santec
The Photonics Pioneer

Polarization Extinction Ratio Meter

PEM-310

OPTICAL MEASUREMENT TEST SYSTEM

Application Notes

Section 1

Instrument Description

Operating Principles, Features, and Specifications.

The PEM-310 Polarization Extinction Ratio Meter provides accurate, real-time information about the polarization state of light in an optical fiber. Incorporating a rapidly-rotating polarizer and a high-sensitivity detector circuit, the PEM-310 can easily measure linear polarization extinction of 40 dB with a 10-Hz refresh rate. In addition, polarization angle and optical power are displayed on the instrument panel. To facilitate usage in production environments, the PEM-310 is fully controllable through the GPIB or RS/232 interface, and provides an analog output for external monitoring.

Input and Output

Input to the PEM-310 is an FC or SC receptacle (non-angle and angle-polish versions are available). The optical signal is collimated by a lens, and is transmitted through the rotating analyzer. High dynamic range is achieved by using Polarcor™ as the analyzer optic. The photodetector signal is processed with a 16-bit A/D circuit, and the polarimetric information is simultaneously displayed on the instrument panel and is also output as analog voltages.

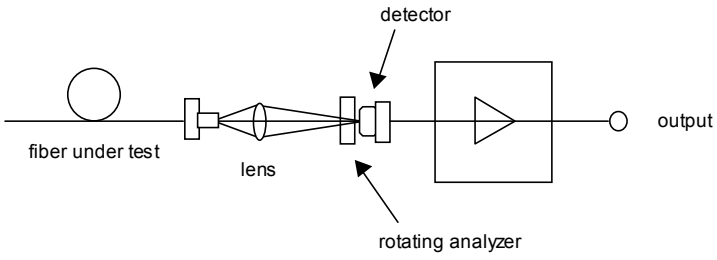

Figure 1. Schematic of the PEM-310 optical path.

Polarimetric Calculations

Real-Time Results
Calculations are updated at a refresh rate of up to 10 Hz, with simultaneous display of PER, power, and ellipse angle.

The polarimetric quantities which describe the optical signal are calculated from the photodetector output. The polarization extinction ratio (PER) is computed by calculating the ratio of the maximum and minimum signals measured by the detector, and the polarization angle (or ellipse angle) is determined by detecting the position of the analyzer at minimum transmission. Finally, optical power is calculated and displayed in units of mW or dBm. To ensure accurate measurements, an offset-cancel function is provided to subtract any spurious signals from the photodetector (caused by dark current or stray light). For reference, the formulas for PER and power are given by:

$$PER = 10\log\frac{I_{\max}}{I_{\min}} \qquad POW = I_{\max} + I_{\min},$$

where I_{max} and I_{min} are the maximum and minimum signals measured by the detector during a complete rotation of the analyzer.

Specifications

Parameter	Units	Specification	Notes
Wavelength range	nm	1520-1600*	power calibrated at 1550
PER range	dB	0-30 0-40	>-30 dBm input >-20 dBm input
PER resolution	dB	0.1 0.3	PER < 30 dB PER > 30 dB
Power measurement	dBm	-40 to +10	
Power resolution	dB	0.1 0.3	>-30 dBm input <-30 dBm input
Polarization angle range	deg	-90 to +90	
Polarization angle resolution	deg	0.45	
DC output (PER) (power) (angle)	V V V	0-2 0-3 0-1.8	0.5V/dB 0.5V/dBm, 2.5V=0 dBm 0.1V/deg, 0.9V=0 deg
GPIB/RS232 communication		standard	see following notes for optional GPIB and RS232 features.
input connector		FC/PC	
DA output		6 pin	
RS232 output		6 pin	
Measurement speed	Hz	10	
Operating temperature	deg C	10-40	

*Additional wavelength regions (980 nm, 1310 nm, 1450 nm, 1480 nm, etc.) are available. Please inquire.

Section 2

External Control

For enhanced performance and utility.

Information about the PER, optical power, and polarization angle are displayed on the instrument panel and are updated in real time. The PEM-310 is truly "plug and play" and requires no computer control for operation. However, the PEM-310 offers several advanced features: full GPIB and RS-232C control, and real-time analog outputs (voltages) corresponding to the PER, power and angle. These features offer the possibility of automating measurements and allow the instrument to be integrated into production environments. In this section we describe the remote commands and the analog outputs, and show an example software utility (available from Santec) which utilizes these features.

GPIB / RS-232C

The PEM-310 can be controlled using either a standard GPIB interface or through the RS-232C (serial) port on a computer. While these command interfaces are fundamentally different, the commands for controlling the PEM-310 are the same for each method. The following table lists the commands and their functions.

Command	Function
OC	Offset cancel (for stray-light cancellation)
PE	Sets output variable to PER (dB)
DP	Sets output variable to optical power (dBm)
WP	Sets output variable to optical power (mW)
AG	Sets output variable to polarization angle (degrees)

In addition, the following command is exclusive for the RS-232C interface:

Command	Function
DI	Receive data

To obtain data through the GPIB interface, a "set variable" command (PE, DP, WP, or AG) must be sent to the instrument, and then each time the software receives input from the GPIB port the value will be equal to the current measurement of the selected variable. To use the RS-232C interface, the variable is set with the same commands, and then the "DI" command is issued. The instrument will then 'echo' back the current measurement value.

The exact details of communicating through the GPIB or RS-232 ports vary by computer language. Please consult your programming manual for more information.

