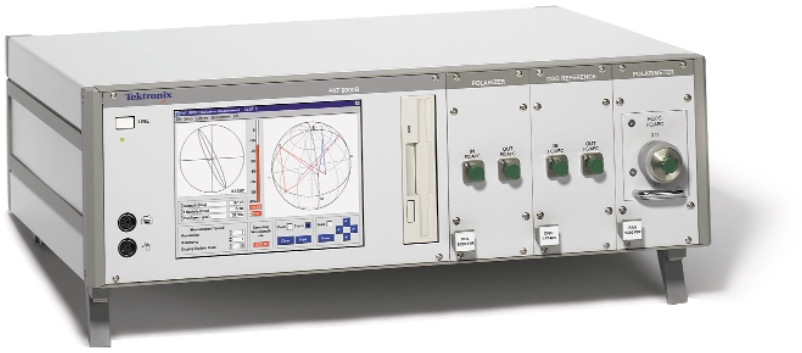
Polarization, PDL and PMD Analyzer

▶ PAT 9000B



▶ Features & Benefits

Accurate Measurements of Polarization Mode Dispersion (PMD), Polarization Dependent Loss (PDL), Polarization States and Stokes Parameters

Based on Jones Matrix Eigenanalysis for Fiber Optical Components and Fibers

Complete Polarimetric Characterization of Optical Components and Fibers

Wide Wavelength Range From 960 to 1160 nm and 1200 to 1700 nm

High Sensitivity Down to –70 dBm

Operation with Various Tunable Laser Sources

Modular Design for Fiber Optic and Free Space Measurements

Removable and Compact Optical Polarimeter Head

▶ Applications

PMD and PDL Measurements of Fibers and Optical Components

Degree of Polarization (DOP) Measurement for Raman Amplifiers

Alignment of Polarization Maintaining Fibers to Laser Chips

PMD Measurement of Deployed Fiber

State and Degree of Polarization (SOP and DOP) Analysis

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PAT 9000B – Polarization, PDL and PMD Analyzer

The PAT 9000B has been specifically designed for accurate measurements of polarization related effects in fiber and in free space optical applications. The PAT 9000B provides an uncompromised polarization-tailored measurement set for fiber optic and free space applications. It is the ideal tool for all kinds of polarization related measurements tasks in R&D laboratories and for final inspection in manufacturing.

Applications include measurement capabilities for all parameters of polarization mode dispersion and polarization dependent loss, for the azimuth and ellipticity angles of the polarization ellipse and for the degree of polarization. The PAT 9000B can also be used for optimal polarization alignment of two cascaded optical elements, e.g., laser chips to polarization maintaining fiber pigtails.

The measurements are primarily based on the Jones Matrix Eigenanalysis (JME) method yielding all four elements of the Jones Matrix for a device under test (DUT). The Jones Matrix of a DUT allows a complete characterization of the polarimetric transformation properties of any input polarization state.

The JME method is known to yield the most accurate results compared to other techniques. In combination with a tunable laser source controlled via the GPIB interface, the JME method gives complete wavelength dependent information on polarization dependent losses and polarization mode dispersion including the differential group delay distribution, the location of the principal states of polarization, as well as higher-order polarization mode coefficients.

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Modularity and Flexibility

The PAT 9000B chassis can be equipped with three different plug-in modules. There are FIR modules for the far infrared wavelength region ranging from 1200 to 1700 nm covering all fiber optic transmission windows and NIR modules for the near infrared range from 960 to 1160 nm for the 980 nm pump laser telecom application.

The polarimeter modules PAN 9300NIR/FIR are the measurement tools for any polarization analysis and for all JME measurement applications (PMD and PDL measurements). The PAN 9300NIR/FIR comprises the module and a very compact optical head. The optical head is removable from the module and the PAT 9000B chassis to allow for excellent handling and positioning of the optical head in free space measurement applications. The optical head accepts angled and non-angled FC connectors and can be equipped with 10 dB or 17 dB attenuators for high-power applications. The fiber adapter is removable and allows free space optics measurements with a wide aperture photodiode.

The polarizer modules POL 9320NIR/FIR deliver highly linear polarization states rotatable to any inclination angle with regard to the horizontal axis. It is needed for all JME measurement applications. It can be operated in the PAT 9000B without the polarimeter module for applications where no polarimeters are needed.

The PAT 9000B offers an automatic optimization routine for optimal transmission through the POL 9320 module and the DUT and thus eliminates the problem of unfavorable measurement conditions on PMD or PDL, which can occur during a wavelength scan.

