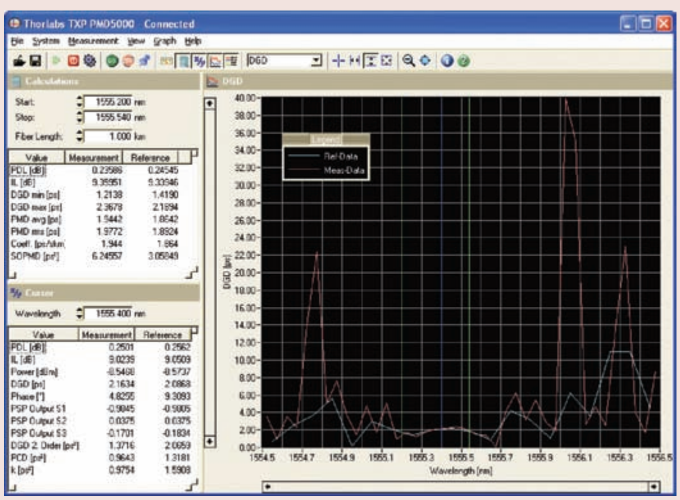
For current pricing, please see our website.

# PMD/PDL Measurement Systems (Page 1 of 4)

**PMD5000 SERIES**
Complete PMD/PDL Analyzation System, Laptop Included

### Introduction - PMD5000

The PMD5000 Series is a high-performance polarization mode dispersion (PMD) testing system based on the Jones Matrix Eigenanalysis. The modular design offers unique flexibility and adaptivity, making it ideal for all kinds of polarization-related measurements. It is especially useful for PMD analysis on broadband and narrowband components, optical fibers, and installed optical networks; these systems are capable of determining Differential Group Delay (DGD), Polarization Dependent Loss (PDL), and other parameters. Efficient PMD measurements of complex optical networks as well as PMD monitoring of dark channels are other applications that benefit from the ability to control a single transmitter unit and multiple receiver units at different locations via one remote computer.




A preconfigured laptop is included with the system. The software includes all features to analyze the PMD and PDL of fiber and optical components. It is intuitive and allows extensive analysis of the measured data set.

The transmitter parts of the PMD5000D consists of a polarization controller and external tunable laser source. For the analyzer, different high-performance polarimeter modules are available, which allow the system to be optimized for a particular application. If the system is being used with a split transmitter analyzer configuration, the unit can be controlled remotely via TCP/IP, Ethernet, or WLAN. The system is based on the TXP architecture and offers full compatibility. See pages 1178 - 1179 for an overview of the different configuration options. For more detailed information, please contact our tech support team.

### Modularity

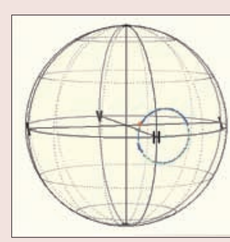
The PMD5000 measurement system includes the TXP5016 mainframe (see page 1179) and is controlled by an external computer via TCP/IP. The TXP architecture allows a separation of the transmitter and receiver units into two mainframes. The mainframes and control PC can be connected to the local area network (LAN) and are not necessarily tied to a single location.

The transmitter unit consists of the DPC5500 Series Deterministic Polarization Controller, which adjusts the necessary states of polarization. These modules are key components for the Jones Matrix Eigen analysis (JME). (Refer to the PMD application note on pages 1194 - 1195 for more information).

For the analyzer unit, either the IPM5300 Series High Speed In-Line Polarimeter or the PAX5720 Series High Dynamic Range Polarimeter may be selected, depending on the application requirements.

The fast IPM5300 is especially suited for PMD measurements on fibers with rapid changes in environmental conditions, which can affect the PMD, and therefore, faster measurement speeds (PMD5000FIN) are required. The high dynamic power range of the PAX5720 Series is required for differential group delay (DGD) measurements of components with bandpass characteristics.

