Model 4600
PDL Meter

Fast, Accurate, Affordable PDL / IL / ORL

The 4600 PDL Meter will characterize loss, polarization dependency and return loss quickly, accurately and repeatably—all at an affordable cost. dBm technology supports unprecedented optical repeatability, accuracy, and speed. A device can be characterized at between one and nine wavelengths over multiple bands in <1 second. An eight-channel device can be fully characterized in <1 second.

Repeatable Loss Measurements

Loss measurements normally require a reference measurement—then a measurement of the loss. The 4600 eliminates the need for the reference measurement entirely by using a proprietary real-time reference. The 4600 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 4600 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 measurement of the 4600 performs fast and accurate measurement of the polarization dependency of the device, using either all-state or matrix method. Both methods are highly accurate, due to real-time referencing within the meter, eliminating the effects of source noise and repeatability. It also eliminates the need to do reference measurements. Further increasing throughput and reducing production uncertainty.

Summary

- IL and ORL simultaneously measured in less than 1 second at multiple wavelengths and multiple channels
- IL, ORL and PDL simultaneously measured in less than 4 seconds
- >65 dB dynamic range at full speed; >100 dB total dynamic range
- Low PDL error and high repeatability
- Real-time referencing reduces test time and increases accuracy
- Built-in or external TLS or fixed wavelength sources
- Built-in or external polarization controller
- Large color display makes data visualization and analysis simple
- Communicate over GPIB or Ethernet
- Exchange data using a USB flash drive
- 1 or 2 channels or 4-16 channels
- Use internal or external polarization controllers
- 4-year warranty

Simultaneous Return Loss Measurements

High dynamic range allows the 4600 to characterize return loss to levels approaching -70 dB. This measurement is performed simultaneously with the loss and PDL measurements with no added time required.

Test Wavelength Flexibility

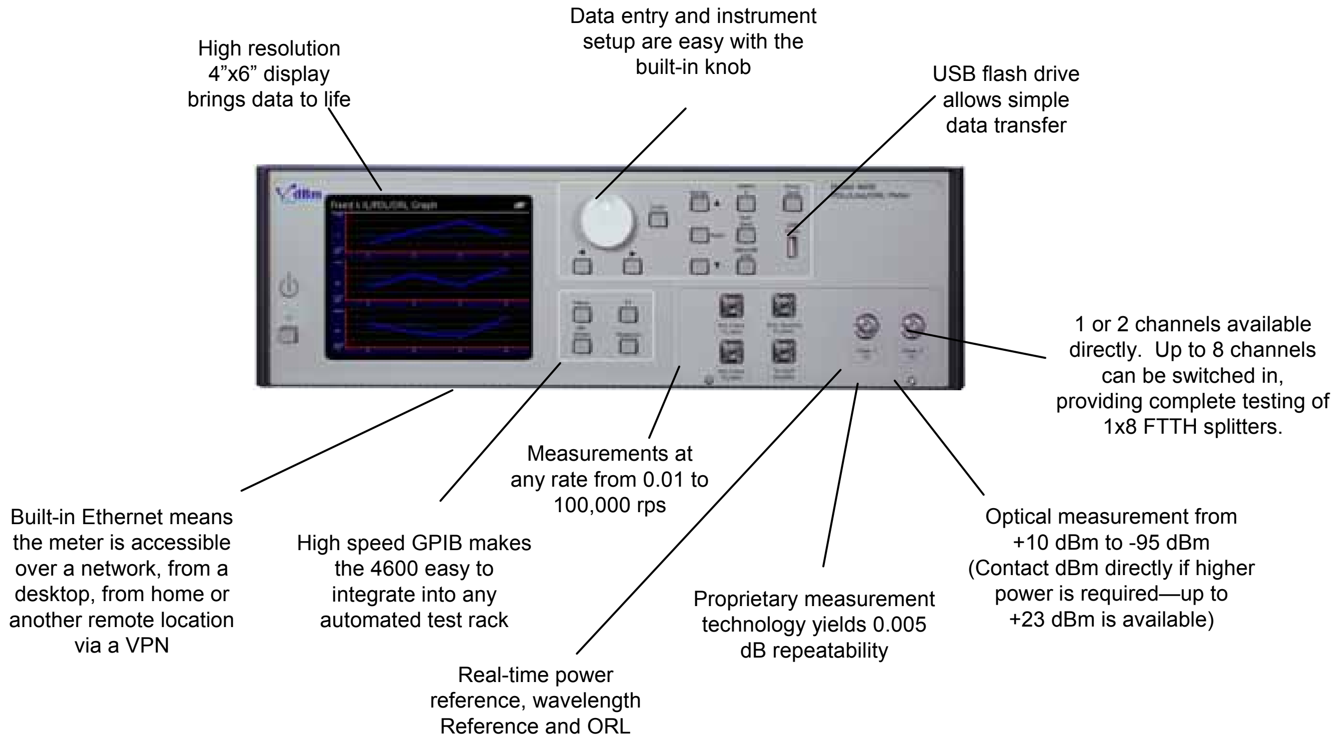
The 4600 may be configured with one to five of the most typical source wavelengths, including single mode 1490 DFB, 1310 FP, and 1550 DFB. Additional choices include 980 nm, 1310 DFB, 1480 DFB, 1490 DFB, 1550 FP, 1620 DFB, any wavelength from 1519-1630 DFBs and multimode 980 Flexcore 5/125.