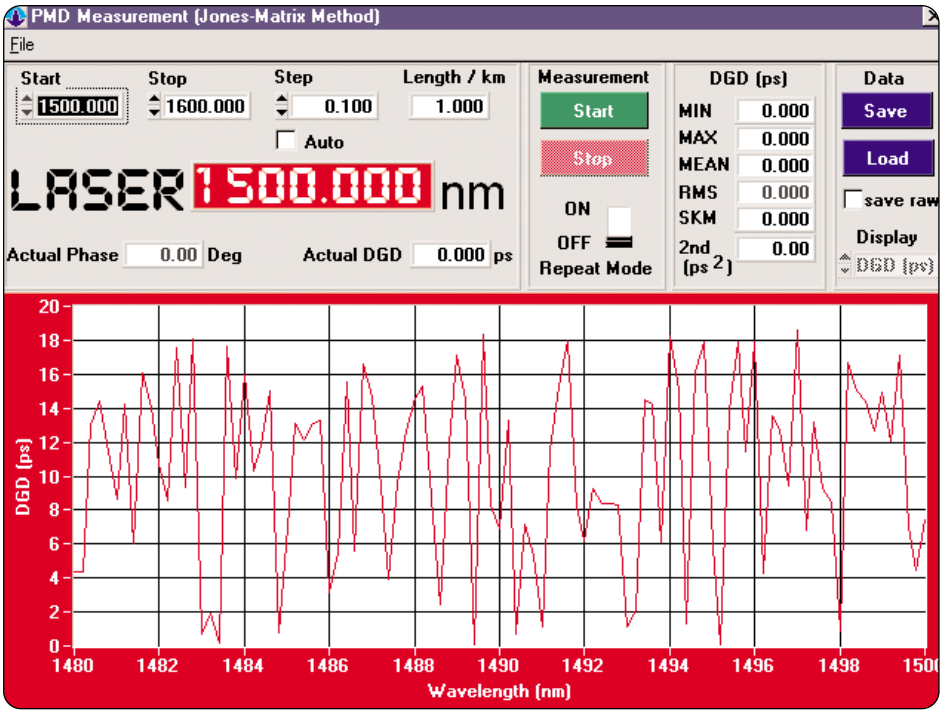
The PAT 9000B supports almost all commercially available wide range tunable laser sources controllable via GPIB interface.

A completely passive DGD reference module can be provided which enables a user to demonstrate PMD measurements with a certified PMD reference value in the range of a few ps PMD. The module is one slot wide and fits in a PAT 9000B.

Polarization Mode Dispersion Analysis

The key parameters on polarization mode dispersion (PMD) in fibers or optical components are the differential group delay (DGD), the principal states of polarization (PSP), the PMD value and its variation with wavelength. For any component or fiber there exist two input polarization states with the slowest and with the fastest signal propagation speed, called the fast and the slow principal states. The DGD is the difference in group delay at a specific wavelength between the slow and the fast PSP.

The PAT 9000B offers the Jones Matrix Eigenanalysis (JME) method for the most complete characterization of the polarization mode dispersion. By scanning the tunable laser over a wavelength range, the DGD and PSPs versus wavelength are measured and plotted on the screen. The mean and RMS PMD values are then evaluated. The DGD distribution can be visualized in a histogram with Maxwellian fit, as well. The measurements can be repeated automatically to monitor temporal variations.



▶ *Differential group delay data as function of wavelength, taken with the Jones Matrix method.*

This method can be ideally applied to measure DGD and PMD in fibers with random mode coupling and in optical components like isolators or demultiplexers with low mode coupling. The optional software package SW PMD HIRES is specially dedicated for narrowband components characterization; e.g., multiplexer, fiber Bragg gratings.

The step size for JME PMD measurements can be dynamically adapted for optimal speed and accuracy.

The PMD of installed fiber links can be done with the package SW PMD EXT/JM and two PAT 9000B chassis.

The PMD measurement methods 3-Stokes parameter-wavelength-scanning method (WLS) and the arc-angle method (ARC) are included in the software package SW PMD for convenience.

Polarization State and Degree of Polarization Measurements

The polarimeter module PAN 9300NIR or FIR is used to analyze the state of polarization (SOP) and the degree of polarization (DOP) of optical signals. The polarimeter set up uses a rotating quarter-waveplate followed by a high extinction ratio polarizer and a photodiode.

The various parameters of the measured polarization state are displayed numerically, in the form of the polarization ellipse and are also converted to a Stokes vector for a representation on the Poincare sphere. The main polarimeter window indicates the measured polarized, unpolarized or total optical power.

PDL Measurements with the PAT 9000B

The PAT 9000B allows the determination of the polarization dependent loss or gain of an optical element based on the Jones Matrix Eigenanalysis. For a single wavelength measurement it is possible to store a reference Jones Matrix for the patch cords, which is subtracted from subsequent measured Jones Matrices with the DUT. This allows the user to eliminate all PDL contributions resulting from connectors and patch cords.