**For More Details on our Line of Polarimeter Tools, See Page 1180**



# PMD and PDL Measurement Systems (Page 2 of 4)

## Features

- Jones Matrix PMD Measurement Method
- Ideal for PMD and PDL on Optical Fiber
- Includes a DPC5500 Deterministic Polarization Controller and an IPM5300 Fast In-Line Polarimeter
- DGD Meter with a 0.001-400 ps Range
- DGD Repeatability* of <0.01 ps
- 30 dB Maximum Insertion Loss of DUT**
- Typical Measurement Time for 1 (100) Data Point(s); 0.5 s (50 s)

** For PMD <0.3 ps*
*** At Input Power ≥1 mW*

### General PMD Measurements

The PMD5000FIN is recommended for general polarization mode dispersion (PMD) measurements. PMD and PDL analysis of fibers and broadband components can be performed with this model, including the PMD measurement of passive components (couplers, isolators) and active components (EDFAs and PDFAs).

### PMD Measurements on Narrow Bandwidth Components

Narrow bandwidth components (e.g., optical filters, Bragg gratings, and OADM) are considerably more challenging to characterize. In narrowband component manufacturing, it is important to assess the PDL in the “wings” of the pass band (typically around 20 dB) to determine if the component meets the isolation requirement for adjacent channels. The PMD5000 System with a PAX5720IR3 polarimeter as a receiver, which some non-standard systems include, facilitates this assessment and thereby increases production yield.

**System Configurations - See Pages 1178 - 1179**

**Thorlabs is recognized throughout the photonics community for providing novel polarization measurement and control solutions. As can be seen from our selection of related products, our team of polarization experts has tackled many measurement and control problems in this specialized field. The selection guide shown on page 1195 describes the various systems offered for a broad array of PMD and PDL measurements.**

## System Capabilities

### PMD Measurement

- PMD Measurements Based on the Jones Matrix Eigenanalysis
- PMD Monitoring of Dark Channels of an Optical Network
- PMD Measurement in Accordance with ITU-T G.650
- DGD Meter with a Range of 0.001 ps to 400 ps
- High Resolution PMD Measurement of Narrowband Components
- Mean and RMS Values of PMD, Plus 2nd Order PMD
- Long-Term PMD Measurement
- Measures the Principal States of Polarization as a Function of Wavelength
- Support of External Laser Sources (Agilent, Ando, etc.).

### PDL Measurement

- PDL Measurements Based on Jones Matrix Eigenanalysis
- PDL Measurement in the Range of 0 to 50 dB with <0.02 dB Reproducibility
- Measurement of the Wavelength and Time Dependency of the PMD and PDL Changes

### Polarization Analysis

- Dynamic Polarization Measurements in Real Time
- Fiber or Free-Space Input (Depending on Polarimeter Module)
- Long-Term Observation of Polarization Effects
- Polarimeter Measurements with Azimuth and Ellipticity Angle Accuracy <0.25°
- Large Dynamic Range: 60 dBm (PAX5720IR3)
- Fast Measurement Speed of 1 Msample/s (IPM5300)
- Operating Wavelength Range: 1510 - 1640 nm

### Polarization Control

- Deterministic Polarization Control and Locking
- Accurate and Precise SOP Tracing
- SOP Scrambling
- Wavelength Range of 1510-1640 nm
- Dynamic Range of 35 dB (-20 to 15 dBm)
- Fast SOP Adjustments are <150 µs (Typ)

### ER Measurement on PMF (only with PAX5710IR3)

- Extinction Ratio Measurement of PM Fiber
- Measurement Range of 0 to 50 dB

# PMD and PDL Measurement Systems (Page 3 of 4)

## Application Note: PMD Measurement

### Polarization Mode Dispersion

Polarization Mode Dispersion (PMD) originates from the polarization dependency of an optical signal's propagation speed, which results in a delay in the arrival time of a bit stream for orthogonally launched polarization states and may lead to bit errors. For a given wavelength, the maximum delay between all pairs of orthogonal polarization states at a given time is called the differential group delay, DGD (see Figure 1). DGD is measured in picoseconds (ps). The polarization states associated with the fastest and slowest speeds are called principal states of polarization (PSP). In general, the PSPs are not associated with the fast and slow axes (the Eigen-Polarizations) of a birefringent component.