Analog Output

In addition to acquiring data remotely through the GPIB and/or RS-232C ports, the user can directly read data from the analog interface (AIF) port on the back of the PEM-310. Please consult your PEM-310 users manual for a pinout diagram of the AIF connector. The PEM-310 continuously outputs a DC voltage signal corresponding to PER, power, and polarization angle, in the following manner:

Measurement	Voltage range
PER	2V to 0V, corresponds linearly to extinction of 40 to 0 dB (i.e., 20 dB extinction gives a 1V output)
power	3V to 0V, corresponds to optical power in dBm between +10 and –50 (i.e., -20 dBm gives a 1.5V output)
angle	0V to 1.8V, corresponding to angle between 0 and 180 deg.

These voltages can be acquired by an oscilloscope, data acquisition card, or can be used to trigger other instruments.

Optional Functions

The following GPIB/RS-232C commands are available as options:

Command	Function
RFn	Sets measurement speed, selectable between 2.5, 5.0, and 10 Hz (corresponds to n=0,1, or 2).
MF	Stops rotating analyzer at position of maximum transmission
BF	Stops rotating analyzer at position of maximum extinction
MO	Resumes analyzer rotation and normal measurements

An additional analog output is also available:

Measurement	Voltage range
raw detector output	0V to 2.5V

These optional functions greatly extend the functionality of the PEM-310. For example, control of measurement speed using the RF command allows for convenient and fast (10 Hz) updates when performing coarse polarization alignment, and also allows for higher-accuracy measurements to be performed at the lower speed (2.5 Hz).

The other optional commands, MF, BF, and MO, are used in conjunction with the raw detector analog output. When the MF command is issued, the rotation of the analyzer is stopped at the position of maximum transmission, while the BF command stops the analyzer at the position of maximum extinction (or, equivalently, minimum transmission). By stopping at the maximum transmission position (i.e., the analyzer

Enhanced Operation
The motor stop/start feature allows the "worst case" extinction to be evaluated as the fiber is perturbed.

transmission axis is aligned with the polarization state from the fiber), the operator can adjust the source-to-fiber coupling to minimize insertion loss. By stopping at the minimum transmission angle (with the analyzer axis perpendicular to the polarization axis), the change in extinction due to perturbing the fiber (mechanically or thermally) can be logged with >1 kHz speed. This "stopped analyzer" measurement is important for fully characterizing PM fibers and components with extremely narrowband sources. For more details on these measurement issues, please contact a Santec engineer. The MO command resumes normal operation of the rotating analyzer.

Utility Software

Control software may be written in lower-level programming languages such as Basic or C. In addition, there are many programming environments that are specifically designed for hardware control and data acquisition, making it possible for the non-programmer to write sophisticated GUI applications. Examples of such applications include TestPoint, LabView, HP Vee, and DASYLab.

A utility program written in TestPoint is available from Santec. This utility allows access to all GPIB and RS-232C commands and to the analog outputs. The acquisition of analog signals (optional) is accomplished using a low-cost ($50) serial-port data acquisition module.

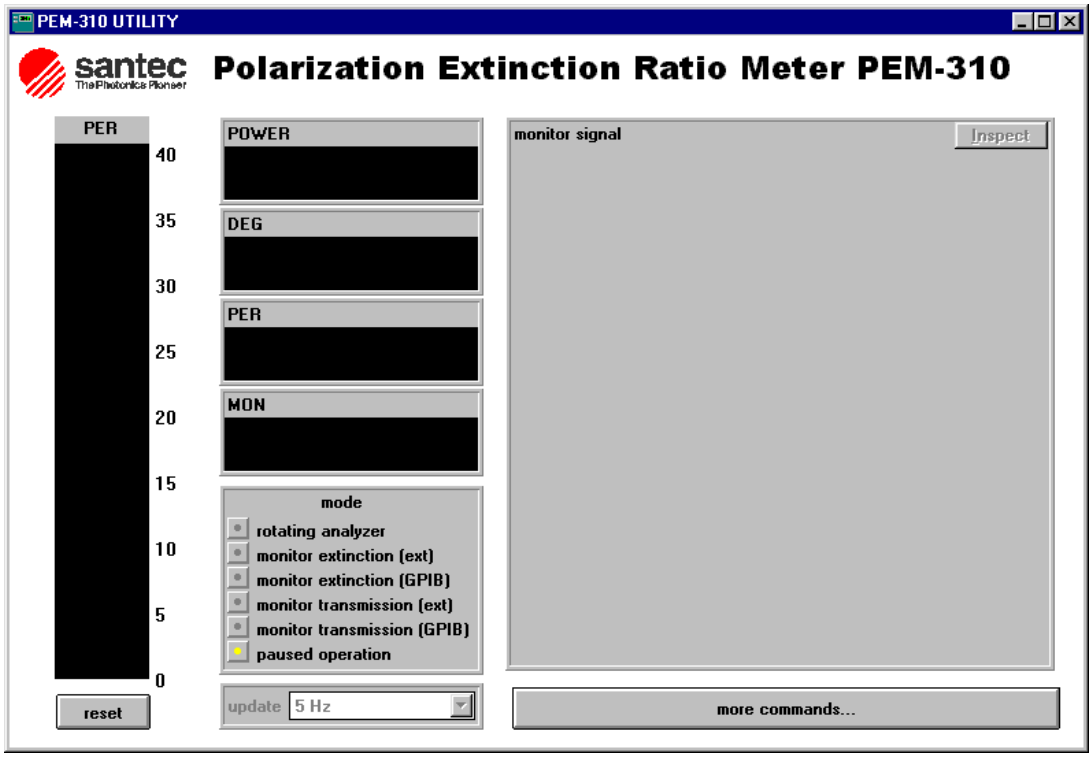

Figure 2. Sample screen shot from utility software.

Custom software can be provided; please contact Santec for more information.