The software add-on SW PDL WL is available to determine the wavelength dependency of the PDL.

Polarization Alignment to PM Fibers

The extinction ratio (ER) is a key qualifier for the optimal launch of polarized light into certain optical elements. The optimal polarization alignment of a laser chip or a polarization maintaining fiber (PMF) to a subsequent PMF are typical applications. The changes of output polarization states are recorded with the PAN 9300 module while manual stress, temperature or wavelength variations are applied to the PMF. These changes follow ideally a circular trace on the Poincare sphere. The diameter of the circle is a measure for the misalignment into the PMF and is referred to as extinction ratio. The software option SW PAN ER ideally covers this application.

PAT 9000B Operating Information

The PAT 9000B is based on a Pentium class CPU and uses Windows as its operating system with three user slots for the POL 9320 and PAN 9300 modules. It is menu-driven via a graphical user interface. An external VGA monitor may be operated optionally for enhanced display capabilities. The measurement results can be stored in ASCII-type data log files on a hard or floppy disk with a date and time stamp. A TCP/IP Ethernet card is included for interfacing with your local network.

Software Packages

The standard software package allows operation of the polarimeter and any polarization state analysis including long term measurements of polarization variations. The option SW TURBO increases the acquisition speed to 200 SOP/DOP values per second. There are different software packages for each measurement application and for the drivers for the different tunable lasers.

ECL Tunable Laser Sources

The PAT 9000B supports almost all commercially available wide range tunable laser sources.

Please contact your Tektronix account manager for more details.

▶ Characteristics

POL 9320NIR/FIR

Wavelength Range –
POL 9320NIR: 960 to 1160 nm.
POL 9320FIR: 1200 to 1700 nm.

Insertion Loss – <1.5 dB*1.

Return Loss – >30 dB.

Extinction Ratio – >50 dB.

Step Size Resolution – 0.18°.

Rotation Range – 0 to 179.82°.

PAT 9000B Slot Width – 1.

Optical Connectors – FC/APC.

PAN 9300NIR/FIR

Wavelength Range –
PAN 9300NIR: 960 to 1160 nm.
PAN 9300FIR: 1200 to 1700 nm.

Speed –
Standard mode: 33 polarization states/sec.
Turbo mode: 200 polarization states/sec*2.

Input Power Range – –70 to +8 dBm.

Active Area of Photodiode – 7 mm^2.

Optical Attenuator Option*3 –
10 dB.
17 dB.

Input Port FO Connector Free Space Operation – FC*4.
≤3 mm null aperture.

PAT 9000B Slot Width – 1.

Dimensions of the Optical Head*5 –
W x H x D: 48 x 60.5 x 139 mm.

*1 For optimal aligned input polarization.

*2 Option SW TURBO required.

*3 PAT 9000B calibration parameters factors are dependent on the attenuator setting; when ordered with the PAT 9000B the factory calibration is done with the attenuator.

*4 The receptacle accepts FC/PC or FC/APC connectors due to internal free space propagation.

*5 Removable from module; optional extension cable required for remote operation.

PAT 9000B Chassis

Number of Slots – 3.

Processor – Pentium class or compatible.

Drives – >2 GB HD, 3.5 in. floppy disk.

Printer Interface – LPT1.

IEEE 488 Interface – 24-Pin IEEE 488.

Output Ports – 3 analog outputs, ext. VGA monitor, mouse, keyboard.

Line Voltage (Automatically Switching) –
115 V + 15%/–20% resp. 230 V + 15%/–20%.

Line Frequency – 50 to 60 Hz.

Operating Temperature – 10 to 40 °C.

Storage Temperature – –30 to 70 °C.

Dimensions (W x H x D)*6 – 449 x 132 x 419 mm.

Weight*7 – <10 kg.

*6 Dimensions of chassis without feet, including PAN head.

*7 Including POL 9320 and PAN 9300.

SOP and DOP Measurements

Input Power Range – –70 to +8 dBm.

Accuracy of the Elevation Angle*8 – <0.25°*9, *10.

Accuracy of the Ellipticity Angle*8 – <0.25°*10.

Accuracy of the Normalized Stokes Components S_1, S_2, S_3 – <0.005*9, *10.

Accuracy of the Degree of Polarization (DOP) – ±2% f.s.*11.

The technical data are valid at 23 ±5 °C and 45 ±15% relative humidity.

*8 Elevation angle is defined as the inclination angle of the major axis of the polarization ellipse to the horizontal axis. The ellipticity angle is given as arctan(b/a) with b the length of the minor axis and a the length of major axis of the polarization ellipse.

*9 Any SOP with –30 °C <ellipticity <30 °C.

*10 Typically a factor of 2 less accuracy in turbo mode.

