

Polarization Optimized PMD Source – PMDPro™

PMD-1000

The PMDPro™ is a breakthrough PMD source that can deterministically generate precise 1st order PMD up to 180 ps and 2nd order PMD up to 8100 ps². Its quasi-continuous operation mode enables independent generation of first order and wavelength independent second order PMD for uniform coverage of the PMD space. The PMDPro™ contains an automatic polarization controller and two polarimeters that monitor the state of polarization (SOP) and degree of polarization (DOP) before and after the PMD generating elements. The polarization controller can be used with the front polarimeter to automatically align and maintain the input SOP at 45° from the principal axis of the DGD element to

obtain the worst-case first order PMD effect. Alternatively, the controller can automatically adjust and maintain the input SOP using the feedback from the rear polarimeter to either minimize or maximize the output DOP for each PMD setting. Minimizing the output DOP enables testing of the worst-case total PMD effect, while maximizing the DOP turns the PMDPro™ into a PMD compensator, allowing the user to estimate the PMD values of an active fiber link and compare its performance with and without PMD compensation. The PMDPro™ can also perform PMD emulation by generating statistical PMD distributions. Finally, the polarization controller and polarimeters enable variable rate polarization scrambling and deterministic polarization control functions, including trace generation and polarization stabilization at any SOP. PMDPro™ makes your PMD related systems testing simple, fast and professional.



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Preliminary Specifications

Operating Wavelength Range ¹	C band, L band, or C+L band				
Insertion Loss (at 1550nm)	5.0 dB				
Input power range	-10 ~ 15 dBm				
Return Loss	50 dB				
PDL	0.4 dB typical				
1 st order PMD Range	0 ~ 91 or 0 ~ 182 ps				
1 st order PMD resolution		90 ps range	180 ps range		
	Discrete mode	0.357 ps	0.714 ps		
Quasi-continuous mode		0.1 ps	0.2 ps		
	2 nd Order PMD Range	2000 ps ² (90 ps range) or 8200 ps ² (180 ps range)			
PMD wavelength dependence	No wavelength dependence in quasi-continuous mode				
PMD variation time	1 ms min.				
SOP alignment accuracy	±2°				
SOP tracking speed	10π/s				
DOP accuracy	± 2%				
Optical Power Handling	300 mW min.				
Operating Temperature	10 °C to 50 °C				
Storage Temperature	-20 °C to 60 °C				
Communication Interfaces	USB, Ethernet, RS-232, and GPIB				
Front panel display	2 line, 20 character				
Power Supply	100-120 VAC, 50-60 Hz or 200-240 VAC, 50-60 Hz				
Dimensions	2U 1/4 19" rack 3.5"(H) x 14" (W) x 14" (D)				

Applications:

- System PMD tolerance test
- PMD compensator evaluation
- PMD measurement for live fiber links
- Diagnosis of system impairments
- PMD measurement instrument calibration

Unique Features:

- 1st and 2nd order PMD source
- 1st order PMD emulation
- Automatic polarization alignment
- Polarization scrambling
- PMD compensation
- PMD determination for live fiber links
- Rapid PMD switching: ~ 1 ms

Ordering Information:

PMD – 1000 – XX – X – XX

PMD Range:
90 = 90 ps
18 = 180 ps

Connector Type:
FC/PC
FC/APC

Wavelength:
C = C band
L = L band
CL = C+L band

System Description

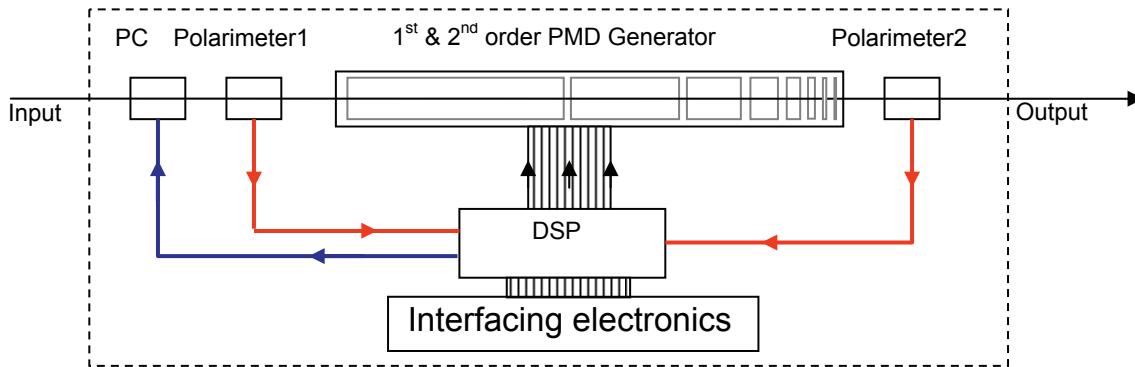


Figure 1 System diagram of the polarization optimized PMD source.

The system diagram of the polarization optimized PMD source is shown above. The DSP based circuit is used to 1) process input instructions and information from the polarimeters, 2) instruct the PMD generator to select the desired PMD values, 3) control the polarization controller (PC) to optimize the input SOP for the selected function. The PMD generator is constructed with patent pending trinary polarization rotation technology and a quasi-continuous rotator for independent DGD and SOPMD control. In its discrete digital control mode, the 8-bit PMDPro™ can generate 6561 individual PMD states, including 256 pure DGD states and 1024 wavelength independent SOPMD states, at a rate as fast as 1ms per state. In its quasi-continuous control mode, the PMDPro™ can independently generate DGD and wavelength-independent SOPMD values, allowing for uniform coverage of the PMD space (see Figure 2). At each PMD state, the SOP can be optimized according to the feedback from one of the polarimeters. Using the SOP information from polarimeter 1 as the feedback, any SOP or set of SOP variations can be programmed, including the special case in which the input SOP is aligned for an equal power split between polarization components aligned to the fast and slow axes of the PMD generator. Using the DOP from polarimeter 2 as the feedback and minimizing it during the control process, the worst-case PMD effect on the optical signal can be assured. Alternatively, by maximizing the DOP from polarimeter 2 during the control process, the link PMD can be compensated. The DOP values measured from polarimeters 1 and 2 can also be compared to determine the effect of PMD or PMD compensation on the optical signal.

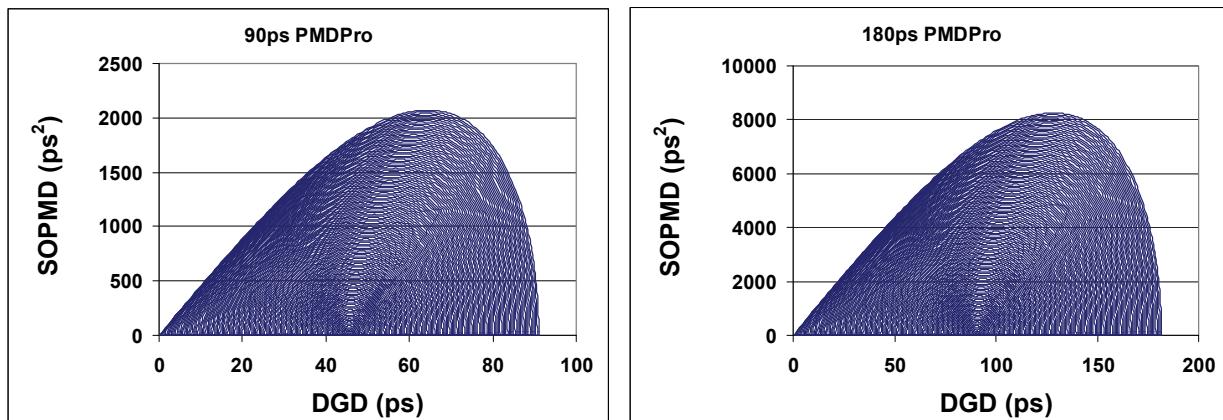


Figure 2 DGD and wavelength independent SOPMD range
 A) 90 ps PMDPro™
 B) 180 ps PMDPro™

