavelength Measurement

Fast, Accurate, Inexpensive PDL Measurement

Today's optical components require better PDL performance than in the past. The dBm 2004 will automatically characterize PDL using either the Matrix method (which allows fast PDL-vs-wavelength measurement) or the all-states method (which is easy to set up and obtains accurate results). The 2004 automates these measurements, making it easy to get the results needed without a lot of setup and software.

Polarization dependency of the power meter places a lower limit on the PDL error. The dBm Precision Power Meters' 0.0015 dB dependency is the best available anywhere.



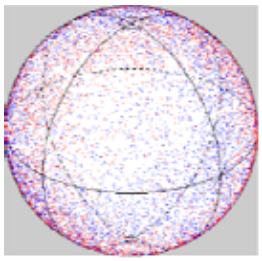
PDL measurement is fast, automatic and affordable

Fully Automatic PDL Measurement

To measure PDL, simply turn on the PDL trace for the measurement channel(s) you are using. The 2004 will automatically perform the PDL measurement (using the specified method) at the same time as it measures IL and ORL. No software to write and debug, no errors—just accurate, fast PDL measurement.

Select the Method

The 2004 supports: 4-state matrix PDL; 6-state matrix PDL; traditional all-states PDL; and Swept All-states PDL. There are advantages of each method. See the chart below for a summary and the following sections for an explanation of each method.



Sphere coverage is key to all-states PDL

Traditional All-states Method

By sweeping a polarization controller in an attempt to get good coverage of the Poincaré sphere and taking measurements rapidly during this sweep, you can identify the maximum and minimum insertion loss points. This difference is the PDL.

The advantage of traditional all-states is its simplicity and familiarity. The downsides are the longer time of measurement for many wavelength points and the insertion loss variation during the polarization sweep (which used to be a direct PDL error).

Traditional all-states PDL can be measured using the dBm Optics –952I internal polarization state sweeper or by using an external polarization sweeper with the dBm Optics –952I option.

Parameter	6-state Matrix	4-state Matrix	Traditional All-states	Swept All-states
Measurement time: 1 point	<2 ms with internal controller, < 3 sec with external controller	<1.5 ms with internal controller, < 2.5 sec with external controller	From 10 ms to 10 sec	N/A
Measurement time: 5 pm spacing over 100 nm	<12.8 sec	<8.3 sec	3.4 min to 5 hours	40 sec – 3 min
PDL Accuracy	Same as 4-state; also corrects for test path birefringence	0.015 dB without PDL ref set; 0.004 dB with PDL Ref Set	0.002 dB best case; 0.015 dB typical	0.002 dB best case; 0.015 dB typical
Short-term repeatability	0.001 dB	0.001 dB	0.002 dB to 0.01 dB	0.002 dB to 0.01 dB
Wavelength range	1400-1640 nm	1400-1640 nm	1250-1640 nm	1250-1640 nm
Alternatives	956I or 953E	956I or 953E		

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Built-in PDL-vs.-Wavelength Measurement

Matrix Method

Matrix method usually offers the best combination of speed and accuracy. The matrix method uses measurements at 4 or 6 orthogonal states to determine the polarization dependency of the device. One of the key advantages of matrix method is that each measurement is made at a deterministic polarization state (all-states "random" sweeps are not deterministic). With older generation equipment, matrix method had been difficult to set up and susceptible to many error sources. This has led many companies to avoid its use in production. Current generation equipment is much easier to use and avoids these potential pitfalls.

Simultaneous IL, PDL, ORL

With the matrix method, all three key measurements can be made simultaneously. In addition, PDCW and PDBW can also be measured simultaneously.

Drastic Improvement with Real-Time Referencing

The dBm 2004 uses a unique real-time referencing which eliminates the need to perform the separate reference sweep and DUT sweep other systems require. This means that the errors associated with connection and disconnection and the moving of fibers between steps are eliminated. This real-time referencing also reduces test time by the elimination of the separate referencing step. Real-time referencing is accomplished by monitoring the input to the device simultaneously with measuring the output from the device. Any changes in the optical source power or other variations in the test path are automatically eliminated. For real-time referencing to work properly, each measurement must be made simultaneously to eliminate the effects of noise. The 2004 makes these measurements with less than 40 ns of latency. Another requirement for effective real-time referencing for PDL is to achieve very low PDSR (polarization dependent split ratio) for the monitor port. The 2004 uses a proprietary device with incredibly low PDSR.

Calibrating Out Test System Error

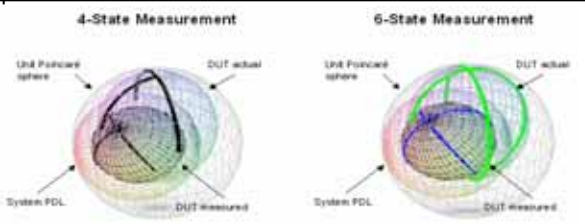
In those cases where ultimate accuracy is needed, matrix method measurements can be further enhanced by doing a Polarization Reference Set. This will further correct for errors in the system, allowing us to get below <0.015 dB to <0.004 dB.

Eliminate PDL Error on Wavelength Dependent Devices

With most equipment making matrix method PDL measurements, there is an additional error due to non-repeatability in wavelength of the measurements at each of the 4 or 6 states. The 2004 Wavelength Reference Option measures the precise wavelength of each point, allowing the system to correct for the non-repeatability of the multiple sweeps. The result is exceptional accuracy, even on the edge of deep-well filters.

6-State Measurements

Although 4-state is the best-know matrix method measurement, the 2004 also supports the 6-state measurement. This allows the measurement to reduce or eliminate the effects of parasitic birefringence in the optical path. The diagram below helps to illustrate. For more information, refer to dBm Optics' 6-State PDL Measurement application note.



6-state measurement corrects for parasitic birefringence

Alternative Implementations

You can use a 2004 system configured with a 956I internal 4- and 6-state polarization controller or you can use it with a the 953E external polarization controller. The instrument automatically runs the external polarization controller over GPIB, making the measurement fully automatic. For the external polarization controller, there is waveplate angle error at different wavelengths. The instrument automatically corrects for these errors. With the external controller, the 2004 will automatically perform the required polarizer alignment as well.



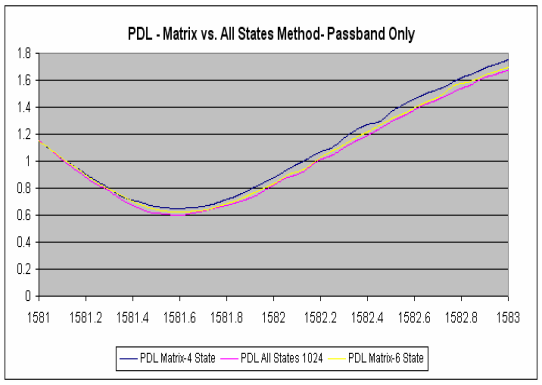
Traditional all-states with built-in controller— or use an external controller

Model 2004 CSA

Polarization Dependency Measurement Accuracy and Determining Wavelength Dependence

Accuracy

This chart (right) illustrates the high degree of consistency between all-states, 4-state and 6-state. In general, all-states will tend to understate PDL with very short measurement times (not enough time to adequately cover the sphere), all-states will overstate PDL with longer measurement times (source variation and test lead IL variation are interpreted as PDL). Matrix 4-state will over state PDL by the amount of the effect of the parasitic PDL of the test setup. Matrix 6-state will generally have the lowest error of any of the methods. It is quite reasonable to achieve a few mdB of PDL accuracy on the factory floor with the matrix method.