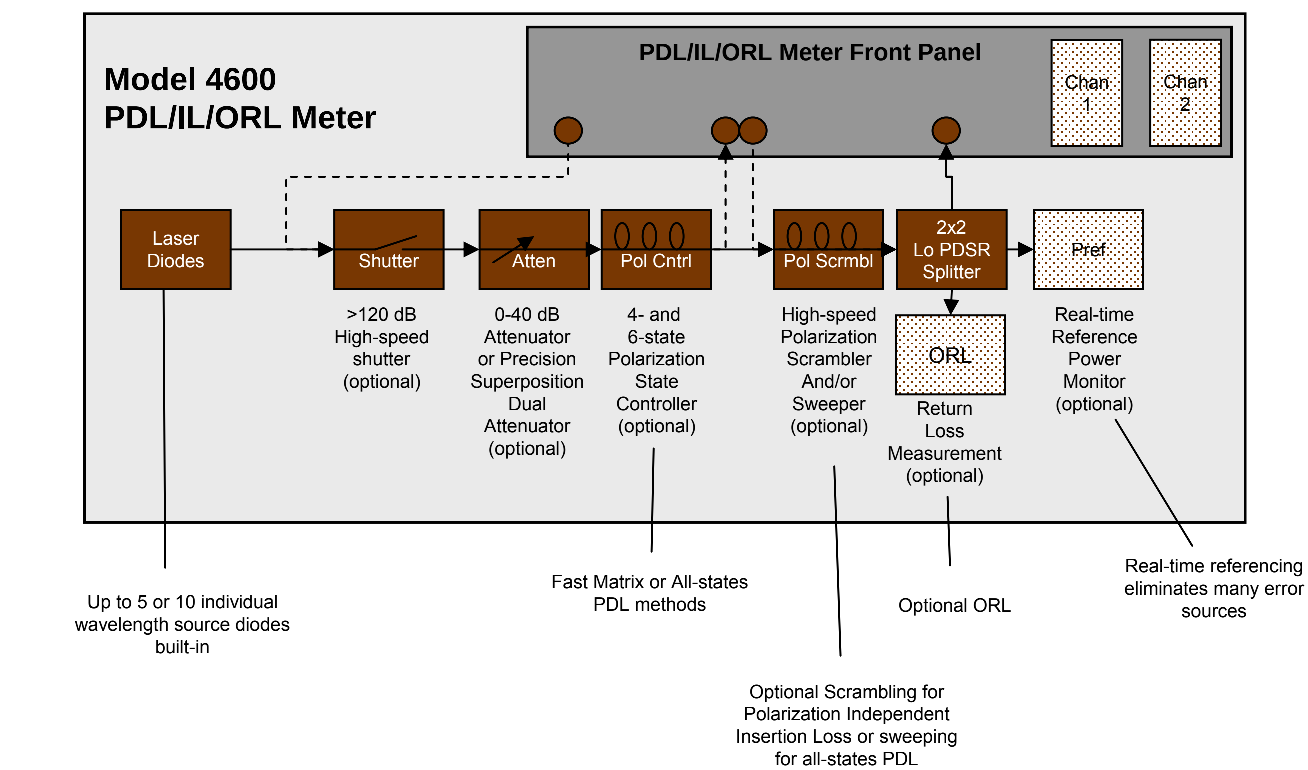
Available Wavelengths	
Most Common	1490 DFB; 1310 FP; 1550 DFB
Standard	850 nm; 980 nm; 1310 DFB; 1480 DFB; 1490 DFB; 1550 FP; 1620 DFB
Available	Any λ from 1519-1630