Application examples

PMD tolerance test

PMD is one of the major transmission impairments for 40G fiber systems. It is therefore important to quantitatively measure how much PMD a system can tolerate. The results of the PMD tolerance tests can be used by network operators to compare systems made by different vendors and verify PMD related specifications promised by the vendors. They can also be used by system vendors 1) to determine which PMD mitigation approach is most suitable, 2) to fine tune the PMD mitigation related parameters in the transceivers during system development, and 3) to perform output quality control of the final system, including transceivers, with respect to PMD related specifications. The key instrument in this setup is the PMD source used to generate precise 1st and higher order PMD values, as shown in Figure 3. The bit-error rate (BER) of the system, or another performance indicator parameter, is monitored as the 1st order PMD (DGD) values generated by the PMD source are gradually increased until the BER reaches the limit set for the system, as shown in Figure 3B. The corresponding DGD is the 1st order PMD tolerance of the system. Both the 1st and 2nd order PMD (SOPMD) values can also be increased as the BER of the system is measured and plotted, as shown in Figure 3C. The system outage probability can be calculated from the data obtained.

The effect of PMD on a system is highly dependent on the input SOP. To eliminate test uncertainties and increase test speed, the input SOP must be optimized and maintained against polarization fluctuations caused by external disturbances. The PMDPro™ has two modes of SOP optimization for PMD tolerance tests. One is to align the input SOP 45 degrees from the principal axes of the DGD generator to obtain the worst-case DGD effect. The other is to align the SOP by minimizing the output DOP to obtain the worst-case total PMD effect on the signal.