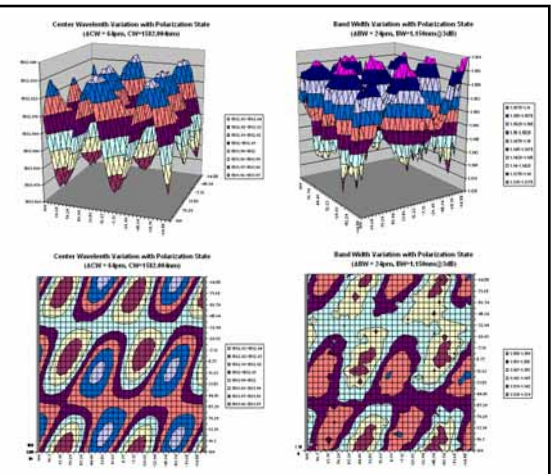


Correlation between the all-states method and dBm's implementation of the matrix method is excellent

Determining the Effect of Polarization on the Wavelength Characteristics of a Filter

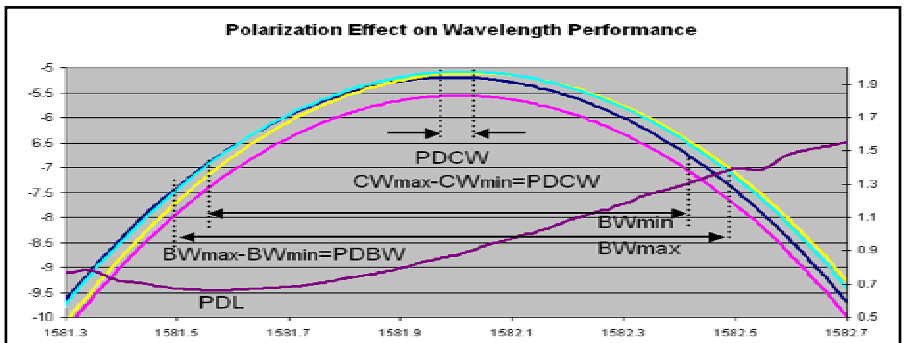
It is widely understood that polarization state can affect the insertion loss of a device. In addition, polarization state has an effect on the center wavelength and bandwidth of most devices. These effects are referred to as PDCW (polarization dependency of center wavelength) and PDBW (polarization dependency of bandwidth). One way of determining these values is to run separate sweeps, each with a different polarization state. Each sweep can be evaluated for its center wavelength and bandwidth, and these can be compared to determine the difference between max and min, which are the PDBW and PDCW. This method is generally referred to as the swept all-states method. The 2004 supports this swept all-states method for PDCW and PDBW.

dBm Optics has developed a much simpler and faster method utilizing the 4- or 6-state matrix method. This methodology is proprietary and yields results that are identical to the swept all-states method to ±2 pm or better. The main advantage is that the test time is reduced from minutes or hours to seconds. The instrument can measure PDBW and PDCW simultaneously across 100 nm at 1 pm resolution in less than 12 seconds.



PDL, PDCW and PDBW mapping assists device designers improve performance

For the design team, the 2004 can also provide additional detail on the polarization characteristics of the device, including maps of the polarization dependent loss, PDCW and PDBW versus the actual polarization state. This can be instrumental in determining design changes to minimize these generally undesirable characteristics.



PDBW and PDCW are key measurements for DWDM and other applications

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Model 2004 CSA

Optical Return Loss Measurement: Fast, Accurate, Automatic

Fast, Accurate, Automatic ORL

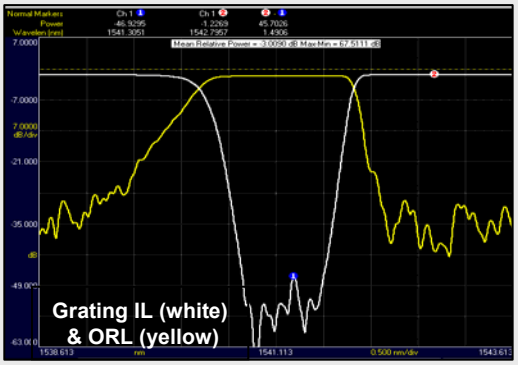
Optical Return Loss is becoming increasingly important as more components are typically in the optical path of a DWDM transmission system. Making good, reliable ORL measurement requires several factors: good low-power measurement, easy calibration, and built-in automation to eliminate test error sources.

Wide Dynamic Range Measurement

Our ORL measurement option includes these key features—making it fast and easy to make accurate and repeatable ORL measurements. In addition, because of the integral implementation, the cost is much lower than with other solutions.

Fully Automated

Measuring ORL with other instruments can take time and expertise to set up. The dBm measurement is completely automated. Perform occasional calibrations, then run ORL measurements simultaneous with your IL and PDL measurements.



ORL measurement is fast, automatic and affordable

Integrate Fast Alignment with Accurate Optical Parametric Test

Combine Verification and Alignment to Reduce Cost

Our instrumentation has the accuracy and broad capability to perform a full subtest of final test on your device and the speed and integration to drive your alignments system. By collapsing these two stages into one, handling, connecting and labor costs are reduced.

Easy Integration

The high-speed Insertion Loss, ORL and PDL measurement of the 2004, combined with its affordable cost, have made it the top choice for alignment systems. The feedback can be either digital (through the GPIB, Ethernet or RS-232 ports) or analog (with the 222) to the alignment stage. Both measurements and overhead time are low, making this a very fast alignment meter.

High Speed

One way passives suppliers are cutting costs is by eliminating manufacturing steps. Once a device is aligned, the 2004 can run a full or partial optical parametric test, ensuring that the device is operational before packaging. This also completely eliminates one manufacturing step—further saving cost. The high speed of the 2004 PDL measurement even allows using PDL as the alignment variable.

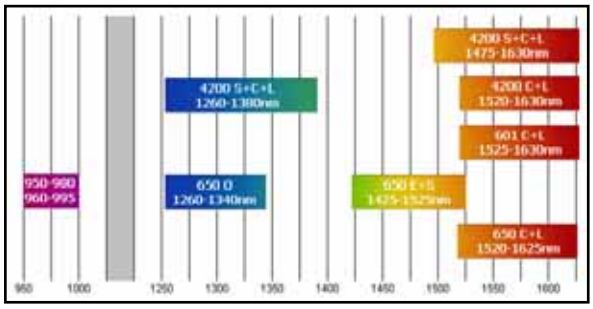
Fast "First Light" Alignment Step

The dBm power meter has very high dynamic range even at high speed. This can make the "first light" step of alignment substantially faster regardless of the type of algorithm used: a traditional search algorithm or an advanced search algorithm based on relative light leakage at triple search points. (Speak with a member of our Applications Team for more information.)

Built-in Tunable Laser (or Use Your Existing TLS)

Built-In TLS

Our line of built-in tunable laser sources includes multiple wavelength ranges, low-noise and high-power versions. Our low mass, small cavity tunables are amazingly resilient to shock and vibration. For more detail on the optical performance characteristics, see the brochure for our Model 4200 Tunable Laser Source, which utilizes the same optical engine as our built-in tunable laser sources.