Fast, Accurate, Affordable PDL/IL/ORL

Model 4600 PDL/IL/ORL Meter

Overview





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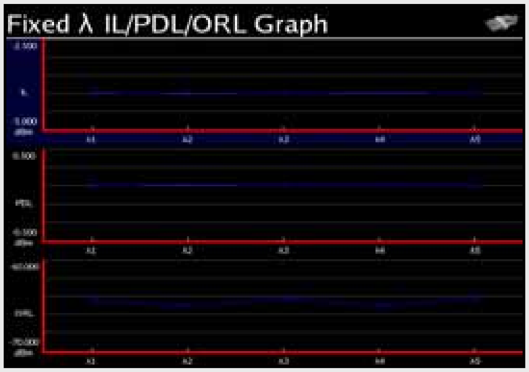
Model 4600 PDL/IL/ORL Meter

Test Many Different Optical Components

Production Testing of WDMs, Triplexers

Characterize insertion loss, polarization dependent loss and optical return loss for devices at channel center, at channel edges, or a combination of wavelengths. Up to 10 wavelengths can be selected. Devices include WDM FTTH and triplexers.

- Very fast characterization means fewer test stations, fewer operators, lower maintenance, and significantly lower equipment costs.
- Low-cost, complete measurement solution.
- Complete characterization in less than one second over 100 nm and at 1 pm resolution.

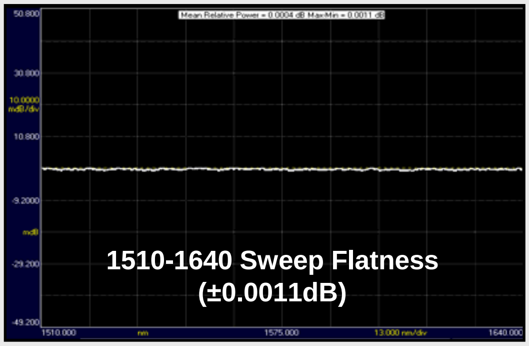


View IL, PDL and ORL Simultaneously

Broadband Device Test

Fast, inexpensive and accurate characterization of devices including FTTH splitters, circulators, isolators, splitters, couplers and attenuators. For information on extinction ratio measurements of polarizers, see our PER Meter.

- Automatic sweep power reference reduces system error dramatically.
- Easy to use—speeds test execution.
- Automated measurements for PDL and ORL.

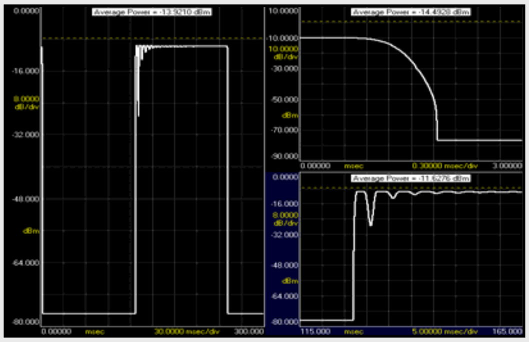


Very Accurate IL Measurement

Optical Switch Testing

Characterize optical transients (switch transition time, attenuator transition time, laser turn-on time or any other fast transient) with resolution up to 10 microseconds.