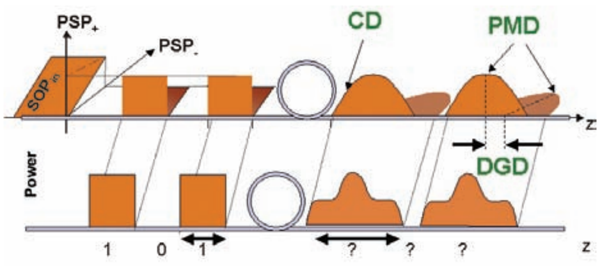



Figure 1 - Differential Group Delay

DGD is the primary measurement parameter for all PMD meters. The measurement of the DGD involves the determination of a phase change (arrival time difference) for a given frequency (wavelength) change. For a Jones Matrix Eigenanalysis, the polarization transformation function (the Jones Matrix) must be determined at two different wavelengths. The changes in the phases of the two Jones matrices divided by the wavelength difference (step size) yields the DGD value.

The PMD5000 is ideally suited for characterizing DGD and PMD in devices with random mode coupling, such as optical fibers, by using the Jones Matrix Eigenanalysis (JME) method. The JME method is the only technique providing wavelength-dependent information about the DGD and the PSP. It is also the only method that shows agreement between the measured DGD histogram and the theoretical Maxwell distribution.

### Jones Matrix Eigenanalysis

The Jones Matrix Eigenanalysis (JME) provides the most comprehensive information about fiber links and active components. Besides the DGD over wavelength and the PMD value, the JME also returns the second order PMD as well as PDL and measures insertion loss versus wavelength. In general, monochromatic light with different input polarizations is fed into the optical device, and the resulting output SOP are measured. A convenient way to measure the Jones Matrix was presented by B.L. Heffner. Linearly polarized light enters the optical element parallel to the X-axis, parallel to the Y-axis, and parallel to the bisector of the angle between the positive X- and Y-axes. The three linear input states and the three corresponding polarization output states are used to calculate the 2 x 2 complex Jones matrix. In a pure mathematical sense, only two pairs of input and output states are needed to calculate a 2 x 2 matrix; however, since optical elements feature Eigen polarization states for which the input polarization is not transformed (i.e., the output polarization is equal to the input polarization), a third unique input polarization is needed.

### PMD in Optical Fiber

Fibers may be modeled as a collection of many infinitesimally small fiber sections, each of which have a different birefringence and Eigen-polarization axes (see Figure 2). Thermal and mechanical stresses will change the polarization properties of these sections. The large number of sections, the randomness in the transformation properties, and environmental sensitivities require a statistical analysis to account for the DGD behavior fully. In a long length of fiber, the DGD (either as a function of time at fixed wavelength or as a function of wavelength at a fixed time) has a Maxwell distribution. The average of the DGD distribution is defined by the ITU standard bodies as the PMD value. Therefore, PMD is independent of the time and wavelength range.

Figure 2 - Model of a Long Fiber

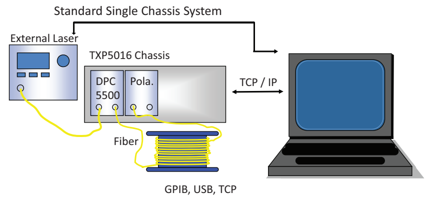
### PMD in Fiber Components

Fiber optic components differ from long lengths of fiber in their thermal and mechanical sensitivity of DGD and PMD. The fixed optical elements integrated in the components are significantly less sensitive to environmental conditions. Fiber optic components have DGD values that are nearly fixed with respect to wavelength. A DGD measurement instrument would therefore produce a normal (Gaussian) distribution. Depending on the test instrument, the width of the distribution is determined by the instrument's performance and not the intrinsic randomness of the polarization modes throughout the component. As in the fiber PMD, the average value of the distribution is the PMD value that quantifies the amount of delay generated by the component. For some fiber optic components, DGD/PMD cannot be measured using the same procedure as those used for systems with random mode coupling. For example, DEMUX filters, with their narrow pass bands, do not allow relatively large frequency steps for high accuracy DGD measurements. Therefore, these filter components require special measurement attention. The PMD5000 Series Polarization Measurement System is designed for analyzing narrow bandwidth components and fiber networks (e.g., single components like Fiber Bragg Gratings (FBG) as well as single channels of a complex optical network with multiplexers and active components like EDFAs).