Use your existing external TLS

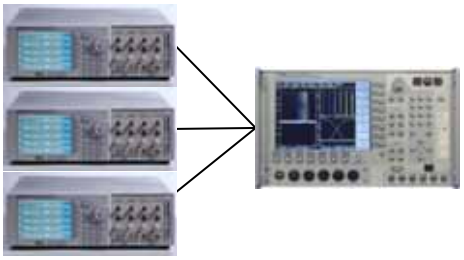
The Model 4650 Swept Spectrometer will operate with all the leading tunable laser sources. The external source can be run manually, or the 4650 will automatically control many different types of TLS's over the built-in secondary GPIB port (option 940). Support includes both stepping and sweeping tunables. Because the 4650 handles measurements from 800 nm to 1700 nm, it can operate in conjunction with a wide range of tunable lasers, covering virtually every communications band in use. We have systems in the field covering 950 nm to 1650 nm.

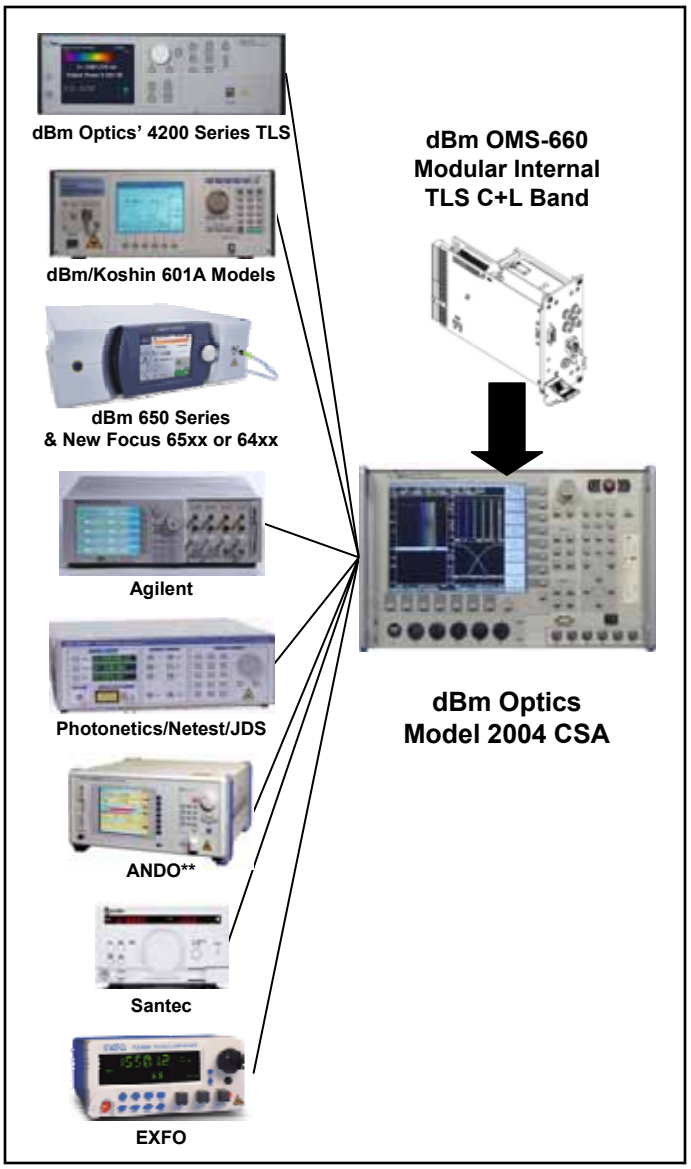
Wavelength and Power Correction

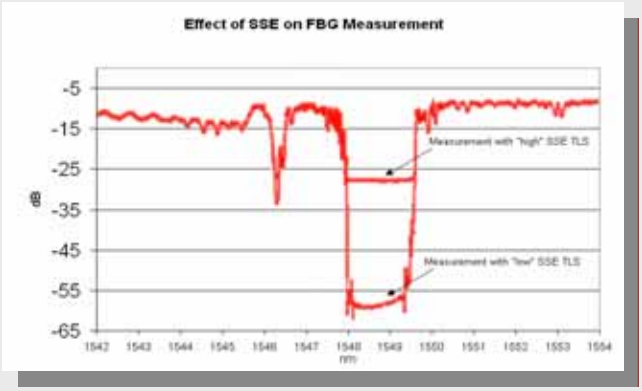
Regardless of the TLS type, the 4650 will automatically correct for many power and wavelength aberrations, yielding increased performance even from aging lasers. In addition to improving performance, this can save you the high cost of TLS maintenance. For more information, see our detailed description of both Real-Time Referencing, and Wavelength Referencing elsewhere in this data sheet.

Multiple TLS Capable

The 4650 has built-in capability of handling one or two tunable lasers in order to cover a wider wavelength band. The 4650 automatically controls the tunable lasers over a secondary GPIB port. You set up the overall wavelength range desired, and the 4650 determines which TLS to employ, handles the setup (including wavelength overlaps), and combines the result into a single dataset across the total wavelength range desired.







When selecting a TLS, the STSE (Source Total Spontaneous Emission) can have a large impact when measuring deep-well devices.

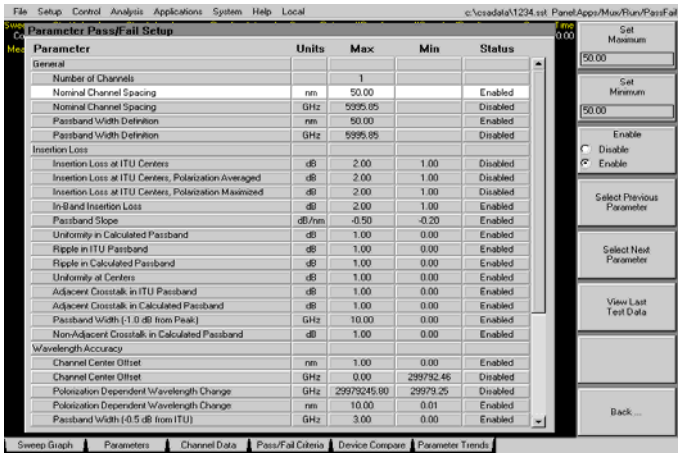
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Model 2004 CSA

Automatic Parameter Extraction

The CSA has the ability to automatically analyze parameters of typical devices. For example, our MUX/DeMUX application performs a rigorous measurement and analysis of the device, confirms alignment with your pass/fail specifications, and provides both tabular and graphical data output.

Since many parameters have numerous definitions, the CSA allows you to define the way you want the parameter determined. You can even simultaneously run with more than one definition. For example, some users define the center wavelength as the middle of the 0.5 dB points, the 1 dB, the 3 dB, the 6 dB or the 20 dB points, or the center of a Gaussian fit, or even as the min IL point. The CSA supports all of these definitions (there are almost 1000 parameter definitions allowed). Contact us for the detailed definitions of the parameters we support.