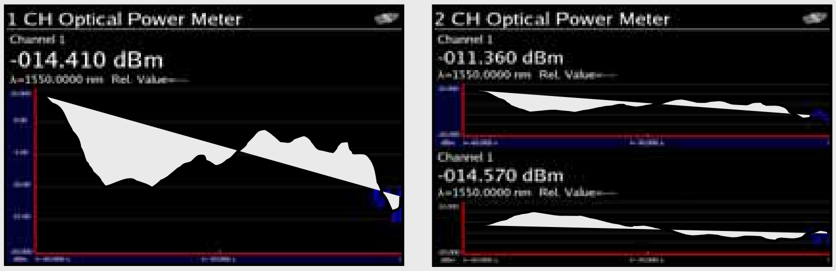
- Catch switch dynamics with 10 μsec measurements—fully characterize switch transitions.
- Wide dynamic range provides resolution to characterize very low cross-talk levels.
- Handle over 1500 channels with one system.
- Trigger the 4600 simultaneously with the switch to characterize total latency of the switch, including electronic delay



Capture Dynamic Signals

Doubles as an Optical Power Meter

Your PDL meter can also be used as a traditional Optical Power Meter.



Single- and Dual-Channel Displays
Make Data Visualization Simple

Model 4600 PDL/IL/ORL Meter

The Technology Behind the Performance

Polarization Dependency

The same breakthrough integrating sphere technology that provides high repeatability also serves 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

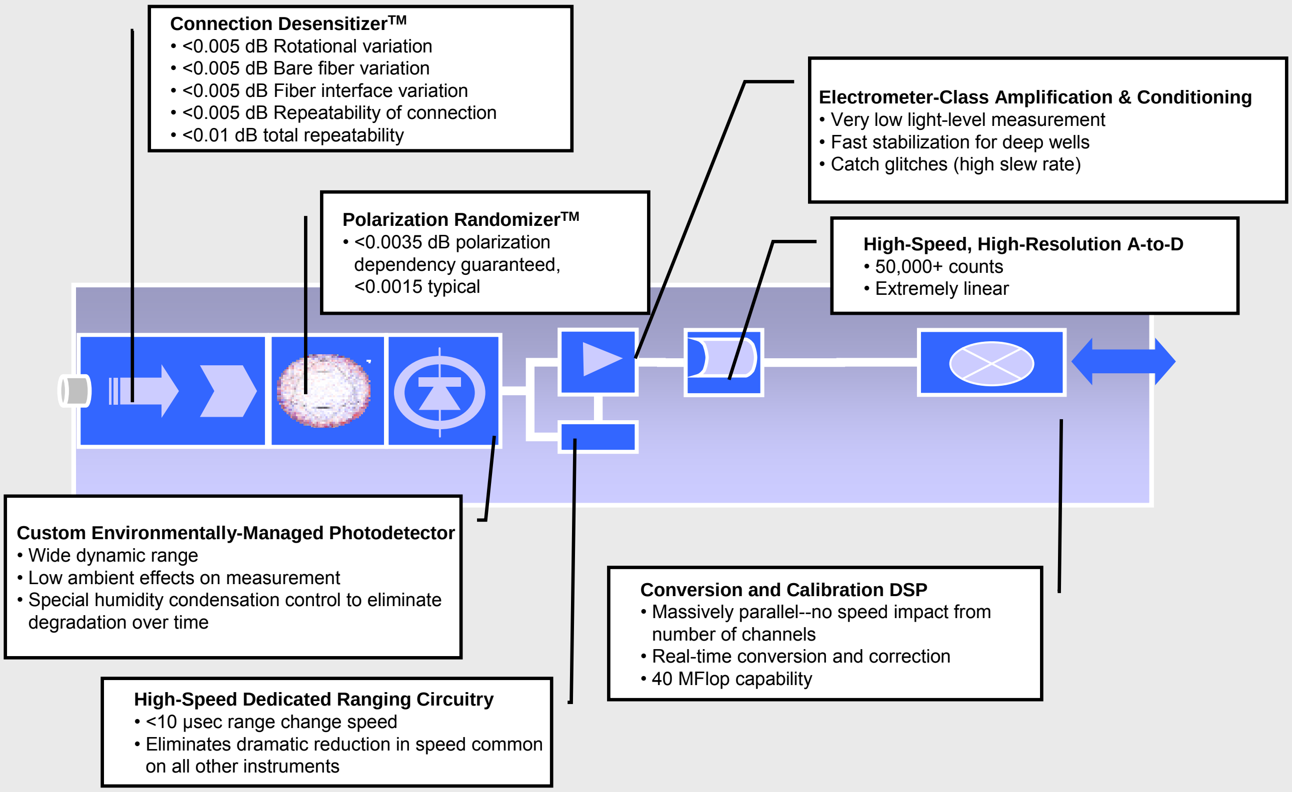
One of the core limits to making low-level measurements is the dark current of the internal photodetector. The 202 uses a special low dark current detector. In addition, because dark current is sensitive to temperature, the photodiode is run at –20°C (which substantially lowers dark current). We hired 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. The dBm 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 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.)