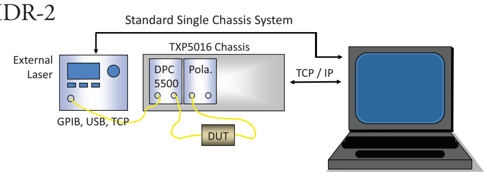
# PMD and PDL Measurement Systems (Page 4 of 4)

## Standard Systems

| Application | Hardware Requirements |
|---|---|
| **PMD and PDL Measurements of Fibers** | **Preconfigured System:** PMD5000FIN-2<br>**Mainframe:** TXP5016<br>**Laser Source:** External Third-Party TLS<br>**SOP Controller:** DPC5500<br>**Polarimeter:** IPM5300<br>(Fully Configured Laptop Included) |



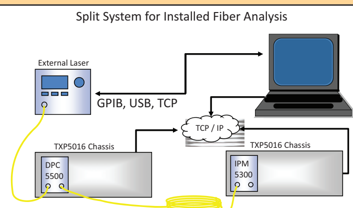

| Application | Hardware Requirements |
|---|---|
| **PMD and PDL Measurements of Narrow Bandwidth Devices** | **Preconfigured System:** PMD5000HDR-2<br>**Mainframe:** TXP5016<br>**Laser Source:** Third-Party TLS<br>**SOP Controller:** DPC5500<br>**Polarimeter:** PAX5720IR3<br>(Fully Configured Laptop Included) |



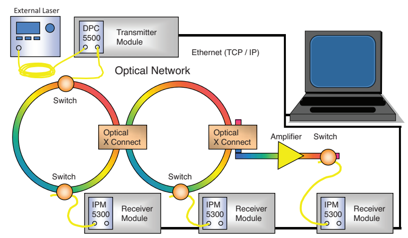

| ITEM # | $ | £ | € | RMB | DESCRIPTION |
|---|---|---|---|---|---|
| PMD5000FIN-2 | $ 34,260.00 | £ 24,667.20 | € 29.806,20 | ¥ 273,052.20 | PMD/PDL Analyzer for External Tunable Laser and IPM5300 Polarimeter |
| PMD5000HDR-2 | $ 30,660.00 | £ 22,075.20 | € 26.674,20 | ¥ 244,360.20 | PMD/PDL Analyzer for External Tunable Laser and PAX5720IR3 Polarimeter |

## Non-Standard Systems

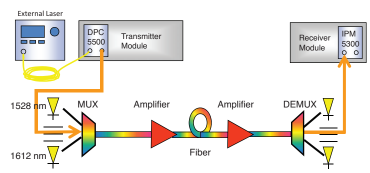
| Application | Hardware Requirements |
|---|---|
| **PMD and PDL Measurements on Installed Fibers with Split Transmitter and Receiver** | **Non-Standard System:**<br>**Mainframes:** TXP5016<br>**Laser Source:** Third-Party TLS<br>**SOP Controller:** DPC5500<br>**Polarimeter:** IPM5300<br>(Fully Configured Laptop Included) |




| Application | Hardware Requirements |
|---|---|
| **PMD and PDL Measurements on Optical Networks with a Single Transmitter and Several Receivers** | **Non-Standard System:**<br>**Mainframes:** TXP5016<br>**Laser Source:** Third-Party TLS<br>**SOP Controller:** DPC5500<br>**Polarimeter:** IPM5300<br>(Fully Configured Laptop Included) |




| Application | Hardware Requirements |
|---|---|
| **PMD and PDL Monitoring on a Live Fiber with Traffic** | **Non-Standard System:**<br>**Mainframes:** TXP5016<br>**Laser Source:** Third-Party TLS<br>**SOP Controller:** DPC5500<br>**Polarimeter:** IPM5300<br>(Fully Configured Laptop Included) |




Please contact *Europe@thorlabs.com* to order the non-standard systems mentioned above.



See pages 1010 - 1012