Summary

- Fully automatic
- Very flexible parameter definitions
- Fast measurement and evaluation
- Custom spec sheets with your logo
- Protected operator and engineer modes

Partial List of Parameters	
Insertion Loss	• At calculated channel center ▪ -0.5 dB, -3 dB, -6 dB, etc. ▪ At ITU channel center • In defined passband • In calculated passband • With our without worst-case PDL
PDL Measurement	• At calculated channel center ▪ -0.5 dB, -3 dB, -6 dB, etc. ▪ At ITU channel center ▪ In defined passband ▪ In calculated passband
Crosstalk	• Adjacent, non-adjacent, total • At calculated channel center ▪ -0.5 dB, -3 dB, -6 dB, etc. • In defined passband • In calculated passband • With our without worst-case PDL
Ripple	• At calculated channel center ▪ -0.5 dB, -3 dB, -6 dB, etc. • At ITU channel center • In defined passband • In calculated passband • With or without worst-case PDL
Uniformity	--
Passband Slope	• At calculated channel center or at ITU channel center
Center Wavelength	• nm or GHz
Bandwidth	▪ nm or Ghz ▪ With or without worst-case PDL ▪ -0.5 dB, -3 dB, -6 dB, etc.
PDBW, PDCW	--

Model 2004 CSA

Achieve High Density and Low Cost

High Capacity

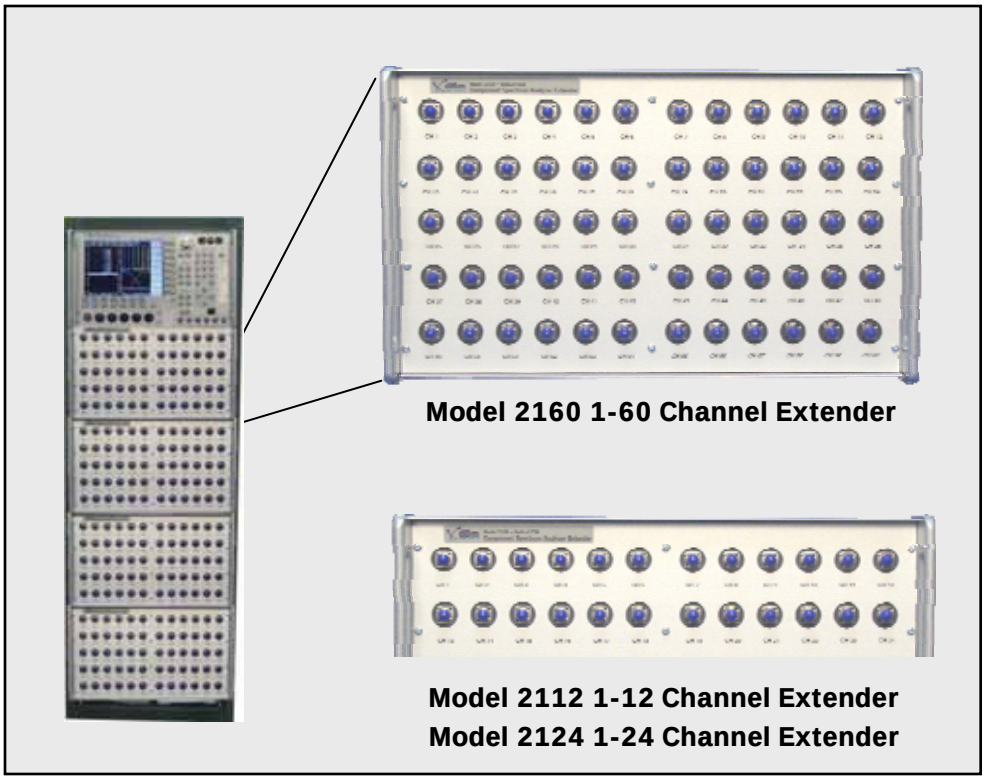
Test systems can consume a considerable amount of space. As increased-channel-count devices become a reality, these test systems can become very large and difficult to integrate. The dBm CSA relies on a high degree of miniaturization and integration to considerably reduce the size of the system.

Several Alternatives

In addition to the four channels in the mainframe, the system includes a 1-12 channel extender (Model 2112); a 1-24 channel extender (Model 2124); and a 1-60 channel extender (Model 2160). One six-foot rack will hold up to 300 channels.

Great Pricing

The CSA is often one-half the price of competitive systems and comparable in price to systems which have significantly lower performance.



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Model 2004 CSA

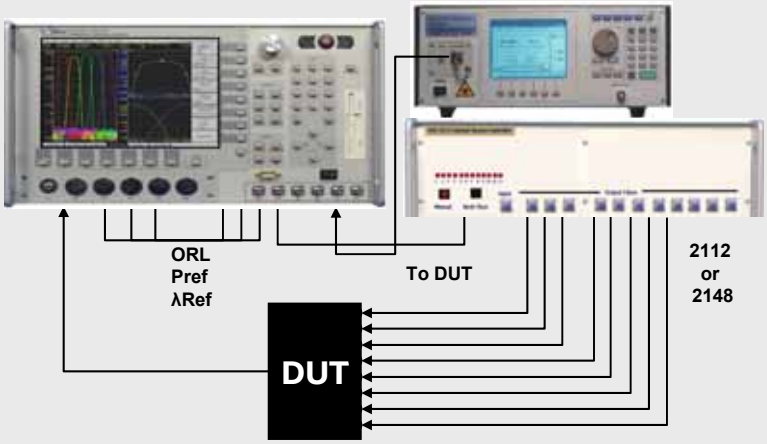
Automatically Test Multiple Devices or Multiple Channel Devices Automatically

Multiple Channel Testing

Testing multiple-input devices has always been troublesome. With the growing requirements to test the PDL and ORL of these multiple input devices with high accuracy as well, the task has become daunting. The CSA, with the Multi-Input DUT option and Optical Source Controllers, allows you to measure multiple input devices automatically. The CSA has correction factors stored for each DUT input path, making measurements both much more accurate, and much simpler and faster. And the integration is already done--no extra software or test integration required. For just 2- or 3-input DUTs, the CSA has internal Optical Source Controller options that do not require additional external hardware.



Model 3012 Source Controller, and Model 4400 Optical Switch



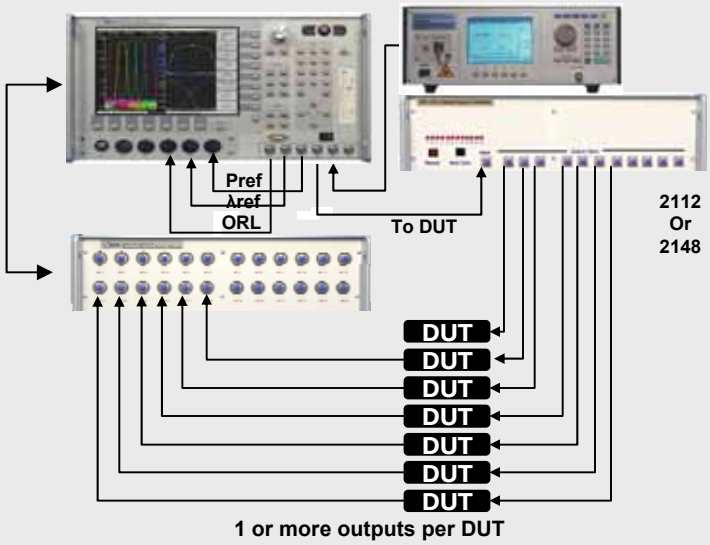
Automatic Testing Configuration for Multi-Input DUT

Multi-Channel

- Automatic testing of multiple inputs
- Per-input correction factors eliminate many system error sources and makes integration very simple
- Select the DUT input path—the CSA does all the work
- Solutions for as few as 2 inputs, as many as 144 inputs
- Optical Source Controller is controlled directly by the CSA automatically

Multiple Device Testing

Making testing throughput higher is not just a matter of convenience—it is critical to cost-effective manufacturing. The CSA with multi-DUT option and our Optical Source Controllers allows one station to simultaneously test many devices (DUTs). The unique configuration of the Optical Source Controller (with the shutter configuration) allows testing of Insertion Loss and ORL on all devices without changing connections. The CSA has correction factors stored for each DUT path—making measurements more accurate, simpler and faster. And the integration is already done—no extra software or test integration is required. For 2 or 3 DUTs, the CSA has internal Optical Source Controller options that do not require additional external hardware.