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Model 4600 PDL/IL/ORL Meter

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.

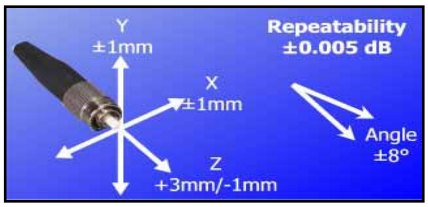
With any of the following changes, a less than ±0.005 dB variation in the measurement can be expected. This compares with typical values for other meters of ±0.05 to ±0.2 dB:

±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 affected 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.

dBm's 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 decreased down time and increased dollar cost savings.

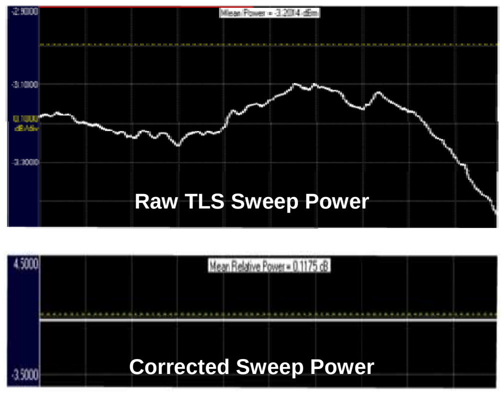
The Technology Behind the Performance

Real-Time Referencing

Real-time referencing cuts measurement time while improving accuracy and repeatability. The dBm 4600 has the ability to correct for many of the key errors often associated with measuring passive components automatically and in real time. 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 even high frequency noise, the 4600 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 4600'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 reference sweeps while removing many error sources

Making Real-Time Referencing Work

One of the major obstacles to real-time referencing is the polarization dependent split ratio (PDSR) of the splitter used for the reference signal. dBm Optics utilizes a proprietary technology, yielding extremely low PDSR.

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

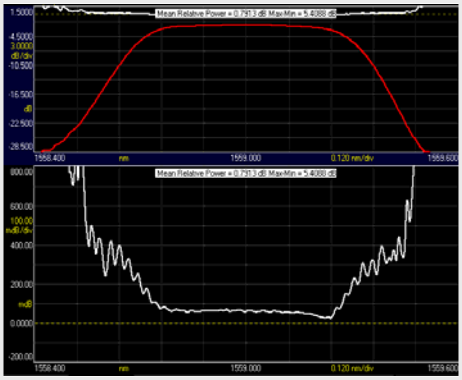
Real-time referencing corrects for most test system amplitude errors

Model 4600 PDL/IL/ORL Meter

Multiple PDL Measurement Alternatives

Fast, Accurate, Inexpensive PDL Measurement

Today's optical components require better PDL performance than in the past. The dBm 4600 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 4600 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

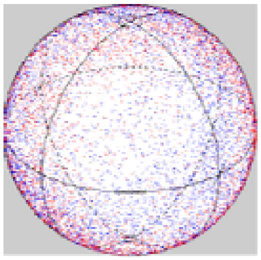
To measure PDL, simply turn on the PDL trace for the measurement channel(s) you are using. The 4600 will automatically perform the PDL measurement (using the specified method) at the same time as it measures IL and ORL. No software to write and debug, no errors—just accurate, fast PDL measurement.

Select the Method

The 4600 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.

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.



