Model 4100
Optical Power Meter

Fastest, Most Accurate Optical Power Measurement

The 4100 Optical Power Meter offers an unparalleled combination of speed, accuracy, repeatability, ease of use, and low cost.

Fast, Accurate, Affordable



High Speed

The 4100 combines 100,000 rps optical power meter modules with a powerful processor that can handle the measurement speed. With two channels, each channel still measures at 100,000 rps.

Wide Dynamic Range

The 4100 with –202 optical power meters measures from +10 dBm to -95 dBm—for a full dynamic range of 105 dB.

Wide Dynamic Range at Full Speed

Even more important than full dynamic range is the range which can be achieved while making a measurement without stopping to change range. Most meters take ~20 ms to change range. The 4100 power meters have a large dynamic range of >65 dB at full speed—in most cases eliminating the need to change range.

Low Polarization Dependency

The 4100 with –202 optical power meters utilize a unique patented technology to achieve <0.0015 dB polarization dependency of measurement. This allows for error-free measurement, even with highly polarized light.

Low Connection Variation

Repeatability is a major obstacle in obtaining consistent results in the lab and in eliminating discrepant materials in production. The 4100 provides repeatability of ±0.005 dB even with widely varying launch conditions.

Clear, Bright Display

The 4" x 6" VGA color display affords excellent ability to understand and analyze measurements directly on the power meter without the need to export to a PC. Trends, drifts, noise, and perturbations are all clearly indicated on the graphical display. The wide viewing angle makes results visible from anywhere in the lab.

Fast Data Transfer to Excel

The removable USB flash memory drive makes transferring data to Excel or other analysis software very simple. Built-in Ethernet and GPIB communications make getting data remotely very simple: Connect to your company's network and retrieve your data from your desktop or from a remote location over your VPN.

Convert to Optical Workbench

The 4100 can be converted into a Model 4500 Optical Workbench—complete with polarization controller options, attenuators, switches and sources. For more information, see the Model 4500 Optical Workbench section of this brochure.

Summary

- High speed measurement: 0-100,000 rps
- >100 dB total dynamic range, >65 dB dynamic range at full speed
- <0.0015 dB polarization dependency
- <0.005 dB total connection variation
- 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
- System can be upgraded with additional capabilities (such as polarization control, attenuation, shutter)
- Full 4-year warranty

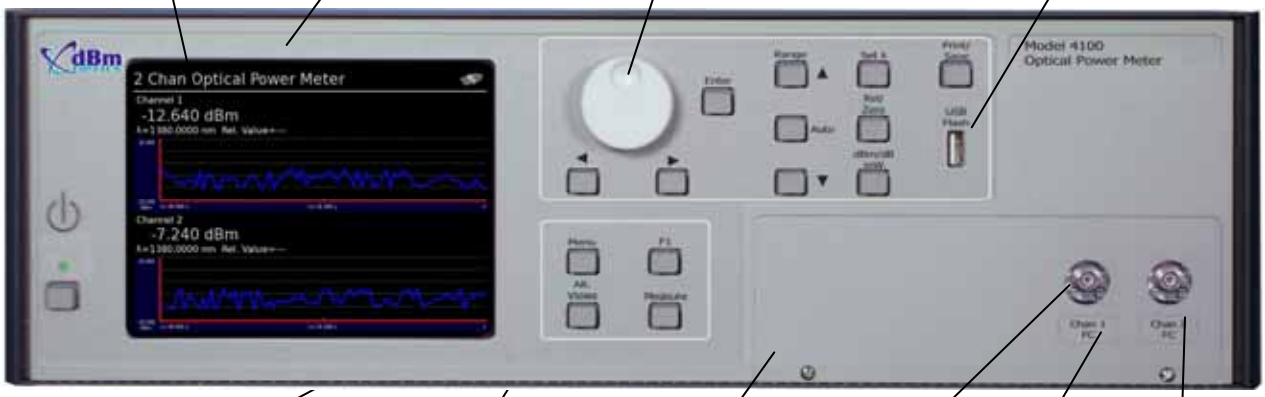
Overview

Alternative displays make data analysis simple:
• Large single-channel with trend chart
• 2-channel with trend chart
• Tabular data
• Very large single- or two-channel numeric display

High resolution 4” x 6” display brings data to life

Data entry and instrument setup are easy with the built-in knob or touch-screen display

USB flash drive allows simple data transfer



Built-in Ethernet means accessibility over a network, from a desktop, from home or other remote location via a VPN