Automatic Testing Configuration for Multiple DUTs

Multi-DUT

- Automatic testing of multiple devices
- Per-DUT correction factors eliminate many system error sources and make integration very simple
- Select the DUT—the CSA does all the work
- Solutions for as few as 2 DUTs, as many as 48 DUTs
- Optical Source Controller is controlled directly by the CSA automatically

Model 2004 CSA

Specifications

	Model 2004	Models 2112 and 2124	Model 2160
Channels per mainframe	1 to 4 channels per mainframe (up to 6 without Power and Wavelength Reference Options)	1 to 12 or 1 to 24 channels per extender	1 to 60 channels per extender
Channels per system	Up to 17 extender mainframes (up to 60 channels each) can be linked for synchronous measurement on up to 1500+ channels. Channels may be added on site (by qualified personnel).		
Input connections	Selectable from among the following at time of ordering: Model FC: FC/APC (Other connectors available upon request). Model BF: Bare fiber interface. Model UNIV: Universal To DUT connection.		
Return loss	>55 dB		
λ range	Overall 800-1700nm (see detail specs for performance over wavelength)		
Speed per channel (averaging)	Variable measurement speed from 100K rps to 0.1 rps		
System speed— burst mode	100K rps times number of channels		
System speed— real-time transmit mode	100K rps times number of channels Transmitting to host with Ethernet is 3 Mbytes/sec (dedicated link); with GPIB 1.7 Mbytes/sec into a PC (See speed section of this document for more detail)		
Multiple channel speed	100K rps per channel speed regardless of number of channels		
Trigger latency[1]	<40 nsec		
Units	pW, nW, µW, mW, W; dBm, dB		
Display	10.4" graphical display, SVGA (800x600), TFT LCD color		
Data storage	Memory for >100K readings per channel on all channels in real-time storage. 10 billion measurements capacity on built-in hard drive.		
Triggering	Software synchronous trigger or external synchronous trigger		
Interfaces	IEEE-488, 100-BateT Ethernet and RS-232 standard		
Command set	IEEE-488.2 compliant (SCPI-like)		
Power	110-240 VAC, ±10%; 700 VA max; 50-60 Hz No switch or fuse change.		
Ambient temperature	10 to 35°C (50 to 95°F); for 0 to 40°C (32 to 10°F) contact factory		
Storage temperature	-40 to +70°C (-40° to 158°F)		
Humidity	<95% non-condensing 0 to 35°C		
Warm-up time	60 minutes to full specifications; useable immediately after turn-on		
Certificate of calibration	Included		
Recalibration period	1 year		
Warranty period	2 years		
Size	16.8"w x 20.5"d x 10.5"h (42.6cm x 52cm x 26.7cm)	16.8"w x 20.5"d x 5.25"h (42.6cm x 52cm x 13.3cm)	16.8"w x 20.5"d x 10.5"h (42.6cm x 52cm x 26.7cm)
Weight	29 lbs (19 kg) with four channels, Power Ref and Wavelength Ref	24 lbs (11 kg) with one channel; <35 lbs (16 kg) with 24 channels	52 lbs (24 kg) with one channel; <78 lbs (36 kg) with 60 channels
Mounting	Bench top or rack mount		

[1]Trigger latency defined as total time from trigger edge to initiation of measurement

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Model 2004 CSA
Optical Measurement Modules 202 and 201
Measurement Specifications

Sensitivity and Noise

Range	Fixed Range	Measurement		Measurement Resolution[1]		Optical Measurement Modules: OMM-202 Noise RMS[2] 5 secs[7]		OMM-202 Noise RMS[2] 100 ms[8]		OMM-202 Noise RMS[2] 10 µs (full speed)[9]		OMM-201 Noise RMS[2] 5 secs[7]		OMM-201 Noise RMS[2] 100 ms[8]		OMM-201 Noise RMS[2] 10 µs (full speed)[9]	
		W	dBm	W	dBm	±W	±dBm	±W	±dBm	±W	±dBm	±W	dBm	±W	±dBm	±W	±dBm
Fast 10 mW	10 mW	10 mW	10	200 nW	-37	50 nW	-43	100 nW	-41	400 nW	-34	100 nW	-41	200 nW	-37	800 nW	-31
	1 mW	1 mW	0	20 nW	-47	8 nW	-51	20 nW	-50	40 nW	-44	20 nW	-47	40 nW	-44	80 nW	-41
	100 µW	100 µW	-10	2 nW	-57	2 nW	-57	2 nW	-57	8 nW	-51	4 nW	-54	4 nW	-54	16 nW	-48
Fast 100 µW	100 µW	100 µW	-10	2 nW	-57	1 nW	-60	1 nW	-60	4 nW	-54	4 nW	-54	4 nW	-54	16 nW	-48
	10 µW	10 µW	-20	200 pW	-67	30 pW	-75	40 pW	-74	800 pW	-61	400 pW	-64	400 pW	-64	4 nW	-54
	1 µW	1 µW	-30	20 pW	-77	12 pW	-75	20 pW	-77	300 pW	-65	200 pW	-67	200 pW	-67	2 nW	-57
Fast 1 µW	1 µW	1 µW	-30	20 pW	-77	10 pW	-80	6 pW	-82	100 pW	-70	20 pW	-73	50 pW	-73	500 pW	-63
	100 nW	100 nW	-40	2 pW	-87	2 pW	-87	3 pW	-85	40 pW	-74	20 pW	-80	50 pW	-80	500 pW	-68
	10 nW	10 nW	-50	0.2 pW	-97	1 pW	-90	2 pW	-87	40 pW	-74	20 pW	-80	50 pW	-80	500 pW	-68
Fast 10 nW	10 nW	10 nW	-50	0.2 pW	-97	1 pW	-90	2 pW	-87	4 pW	-84	20 pW	-80	50 pW	-80	500 pW	-75
	1 nW	1 nW	-60	.02 pW	-107	1 pW	-90	2 pW	-87	3 pW	-85	20 pW	-80	50 pW	-80	500 pW	-80
	100 pW	100 pW	-70	2 fW	-117	1 pW	-90	2 pW	-87	2 pW	-87	20 pW	-80	50 pW	-80	500 pW	-80
Fast 100 pW	100 pW	100 pW	-70	2 fW	-117	300 fW	-95	300 fW	-85	300 fW	-95	20 pW	-80	50 pW	-80	500 pW	-80

Accuracy[1, 6]

Absolute uncertainty at reference conditions[4]: 2.5%
Absolute operational uncertainty[5]: 5%
Relative uncertainty: <1% + noise (per table above)

Measurement Speed

(**Note**: This includes the time to change range and take readings. All readings are equally spaced.)