*11 $P_{in} \geq$ –40 dBm at 1550 nm, w/o optical attenuator; for other wavelengths guaranteed by design.

PDL and PDG Measurements, Jones Matrix Eigenanalysis

PDL Measurement Range – 0 to 50 dB.

Repeatability – ±0.02 dB*[12].

Dynamic Range – >55 dB*[13].

Measurement Time – >0.5 s.
The technical data are valid at 23 ± 5 °C and 45 ±15% relative humidity.

PMD Measurement, Jones Matrix Eigenanalysis

DGD Measurement Range –
1310 nm: 0.001 ps to 280 ps.
1550 nm*[14]: 0.001 ps to 400 ps.

Repeatability – <0.01 ps*[15].

Maximum Insertion Loss of DUT*[16] – 55 dB.

Typical Measuring Time*[17] –
1/100 Datapoints: 2 s/100 s.
The technical data are valid at 23 ±5 °C and 45 ±15% relative humidity.

*[12] PDL <3 dB.

*[13] P_{in} ≥0dBm at input port of POL 9320.

*[14] Maximum measurable DGD is limited by the smallest possible wavelength step. The given values are for a 10 pm step size.

*[15] PMD <0.3 ps.

*[16] P_{in} ≥1 mW.

*[17] If the scan speed of the laser is not a limiting factor.

PMD Measurement	Arc-angle Method	3-Stokes Parameter Wavelength Scanning Method
DGD Measurement Range		
1310 nm	0.001 ps to 280 ps	0.050 ps to 280 ps
1550 nm*[18]	0.001 ps to 400 ps	0.050 ps to 400 ps
Repeatability	<0.01 ps*[19]	<0.05 ps*[20]
Maximum Insertion Loss of DUT*[21]	60 dB	60 dB
Typical Measuring Time*[22]	1 s/50 s for 1/100 datapoints	1 s/50 s for 1/100 datapoints

The technical data are valid at 23 ±5 °C and 45 ±15% relative humidity.

*[18] The maximum measurement DGD is limited by the smallest possible wavelength step. The given values are for a 10 pm step size.

*[19] PMD <0.3 ps; if the DUT is free of random mode coupling and the optimal input polarization is hit.

*[20] At 100 nm scanning range.

*[21] P_{in} ≥1 mW.

*[22] If the scan speed of the laser is not a limiting factor.

▶ Ordering Information

PAT 9000B Chassis

PAT 9000B – Chassis, modular controller unit with integrated TFT Display, 3 slots for modules of the 9000 Series, keyboard and mouse, IEEE 488 and Ethernet interface included in the chassis.

Rack 19-32 – 19 in. mounting kit for PAT 9000B.

Software Options

SW TURBO – Turbo mode with 200 measurements/s enabled.

SW PAN ER – Software to measure the extinction ratio of PM fibers and components.

SW PDL WL – Add-on software to measure the PDL Wavelength Dependency (Tunable Laser Source required)*[1].

SW PMD – PMD Analysis Software. Basic module for 3 Stokes Parameter Wavelength Scanning, ARC Angle (PSP) and Jones Matrix Eigenanalysis (JME)*[1].

SW PMD HIRES – PMD Analysis Software for narrow band devices with Jones Matrix Eigenanalysis (JME)*[1].

Please contact your Tektronix account manager for more details about the software available to support most commercially-available tunable lasers.

*[1] Requires a POL 9320 for JME.

Ordering Information Modules for PAT 9000B

PAN 9300FIR – Polarimeter for the Wavelength Range from 1200 nm to 1700 nm, removable Optical Head, Open Beam Input, FC receptable for any FC/PC or FC/APC connector.

PAN 9300NIR – Polarimeter for the wavelength range from 960 nm to 1160 nm, removable Optical Head, Open Beam Input, FC receptable for any FC/PC or FC/APC connector.

PAN ATT10 – 10 dB Attenuator.

PAN ATT17 – 17 dB Attenuator.

PAN EXT – Extension cable to operate the Optical Head outside the module PAN 9300, 1.5 m.

POL 9320FIR – Polarizer Module for PDL/PMD Measurements with automatic setting of Linear Polarization, Wavelength Range 1200 nm to 1700 nm, FC/APC Connector.

POL 9320NIR – Polarizer Module for PDL/PMD Measurements with automatic setting of Linear Polarization, Wavelength Range 960 nm to 1160 nm, FC/APC Connector.

DGD REFERENCE – Module with PMF Reference Fiber with certified measurement DGD vs. wavelength, FC/APC Connectors.

Service Options

CAL PAT-1 – Recalibration of a PAT 9000B with one PAN 9300.

CAL PAT-2 – Recalibration of a PAT 9000B with one PAN 9300 and one POL 9320.

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