High-speed GPIB makes the 4100 simple to integrate into any automated test rack

Measurements at any rate from 0.01 to 100,000 rps

Proprietary measurement technology yields 0.005 dB repeatability

1 or 2 channels available

Optical Measurement from +10 dBm to -95 dBm (Contact dBm directly if higher power is required—up to +23 dBm is available)

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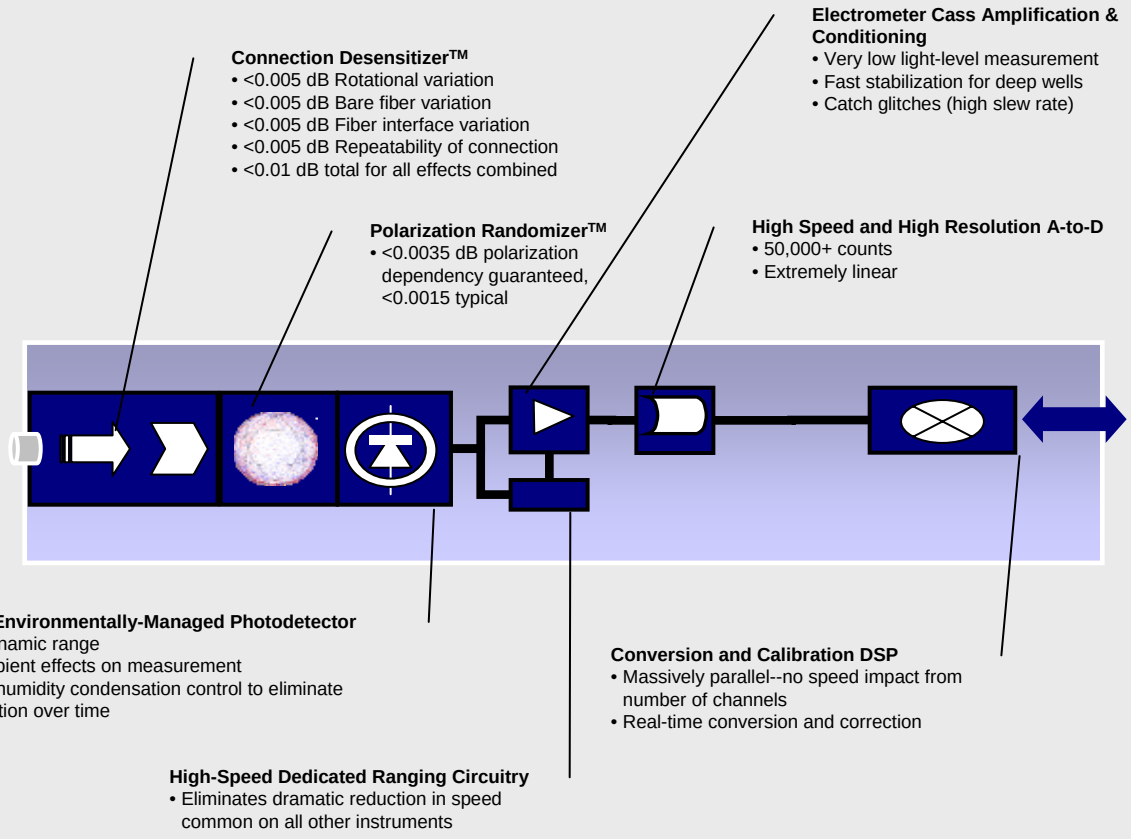
The Tech Behind the Performance

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 patented miniature integrating "sphere." This ensures that the polarization of the light reaching the detector is very well randomized, enabling a clean, consistent measurement. 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 reduced dark current detector. In addition, because dark current is sensitive to temperature, we hired the world's authority on temperature control to design our temperature control circuitry. The photodiode is run at -20°C (which substantially lowers dark current), and we 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.



The Tech Behind the Performance

Low-Level Amplification Without Compromising Speed

Most optical power meters use traditional current measurement techniques, which involves putting an equivalent resistance across the diode and measuring the voltage drop. This technique is great for many current measurement applications, but breaks down at extremely low currents, which makes this technique very slow and susceptible to drift in photodiode current measurements. The high resistance needed for low currents, 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), at higher speed with less drift. The electrometer technique compensates for some of the capacitance of the photodiode, and provides for lower equivalent input resistance yielding lower noise and faster response.