Auto-Range Mode	Full Measurement Range	Reading Time with Averaging of: 1 Reading	2,000 Readings	500,000 Readings
Fast 10 mW – 2 nW	10 dBm to –57 dBm	10 µs	20 ms	5 sec
Fast 100 µW – 20 pV	-10 dBm to –77 dBm	10 µs	20 ms	5 sec
Fast 1 µW – 200 fW	-30 dBm to –97 dBm	10 µs	20 ms	5 sec
Fast 10 nW – 2 fW	-50 dBm to –107 dBm	10 µs	20 ms	5 sec
Fast 1 nW – 0.5 fW	-60 dBm to –117 dBm	10 µs	20 ms	5 sec
Med 10 mW – 20 pW	10 dBm to –77 dBm	1 ms	21 ms	5 sec
Med 10 mW – 200 fW	10 dBm to –97 dBm	10 ms	30 ms	5.01 sec
Slow 10 mW – 2 fW	10 dBm to –107 dBm	1.5 sec	1.52 sec	6.52 sec
Slow 10 mW – 0.5 fW	10 dBm to –117 dBm	5 sec	5.02 sec	10.02 sec

Connections

Selectable from among the following at time of ordering:

Model FC: FC/APC (Other connectors available upon request.)	Model DN: DIN Model BF: Bare fiber interface (Note: Input connection can be changed in the field.)

Analog Output

Analog output available on –202 or –201 options

Polarization Uncertainty of Measurement

<± 0.0015 dB typical; 0.0035 dB guaranteed for model –202; <±0.005 dB for model --201

Return Loss

>55 dB

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[1] From 1500 to 1620 nm. For 1400-1635, add 3 dBm; for 800 nm-1650 nm, add 10 dB noise and resolution specs (or multiply to W by 10). Assume automatic or manual dark calibration performed.
[2] Peak noise is typically 3 to 3.5 times the RMS figure. Noise figures are typical performance.
[3] Per "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results;" NIST Technical Note #1297.
[4] Wavelength = 980, 1310, 1520-1625 nm, $T_{(ambient)}$ = 23C ± 2C, 1.1 mm diameter beam, 10 mW (-20 dBm).
[5] Wavelength = 800-1650 nm, $T_{(ambient)}$ = 10 to 35C, Fiber with N.A. <0.3, -70 dBm to +3 dBm (total wavelength range 800 nm-1700 nm).
[6] Above 5 dBm, accuracy is typical.
[7] Maximum variation ± for 4 measurements, filter on.
[8] Maximum variation ± for 50 measurements, filter on.
[9] Maximum variation ± for 10,000 measurements, filter on.

Option Specifications

Note: For Photodiode Measurement Modules data, see the 4700 Photodiode Test Instrument specifications sheet.

Model	Description	Specifications	
270	DCV Measurement Module, 0-10 V	Input range: Max input: Resolution: Accuracy: Bandwidth: Sample rate: Input impedance:	±10 V true differential ±42 V (no damage) 500 µV 0.025% ±1 mV >15 KHz (3dB) 10 µs <50 pF, > 10 MΩ (typ 1 GΩ)
222-cc	Precision Optical Measurement Module with Analog Output	Analog output: Output impedance: Maximum input voltage: Bandwidth:	0-2 V (4 V max) 600 ohms typ +/-10 V DC up to 7.5 kHz depending on range
301	Power Reference Module (includes 931)	Accuracy:	Reference accuracy identical to −202 specifications
310	Automatic Dark Calibration Module	"Off" blocking: Wavelength range:	>100 dB 700-1700
401	Wavelength Reference Meter	Accuracy: Repeatability: Optical Tap (930): Optical input power: Wavelength range: Maximum step size: Sweep rates supported: Wavelength Resolution: Optical Power:	<5 pm; <1.8 pm with "learn" <2 pm Included 10 dBm to -10 dBm 1525-1630 40 pm 0.01 nm/sec to 100 nm/sec 0.12 pm >-15 dBm into "TLS IN" port
410	Precision Wavelength Reference Meter	Accuracy: Wavelength Range: Wavelength Resolution: Optical Power:	<1 pm. Mode Hop correction 1520-1630 standard; for other wavelengths, call factory 0.12 pm >-15dBm into "TLS IN" port
740	System Communications Controller (GPIB Controller)	Allows control of external TLS or external polarization controller via second GPIB controller port on rear of instrument	
921	Built-in Variable Attenuator, >20 dB	Attenuation range: Wavelength range: Accuracy: Excess loss:	>20 dB 1260-1360 and 1510-1630 nm Call factory <0.5 dB typical, <0.7 dB max
922	Built-in Variable Attenuator, >40 dB	Attenuation range: Wavelength range: Accuracy: Excess loss:	>40 dB 1260-1360 and 1510-1630 nm Call factory <1 dB typical, <1.4 dB max
923	Precision Superposition Dual Attenuator	Attenuation range: Wavelength range: Linearity: Accuracy: Excess loss:	>60 dB 1260-1360 and 1510-1630 nm <0.05 dB Call factory <2 dB typical, <2.4 dB max
940	Optical Return Loss Module (ORL) with −202 Module	ORL Measurement range:	Dependent on test system configuration. >55 dB under most conditions >70 dB with properly configured system

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Option Specifications *(continued)*

Model	Description	Specifications	
952E	All States PDL Measurement including external controller	Measurement time: Accuracy:	1 second. Additional accuracy achieved with measurement times from 1-10 seconds. Depending on measurement time, typical accuracy from ±0.015 dB PDL to ±0.004 dB PDL. (See Application Note 2004-001 for more detail.)
952I	All States PDL Measurement including internal controller	PDL Measurement time: Accuracy: Insertion Loss: Center Wavelength: Wavelength Range: Output degree of polarization: Insertion loss variation:	1 second. Additional accuracy achieved with measurement times from 1-10 seconds. Depending on measurement time, typical accuracy from ±0.015 dB PDL to ±0.004 dB PDL. (See Application Note 2004-001 for more detail.) <0.05 dB 1550 nm standard. 980 nm, 1310 nm available >100 nm <5% <0.01 dB
953E	Fully Automatic Matrix Method PDL/IL Measurement with external controller	Measurement time: Accuracy:	10 µseconds to 1 second. Depending on measurement time, typical accuracy from ±0.015 dB PDL to ±0.004 dB PDL. (See application note for more detail).
953I	Fully Automatic Matrix Method PDL/IL Measurement with Internal Controller	Measurement time: Accuracy: States generated: Insertion loss: Insertion loss variation: Wavelength Dependent Loss: SOP repeatability: SOP switching speed: Wavelength range:	10 µseconds to 1 second. Depending on measurement time, typical accuracy from ±0.015 dB PDL to ±0.004 dB PDL. (See application note for more detail). -45, 0, 45, 90, RHC, LHC 1 dB typical <0.1 dB; <0.015 dB with real time referencing; <0.004 dB with RT reference and Polarization Reference <0.2 dB; <0.015 dB with real time referencing; <0.004 dB with RT reference and Polarization Reference 0.1 degrees on Poincaré sphere <250 µsec 1480-1630
957E	High-Speed External Polarization Scrambler	Speed:	Fully scrambled in 10 µs
957I	High-Speed Internal Polarization Scrambler	Insertion Loss: Center Wavelength: Wavelength Range: Output degree of polarization: Insertion loss variation: Scrambling base freq:	<0.05 dB 1550 nm standard. 980 nm, 1310 nm available >100 nm <5% <0.01 dB 700KHz
962-cc/ccc	Built-in source split with shutters for 2 DUTs	Additional PDL:	+0.015 PDL
972-cc/ccc	Built-in source split with switches for 2 DUTs	Additional PDL	+0.04 PDL
982-cc/ccc	Built-in source split for 2 DUTs	Additional PDL	+0.015 PDL
992-cc/ccc	Built-in 1x2 switch for 2 DUTs	Additional PDL	+0.04 PDL