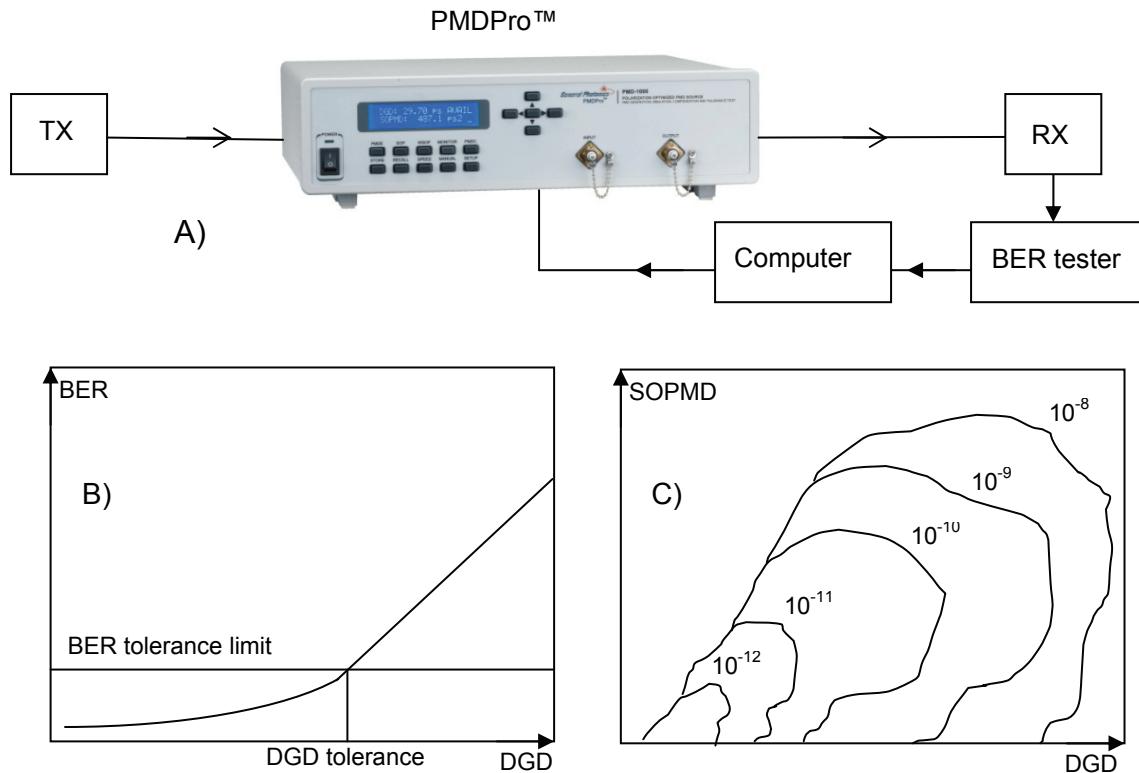


Figure 3 A) PMD tolerance test setup using a PMD source. The computer selects PMD settings and collects BER readings. B) BER vs. DGD curve. The DGD tolerance for a given BER threshold can be deduced from this curve. C) Map of BER vs. DGD and SOPMD. Each contour represents a BER value, and the PMD tolerance can be obtained from the contour plot.

PMD compensator performance evaluation

The PMDPro™ is also ideal for evaluating the performance of a PMD compensator, as shown in Figure 4. This technique can be used with either electrical or optical PMD compensators. First, the system improvement margin at different PMD settings can be evaluated. Second, the PMD compensation range of the compensator can be evaluated by gradually increasing the PMD values while measuring the BER of the fiber link. 3) Third, the speed of the compensator's response to quick PMD variations in the link can be determined by rapidly changing the PMD values. Finally, the compensator's response time with respect to changes in SOP at each PMD setting can be determined by changing the SOP rapidly at different PMD settings. Clearly, the PMDPro™'s fast PMD change and fast polarization control capabilities are attractive for PMD compensator evaluation.

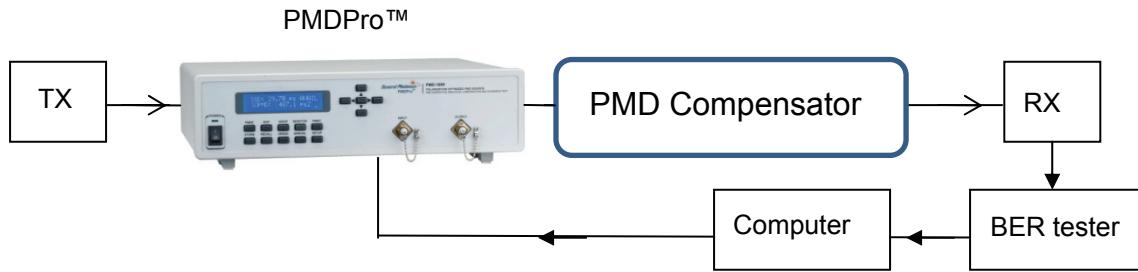


Figure 4 A PMDPro™ is placed before a PMD compensator to generate different PMD values for the compensator to compensate, while the signal's BER or some other parameter that reflects signal quality is monitored. For electrical compensation, the compensator may be inside the receiver (RX). The plots shown in Figure 3 can be generated using this setup, with PMD compensation at different PMD settings, to determine the effectiveness of the compensator at different PMD settings. The high speed polarization control and high speed PMD variation capabilities of the instrument can be used to evaluate the response times of the compensator against rapid polarization and PMD variations.

PMD compensation and related applications

PMD compensation is an extremely attractive feature. First, system vendors and network operators need to know how much PMD compensation can improve system performance in order to decide whether to deploy a PMD compensator on a link with performance issues. Second, if PMD compensation significantly improves the system performance, it can be concluded that PMD, rather than other impairments, is the major issue for that link. Therefore a PMD source with PMD compensation capability can be used for the diagnosis of system problems. Finally, optimized PMD compensation can help to determine the PMD values of the fiber link, because the PMD value used for optimal PMD compensation is close to the real PMD value of the fiber link. Such a feature is attractive for frequent PMD monitoring of a live fiber link, a task that cannot be accomplished with PMD analyzers currently on the market.