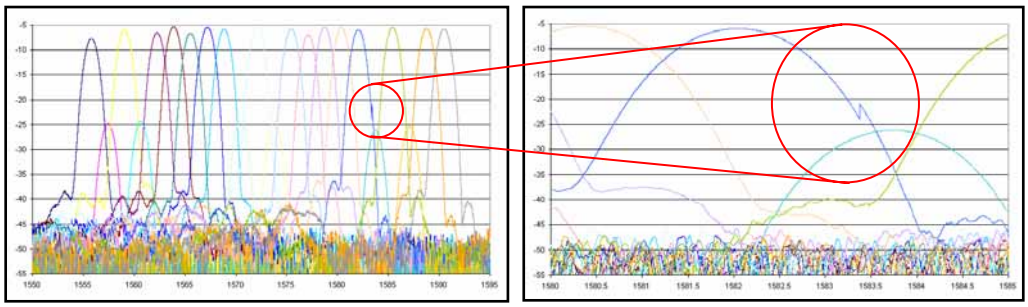
High Dynamic Range at Speed

The dBm 4100 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 4100 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 our Applications Team about built-in stitched measurements which expand the dynamic range at speeds to >85 dB.)

Application

Deep-well devices are especially challenging to test. The desire is to test at narrowly spaced wavelengths using a continuously sweeping tunable laser. Measurements include the detailed nature of the passband and the structure of the stop band (which is important for crosstalk specifications and for development understanding of the device characteristics).

There were three alternatives in legacy systems: 1) Use a logarithmic amplifier, which compresses wide ranging signals into a small dynamic range, but the non-linearity (which varies with time and temperature) and the low-end noise have motivated most suppliers to avoid this approach. 2) Use slow sweeping and slow measurement with linear ranges; auto ranging the measurement for each point. This is impractical for a continuously sweeping laser but can be used with slower stepping systems. 3) Run multiple sweeps, one on each of two or three different ranges, then “stitch” them together after the fact. This requires the time to run the additional sweeps (and for the laser to return to home wavelength), and it also is susceptible to non-linearity between ranges, a specification that is typically not available. The graph below illustrates a typical problem in a legacy system.



dBm Optics uses a patented technique to rapidly determine the correct measurement range, change to that gain, forcibly inject or deplete charge from the amplifiers (to force rapid settling), then make the measurement. All this (including the measurement) takes less than 10 µs. Our intra-range linearity is assured using a special calibration technique that occurs in the background.

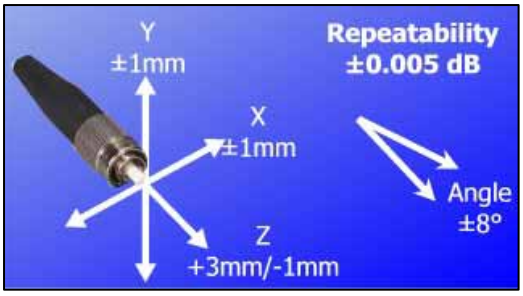
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The Tech Behind the Performance

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.

The low connection sensitivity results in excellent performance with a Bare Fiber Adapter (BFA). 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.



Integrating sphere-like input eliminates most input variation



OMM-502



OMM-501

Measurement repeatability with bare fiber adapters is <0.01 dB

Technical Note

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

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.

The Tech Behind the Performance

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.

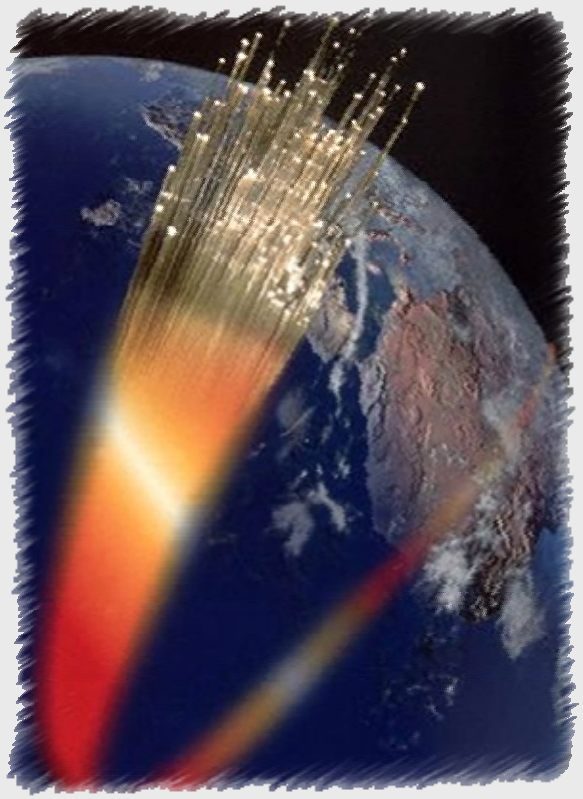
dBm's –202 power meter virtually eliminates this problem by actively heating the photodiode enclosure (including the window). By holding the window 5°C above ambient, any condensate (and the contamination that comes along with it) is discouraged. The result is an incredibly stable measurement over long periods of time. Many of our customers use two-year calibration cycles (rather than one-year calibration cycles) resulting in less downtime and dollar cost savings.