Model 2004 CSA

Internal Polarization Controller Option Specifications

	952I Specification	953I Specification	957I Specification
Insertion Loss	<0.05 dB typical	1 dB typical	<0.05 dB typical
Insertion Loss variation with polarization state	<0.01 dB	0.1 dB, typically much less	<0.01 dB
Wavelength Dependent Loss	<0.2 dB 1530-1565 nm	<0.2 dB 1530-1565 nm	
Return Loss	<65 dB	>55 dB	>65 dB
SOP Repeatability	+/- 0.1 degree on sphere	+/- 0.1 degree on sphere	N/A
Rotation angle wavelength dependence	0.068 degrees/nm	0.068 degrees/nm	
SOP Switching Speed	<250 us	<250 us	
Residual degree of polarization	N/A	N/A	<5%
States generated	All	-45, 0, 45, 90, RHC, LHC	All
Intrinsic PDL			<0.01 dB typical; <0.05 dB max
Maximum power			1W
Wavelength range	1480-1620	1480-1620	100 nm centered on 980, 1060, 1310, 1450, 1550 or 1600 nm selectable
Display	4”x6” graphical display, VGA (800 x 600), TFT LCD color		
Interfaces	IEEE-488, 100-BaseT Ethernet standard		
Command set	IEEE-488.2 Compliant (SCPI-like)		
Power	90-265 VAC, 175 VA max, 47-63 Hz. No switch or fuse change required.		
Ambient temperature	10º C to 35º C (50º F to 95º F). For 0º C to 40º C (32º to 104º F), contact factory.		
Storage temperature	-40º C to +70º C (-40º F to 158º F)		
Humidity	<95% non-condensing 0º C to 35º C		
Warm-up time	60 minutes to full specifications; useable immediately after turn-on		
Recalibration period	1 year; certificate of calibration included		
Warranty period	4 years		
Size	16.8” w x 16.4” d x 5.25” h (42.6 cm x 41 cm x 10.5 cm)		
Weight	15 lbs (10 kg) with 2 channels, Power Ref & Wavelength Ref (401)		
Mounting	Bench top or rack mount		

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Model 2004 CSA

Internal Tunable Laser Source Option Specifications

Key Specification	680LN	680HP
Wavelength range	1460-1625 nm standard; other wavelengths available from 960-1620 nm	1520-1630 nm standard; other wavelengths available from 960-1620 nm.
Wavelength range, mode-hop free	1460-1625 nm with optional wavelength reference 410; 1510-1620 nm standard	1520-1630 nm standard; other wavelengths available from 960-1620 nm.
Tuning Speed	1 to 1000 nm/second	
Wavelength resolution [2,3]	0.08pm (10MHz)	
Absolute λ accuracy [1]	<±5pm or <±1pm with dBm Wavelength Meter, <±30pm without	
λ repeatability [2]	<±1pm with dBm Wavelength Meter, <±2.5pm without	
λ stability	<±1pm with dBm Wavelength Meter, <±2.5pm without	
Tuning Linearity	<1pm with 410 option (actual wavelength readout); <25% without	
Linewidth (coherence control off)	<100KHz (30kHz line, ±30kHz chirp)	
Linewidth (coherence control on)	Up to 50MHz	
Output power	>+3 dBm (1560–1625 nm) >0 dBm (1510–1540 nm) >–1 dBm (1460–1510 nm)	>+8 dBm
Attenuation	Available with option 922, 0-20 dB, or 923, 0 to -40 dB	
Optical power flatness	<±0.25 dB typical, <±0.5 dB max	
Side Mode Suppression (SMSR)[2,8]	>50dBc typical	
Signal to Source Spontaneous Emission ratio (SSE)	>70 dB[2,5] >90 dB[2,6]	>45 dB (1540-1630) >40 dB full range
Signal to Total Source Spontaneous Emission ratio (STSE)	>60 dB[6, 7] (1540–1625 nm) >55 dB[6] (1510–1540 nm) >50 dB[6] (1460–1510 nm)	>20 dB typical >15 dB guaranteed
Optical Shutter	Available with option –310, >80dB extinction	
Coherence Control	Yes, selectable	
RIN	-140 dBc (0.1GHz to 1 GHz), -150 dBc/Hz (1 GHz to 2.5 GHz) typical	
Connector	FC/APC PM	
Trigger output	Yes; trigger pulse on each l step after settle in sweep mode	
Environmental: Operating	+10°C to +32°C (+55°F to +90°F), <80% RH non-condensing	
Environmental: Storage	-20°C to +70°C (-4°F to +158°F), <80% RH non-condensing	

CAUTION: Viewing the laser output with certain optical instruments (for example, eye loupes, magnifiers, and microscopes) within a distance of 100 mm may pose an eye hazard.

[1] After wavelength recalibration (user-performed function).
[2] 1 pm in step mode.
[3] 1 hour, temperature ±2 °C.
[4] 0.1-nm bandwidth, signal to max ASE, 1-3 nm from carrier.
[5] 0.2-nm bandwidth, signal to max ASE, >5 nm from carrier.
[6] Signal to total ASE >0.5 nm from carrier.
[7] Measurement taken at maximum rated power.

Remote Measurement Model 210

Specifications

Input configurations	3 mm free space, 1 mm free space, FC, SC, ST, UC Universal connector or BF (bare fiber)
Input orientation	End (axial) entry or side entry
Cable length	User-specified (from 1 meter to 10 meters)

Photodiode Measurement Modules 280 and 288 Specifications

Measurement rate:	100,000 readings per second (10 µsec measurement time)
Measurement modes:	Current Measurement, Voltage Measurement
Photodiode bias supply voltage range:	0 to 10V
Photodiode bias supply voltage resolution:	5 mW resolution
Photodiode bias supply voltage noise:	<50 µV DC to 20 KHz
Display, absolute measurement:	Displays 1 mW per mA measured from Photodiode with no user calibration applied. Display in linear (mW) or log (dBm).
Display, relative measurement (Pref ON):	Displays the cal factor of mA per mW applied. Display in Log (dB).
Math:	Both dB and linear offset functions available standard.
Module location:	May be placed in 2004 mainframe; in remote 2112, 2124 or 2160 extension chassis; or in the Remote Module enclosure.
PD calibration factors:	Selectable from front panel; GPIB, Ethernet; or RS-232.
Triggering:	Selectable through CSA mainframe. <40 nsec maximum trigger misalignment.
Maximum input:	±40 V peak (no damage)
Channels:	1 channel for Model –280; 8 channels for Model –288
Input connection:	BNC for Model –280; 12-pin circular connector for Model –288

Voltage Mode Specifications

Range	Resolution	Noise @ 10 µsec[1]
10 V	200 µV	<1 mV
1 V	200 µV	<200 µV

([1] Peak-to-peak noise.)