Sphere coverage is key to all-states PDL

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 points	<125 ms	<125 ms	From 50 ms to 50 sec	2 – 15 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	--	--

Accurate, Fast Matrix PDL 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. The 4600 adheres to IEC 61300-3-12 Polarization dependence of attenuation of single mode fiber-optic component: matrix method.

Simultaneous IL, PDL, ORL

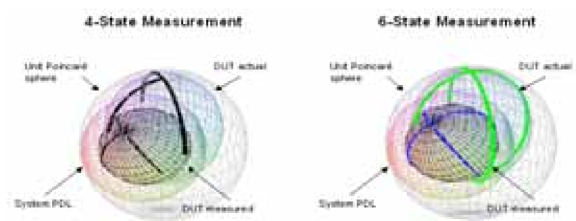
With the matrix method, all three key measurements can be made simultaneously. In addition, PDCW and PDBW can also be measured simultaneously.

Drastic Improvement with Real-Time Referencing

The dBm 4600 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 4600 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 4600 uses a proprietary device with incredibly low PDSR.

6-State Measurements

Although 4-state is the best know matrix method measurement, the 4600 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 4600 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. External polarization controllers have a wave plate angle error dependent on wavelength, and the 4600 automatically corrects for these errors. With the external controller, the 4600 will automatically perform the required polarizer alignment as well.

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.

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Model 4600 PDL/IL/ORL Meter

Optical Return Loss Measurement: Fast, Accurate, Automatic

Fast, Accurate, Automatic ORL

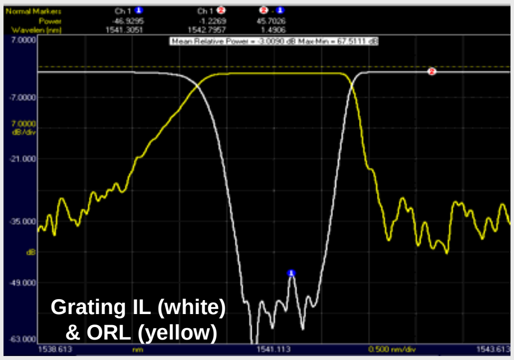
Optical Return Loss is becoming increasingly important as more components are typically in the optical path of a DWDM transmission system. Making good, reliable ORL measurement requires several factors: good low-power measurement, easy calibration, and built-in automation to eliminate test error sources.

Wide Dynamic Range Measurement

The 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

dBm Optics' instrumentation has the accuracy and broad capability to perform a full suite of tests on your device with 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 4600, 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 4600 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 4600 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. (Contact a member of our Applications Team for more information.)

Model 4600 PDL/IL/ORL Meter

Multiple-Channel Device Testing

Low-cost 1xN Device Testing

The proliferation of devices such as 1x4, 1x8, 1x16 and 1x32 FTTH splitters has placed new demands on test equipment. One of the top drivers is the tremendous price pressure on these high volume components. The 4600 PDL/IL/ORL Meter tackles this situation with a combination of high accuracy, ease of use, and very high throughput. The high throughput means that you need fewer test stations and fewer operators, helping you to increase your margins in this demanding market segment.

PDL Measurement

The 4600 can perform PDL measurements using either swept all states method or using IEC 61300-3-12 matrix method. Many users select the matrix method because it can be more accurate, faster and more reliable than all-states. In systems like those from dBm Optics, real-time referencing eliminates nearly all the traditional error sources that created inaccuracy in older generation matrix solutions. Of systems purchased over the last 24 months, over 80% have employed the matrix method. If you prefer all-states, order the model 952 polarization sweeper option.

ORL Measurement

ORL measurement is performed simultaneously with IL and PDL measurements. Measurements to 70 dB ORL are attainable.

Front panel connections can be individual or ribbon fiber

Directivity

This specification has been key for many systems providers specifying components for FTTH. The most common method for testing directivity focuses on measuring directivity for each splitter path, leading to seven discrete measurements for a 1x8 device (1-2, 3-4, 5-6, 7-8, 1-4, 5-8, 1-8). If desired, each separate path may be characterized. The 4600 or 4650 can be configured for directivity measurement, with measurement to -65 dB or lower.