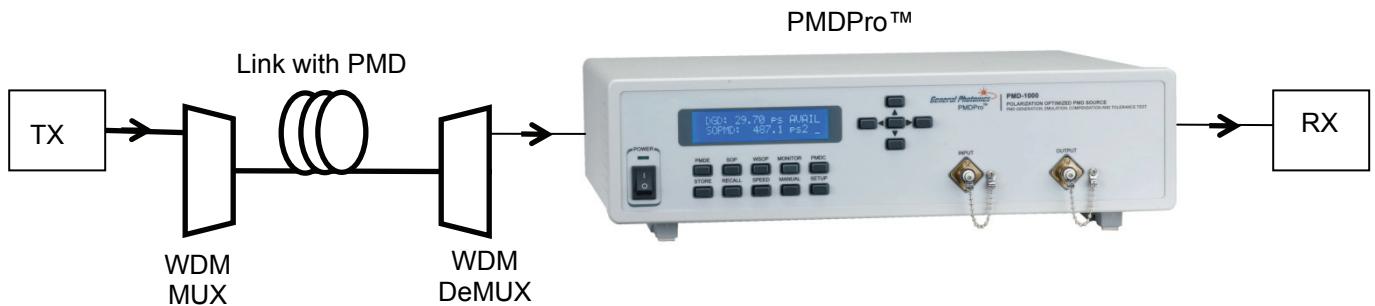


Figure 5 A setup using a PMDPro™ to test an in-service WDM link. The PMD compensation function is used to determine the link's PMD and diagnose performance issues.

- 1) **PMD compensation with either optimized PMD value or user selected PMD value.** The PMD compensation is accomplished by maximizing the DOP detected by the polarimeter at the output port. Both PMD and DOP values will be shown on the front panel LCD display. Using the user-selected PMD mode, the user can directly see how the PMD value chosen affects PMD compensation by stepping the PMD values up and down and looking at the maximized DOP values. By comparing the DOP values obtained by polarimeters 1 and 2, the user can determine how well the PMD is compensated. When the optimized PMD mode is selected, the instrument will scan through all of the PMD states and search for the maximum DOP. The PMD state with maximum DOP is selected as the optimized PMD for PMD compensation.
- 2) **Determination of PMD value of an in-service fiber link.** The optimized PMD compensation mode can be used to determine the PMD in the link, as shown in Figure 5, because the optimized PMD value for compensation should be close to the PMD value of the fiber link. Therefore, the PMD value of a fiber link can be determined by simply inserting the PMDPro™ into the system and enabling the PMD compensation function. The optimized PMD shown on the LCD display is then the PMD value of the link. It may also be necessary to determine the PMD condition of a particular channel route in an in-service ROADM network to determine its suitability for 40G operation before installing 40G transmitters and receivers. This test can be accomplished by simply placing an ASE source at the transmitter end and a polarization optimized PMD source at the receiver end to perform PMD compensation. Again, the optimized PMD value determined by the PMD source is the PMD value of the fiber route. With this information, it is possible to decide whether the route is suitable for 40G transmission and whether a PMD compensator is required. An EDFA may be used before the PMD source to boost the signal level.
- 3) **System impairment diagnosis.** In a fiber link with performance problems, it is sometimes difficult to determine whether the primary cause of the problem is a PMD issue, a chromatic-dispersion issue (CD), a signal-to-noise ratio (SNR) issue, or something else. Performing PMD compensation can help to isolate or eliminate PMD as the source of the problem: If PMD compensation solves the transmission problem, then PMD is the main cause. Otherwise, PMD may not be an issue. With such a diagnosis, one can then determine whether PMD compensation is required for the fiber link.

PMD emulation

Because the PMDPro™ can generate individual PMD states with high repeatability at user defined time intervals, it can be programmed to generate statistical distributions of PMD states using Maxwellian or other types of distributions to emulate PMD variations in fiber systems.

General purpose polarization control

Using its internal polarization controller and polarimeters, the PMDPro™ can perform several built-in polarization control functions, including deterministic SOP generation, polarization scrambling, and polarization trace generation. Therefore, it can be used as a general purpose polarization synthesizer/controller for all polarization control needs.