PD Current Mode Specifications

Range	Resolution	Noise @ 100 msec[1]	Noise @ 10 µsec[1]	Equiv Optical Power (direct)		Equiv Optical Power (10% tap)	
1 A	20 µA	<20 µA	<80 µA	30 dBm	1 W	40 dBm	10 W
100 mA	2 µA	<2 µA	<8 µA	20 dBm	100 mW	30 dBm	1 W
10 mA	200 nA	<200 nA	<800 nA	10 dBm	10 mW	20 dBm	100 mW
1 mA	20 nA	<20 nA	<80 nA	0 dBm	1 mW	10 dBm	10 mW
100 µA	2 nA	<2 nA	<8 nA	-10 dBm	100 µW	0 dBm	1 mW
10 µA	200 pA	<200 pA	<800 pA	-20 dBm	10 µW	-10 dBm	100 µW
1 µA	20 pA	<20 pA	<80 pA	-30 dBm	1 µW	-20 dBm	10 µW
100 nA	2 pA	< 2 pA	< 40 pA	-40 dBm	100 nW	-30 dBm	1 µW
10 nA	200 fA	< 200 fA	< 4 pA	-50 dBm	10 nW	-40 dBm	100 nW

([1] Peak-to-peak noise.)

Response Time

Range	Response with 1pF PD Capacitance
1 A	~ 20 KHz
100 mA	~ 20 KHz
10 mA	~ 20 KHz
1 mA	~ 20 KHz
100 µA	~ 7.5 KHz
10 µA	~ 7.5 KHz
1 µA	~ 0.1 KHz
100 nA	~ 0.1 KHz
10 nA	~ 0.01 KHz

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Model 2004 CSA

APD/PD Models 290 and 298 Specifications

Control Modes	Constant Voltage or Constant Current
Measurement rate:	100,000 readings per second (10 µsec measurement time)
Measurement modes:	Current Measurement, and Voltage Measurement at specified Current
Photodiode bias supply voltage range:	0 to 100V
Photodiode bias supply voltage resolution:	5 mV resolution
Photodiode supply current range:	0 to 1mA
Photodiode supply current resolution:	250 nA resolution
Current measurement noise	<25 nA rms DC to 20 KHz
Photodiode bias supply voltage noise:	<10 mV rms DC to 20 KHz
Display, absolute measurement:	Displays 1 mW per mA measured from Photodiode with no user calibration applied. Display in linear (mW) or log (dBm).
Display, relative measurement (Pref ON):	Displays the cal factor of mA per mW applied. Display in Log (dB).
Math:	Both dB and linear offset functions available standard.
Module location:	May be placed in 2004 mainframe; in remote 2112, 2124 or 2160 extension chassis; or in the Remote Module enclosure.
PD calibration factors:	Selectable from front panel; GPIB, Ethernet; or RS-232.
Triggering:	Selectable through CSA mainframe. <40 nsec maximum trigger misalignment.
Maximum input:	±110 V peak (no damage)
Channels:	1 channel for Model –290; 8 channels for Model –298
Input connection:	12-pin circular connector

APD/PD Current Measurement Specifications

Range	Resolution	Noise @ 100 msec[1]	Noise @ 10 µsec[1]	Equiv Optical Power (direct)		Equiv Optical Power (10% tap)	
10 mA	200 nA	<200 nA	<800 nA	10 dBm	10 mW	20 dBm	100 mW
1 mA	20 nA	<20 nA	<80 nA	0 dBm	1 mW	10 dBm	10 mW
100 µA	2 nA	<2 nA	<8 nA	-10 dBm	100 µW	0 dBm	1 mW
10 µA	200 pA	<200 pA	<800 pA	-20 dBm	10 µW	-10 dBm	100 µW
1 µA	20 pA	<20 pA	<80 pA	-30 dBm	1 µW	-20 dBm	10 µW
100 nA	2 pA	< 2 pA	< 40 pA	-40 dBm	100 nW	-30 dBm	1 µW
10 nA	200 fA	< 200 fA	< 4 pA	-50 dBm	10 nW	-40 dBm	100 nW

([1] Peak-to-peak noise.)

Response Time

Range	Response with 1pF PD Capacitance
10 mA	~ 20 KHz
1 mA	~ 20 KHz
100 µA	~ 7.5 KHz
10 µA	~ 7.5 KHz
1 µA	~ 0.1 KHz
100 nA	~ 0.1 KHz
10 nA	~ 0.01 KHz

Voltage Measurement Noise & Accuracy

Range	Resolution	Noise	Accuracy
100V	2mV	2mVrms	0.19% +/-10mV

Ordering Information

Model	Description
2004	Component Spectrum Analyzer™ (Included accessories: power cord; operating manual)
201	Power Meter Module, 800nm-1700nm
201V (upcoming)	Power Meter Module, 190nm-1100nm
202	Precision Power Meter Module, 800nm-1700nm
210	Remote Power Meter Module, 800nm-1700nm
210V (upcoming)	Remote Power Meter Module, 190nm-1100nm
222	Precision Power Meter Module, 800nm-1700nm, with Analog Output
270	DC Voltage Measurement Module
280	Photodiode measurement module
288	8 channel Photodiode measurement module
290	APD measurement module
301	Real-time Power Reference Module
310	Optical Shutter/Automatic Dark Calibration
401	Wavelength Reference Module
410	Precision Wavelength Reference Module
501	Bare Fiber Adapter, low stress, easy alignment
502	Bare Fiber-to-FC Adapter
680LN	Tunable Laser Source (low noise); 1460-1625 nm; Internal
680HP	Tunable Laser Source (high power); 1460-1625 nm; Internal
692	Laser Diode Sources, 1-5 sources. Specify 1-5 of the most common sources: 1490 DFB, 1310 FP, 1550 DFB, or any of 1480 DFB, 980 SM, 980 MM Flexcore 5/125, 1490 FP, 1310 DFB, 1550 FP, or any wavelength from 1519 to 1630 nm DFB.
705	Rack ears and slides
706	Swivel handle
732	Add large data memory, +500MB
740	Internal GPIB controller (required for automatic external TLS or Polarization Controller control)
750	Add printer port, external keyboard & mouse ports
921	Built-in variable attenuator; 0-20 dB
922	Built-in variable attenuator; 0-40 dB
923	Precision superposition dual attenuator
940	Optical Return Loss (ORL) module
952E	All-states PDL measurement including external polarization sweeper
952I	Automated PDL all-states method and slow speed polarization independent insertion loss measurement
953E	Matrix Method PDL for use with external 8169 polarization state controller
953I	Matrix Method PDL including internal 4- and 6-state polarization controller
957E	Polarization scrambler, external
957I	Polarization scrambler; internal
962	Built-in source split with shutters for 2 DUTs
963	Built-in source split with shutters for 3 DUTs
972	Built-in source split with switches for 2 DUTs
973	Built-in source split with switches for 3 DUTs
982	Built-in source split for 2 DUTs
983	Built-in source split for 3 DUTs

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