Fast Measurement

For fixed wavelength testing, our fast optical source switching ensures short overall test time. Our 1 ms measurement time is the fastest in the industry (it can be further reduced to 10 us). Our polarization controller transition time of 250 ųs is also the fastest in the industry. As the chart indicates, our measurement time is very fast—allowing a single test station to test many more components—significantly reducing manufacturing cost.

If you wish to do full swept testing, our 1000 nm/sec tunable lasers also keep testing times very low.

	Test Time for 1x8 Device		
Test Parameters	**Using Model 4600 at 4 Wavelengths**	**Using Model 4650 Swept Spectrometer across 1310, 1490 and 1550 Bands**	**Using Model 2004 CSA Across 1310, 1490 and 1550 bands**
IL and ORL	<1 sec	3.20 sec	2.0 sec
IL, ORL and PDL	<1 sec	12.80 sec	8.20 sec
IL, ORL and Directivity	<2 sec	6.0 sec	N/A
IL, PDL, ORL and Directivity	<2 sec	15.60 sec	N/A

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Model 4600 PDL/IL/ORL Meter

Multiple-Channel Device Testing

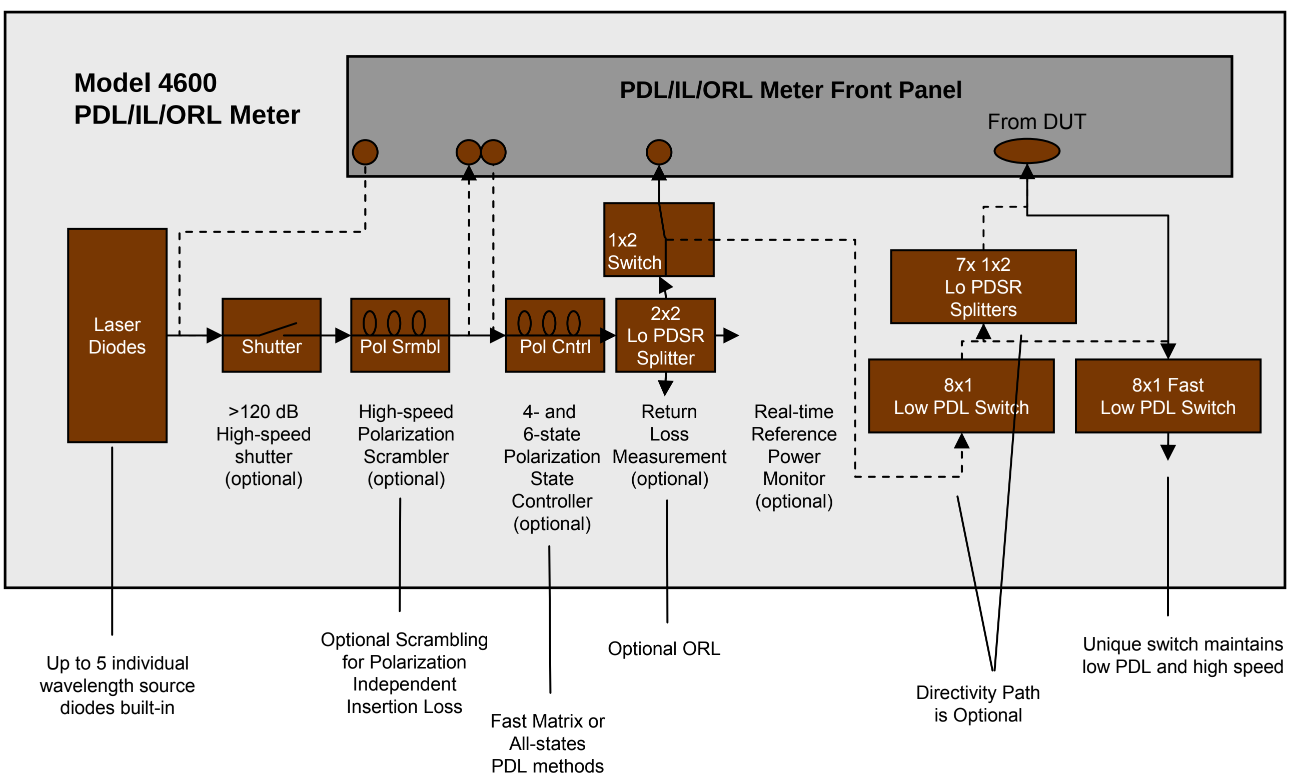
High Accuracy

The 4600 provides high accuracy on multiple channels even at high speeds. Our personnel will come to your facility for delivery of your instrument and ensure that you are meeting your device specifications.