High-Speed Processing

Measurement speed without the ability to retrieve the data quickly can be a big limitation. The 202 Optical Power Meter modules have on-board 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.

Companion DC Voltage and Photodiode Measurements

In addition to optical signals, the 4100 Optical Power Meter 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.

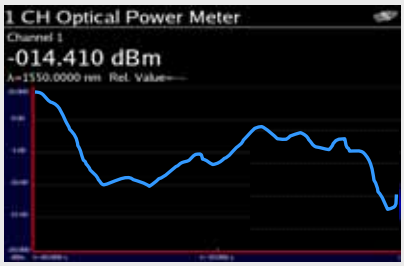


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A Front Panel that Makes Your Work Easier

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 4100 Optical Power Meter offers a number of unique capabilities that will make a difference in the lab or on the production floor—at an affordable cost.



Single- and Dual-Channel Displays Make Data Visualization Simple



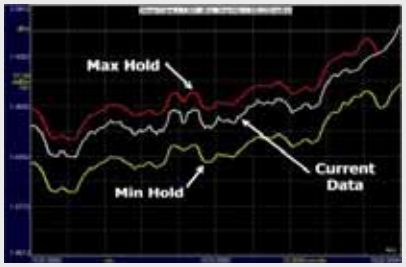
Comprehensive Control from a Single Display

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 your measurement at each wavelength. The maximum and minimum excursions of your 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.

Digital Filtering

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

Model 4100 Optical Power Meter

Specifications

Channels per mainframe	1 or 2 channels, plus ORL, Pref, and WL Ref (401 or 410)
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 ns latency; < 40 ns jitter
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 1 pm across 100 nm) Removable flash drive optional.
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 41.6 cm x 10.5 cm)
Weight	22 lbs (10 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

For information on photodiode measurement, see the Model 4700 Photodiode Characterizer datasheet.
Photodiode measurement cards will operate in the Model 4100.

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Model 4100 Optical Power Meter
Optical Measurement Modules 202 and 201
Specifications

Sensitivity and Noise

Range	Fixed Range	Measurement		Measurement Resolution[1]		Optical Measurement Modules											
						OMM-202 Noise RMS[2]						OMM-201 Noise RMS[2]					
						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	20 pW	-77	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:

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

Note: A slight increase in noise may be apparent with the analog output cards

Polarization Uncertainty of Measurement

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

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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 4100 Optical Power Meter

Ordering Information

Model	Description
4100	1-2 Channel Optical Power Meter (Standard accessories: USB flash memory card; power cord; user manual)
201	Power Meter Module, 800 nm-1700 nm
201V (upcoming)	Power Meter Module, 190 nm-1100 nm
202	Precision Power Meter Module, 800 nm-1700 nm
210	Remote Power Meter Module, 800 nm-1700 nm
210V (upcoming)	Remote Power Meter Module, 190 nm-1100 nm
222	Precision Power Meter Module, 800 nm-1700 nm, with Analog Output
270	DC Voltage Measurement Module
280	Photodiode measurement module
288	8-channel photodiode measurement module
290	APD measurement module
501	Bare Fiber Adapter, low stress, easy alignment
510	Bare Fiber-to-FC Adapter
705	Rack ears and slides
706	Swivel handle
732	Add large data memory, +500 MB
750	Add printer port, external keyboard & mouse ports
Upgrade to Model 4500 Optical Workbench	• Polarization Scrambling • Polarization 4- and 6- state controller • 0-20 dB and 0-40 dB attenuators • Precision superposition dual attenuator • Optical Shutter • Internal TLS or fixed wavelength sources • Wavelength reference • Real-time power referencing

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