The table below summarizes the capabilities of the system. Contact a member of our Applications Team for information on your specific requirements.

1xN Devices include planar and fused biconic splitters for FTTH

Test Parameters	Measurement Performance: 4600/4650 Without Directivity	4600/4650 With Directivity	2004 CSA
Insertion Loss (IL)	±0.02 dB	±0.05 dB	±0.004 dB with cal; ±0.015 dB without
Polarization Dependent Loss (PDL)	±0.02 dB typ	±0.05 dB typ	0.004 dB with cal; 0.015 dB without
Optical Return Loss (ORL)	to -65 dB	to -65 dB	to -65 dB
Directivity	to -70 dB	to -70 dB	to -70 dB



Model 4600 PDL/IL/ORL Meter

Specifications

Channels per mainframe	1 or 2 channels, plus ORL, Pref,
Input connections	Selectable from among the following at time of ordering: Model FC: FC/APC or FC/PC; Model SC, Model DN: DIN, Model BF: Bare fiber interface. (Other connectors available upon request.)
Speed per channel	Variable measurement speed from 100K rps to 0.1 rps
System transmit speed	Transmitting to host with Ethernet is 3 Mbytes/sec (dedicated link); with GPIB 1.7 Mbytes/sec into a PC.
Multiple channel speed	100 K rps per channel speed regardless of number of channels.
Trigger latency [1]	<40 nsec
Display	4"x6" graphical display, VGA (800 x 600), TFT LCD color
Data storage	Memory for >100 K readings per channel on all channels real time storage. With memory expansion option –750, 40 million measurements capacity (200 sweeps of 2 channels at 1pm across 100nm)
Triggering	Software synchronous trigger or two selectable external trigger inputs
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	28 lbs (12.73 kg)
Mounting	Bench top or rack mount

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

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

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Model 4600 PDL/IL/ORL Meter

Optical Measurement Modules 202 and 201

Measurement Specifications

Sensitivity and Noise

						Optical Measurement Modules									
						OMM-202 Noise RMS[2]						OMM-201 Noise RMS[2]			
Range	Fixed Range	Measurement		Measurement Resolution[1]		5 secs[7]		100 ms[8]		10 µs (full speed)[9]		5 secs[7]		100 ms[8]		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.)

		Reading Time with Averaging of:		
Auto-Range Mode	**Full Measurement Range**	**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.

Model 4600 PDL/IL/ORL Meter

Option Specifications

Note: **For Optical Measurement Modules data, see the 4100 Optical Power Meter specifications sheet.**
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
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 (See Application Note 2004-014A)

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Model 4600 PDL/IL/ORL Meter

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: 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 <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 at high speed 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 for high speed. (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
959	Extinction Ratio Enhancement (extended PER)		
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 4600 PDL/IL/ORL Meter

Ordering Information

Model	Description
4600	1-2 Channel PDL/IL/ORL Meter (Included accessories: USB flash memory card; power cord; operating manual)
750	Add printer port, external keyboard & mouse ports
732	Add large data memory, +500MB
202	Precision Power Meter Module, 800nm-1700nm
201	Power Meter Module, 800nm-1700nm
201V (upcoming)	Power Meter Module, 190nm-1100nm
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
501	Bare Fiber Adapter, low stress, easy alignment
502	Bare Fiber-to-FC Adapter
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, or 850 nm.
705	Rack ears and slides
706	Swivel handle
740	Internal GPIB controller (required for automatic external TLS or Polarization Controller control)
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
952I 952E	Automated PDL all-states method and slow speed polarization independent insertion loss measurement
957I	Polarization scrambler; internal
958I	Precision arbitrary polarization controller
959	Extinction ratio enhancement (extended PER)