DATA SHEET

N778xC Polarization Test Products

Polarization Analyzers and Polarization Controllers

Overview

Test & measurement capabilities for analyzing polarization properties of optical signals and components are indispensable in today´s optical R&D labs and manufacturing floors. The Keysight N778xC polarization test products enable high-speed, high performance characterization and verification of optical components and sub-systems.

Figure 1: N77xxC optical component test instruments – tunable laser (bottom), optical multiport power meters (left) and polarization test products (right)

Web User Interface but no LAN?

Connect instrument and PC via USB. The instrument shows up as a new drive: double-click the shortcut on that drive. This lets the default browser open an RNDIS connection to the instrument: the graphical user interface appears. It's as simple as that!

KEYSIGHT TECHNOLOGIES

N7781C Polarization Analyzer

The Keysight N7781C is a compact high-speed polarization analyzer that provides comprehensive capabilities for analyzing polarization properties of optical signals. This includes representation of the state of polarization (SOP) on the Poincaré sphere (Stokes parameter). The on-board algorithms together with the on-board calibration data ensure highly accurate operation across a broad wavelength range.

Due to its real time measurement capability of 1 M samples/s, the instrument is well suited for analyzing disturbed and fluctuating signals as well as for control applications requiring real time feedback of polarization information, for example in digital control loops in automated manufacturing test systems.

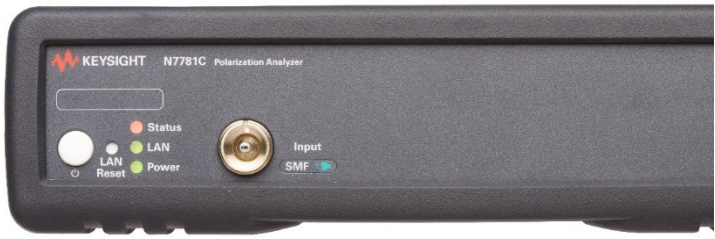
The built-in user interface allows a comprehensive analysis of the obtained measurement data and replaces the Polarization Navigator software that was required with the N7781B, the predecessor of N7781C. Programming uses a new SCPI command set and the instrument is addressed as a VISA resource.

The instrument comes in a compact form factor of just one rack height unit, with LAN and USB interfaces.

Applications

Monitoring and measurement of:

- State of polarization (SOP)
- Stokes parameters
- Degree of polarization (DOP)
- High-speed analysis of SOP/DOP of recirculating signal
- Analysis of PM-fiber extinction ratio
- Performance analysis of polarization scramblers
- Intrusion detection



Key features

- High-speed operation up to 1 M samples/s
- Memory for up to 1 M samples
- Up to 250 kHz analog bandwidth
- Compact size, one rack height unit
- Robust, no moving optical parts

N7785C Synchronous Scrambler

The Keysight Technologies N7785C is a high-speed synchronous scrambler that can repeatably switch through a series of States of Polarization (SOP) with both input and output triggering functions. This unit can operate in various modes:

- As a synchronous scrambler, the device switches the SOP of the output signal in a random but repeatable pattern. Switching of the SOP occurs within a few microseconds. The SOP is stable for a predefined time until it again switches to a new SOP. An electrical trigger input can be used to synchronize the scrambler with external events.
- As an SOP switch, the N7785C allows switching the internal waveplates to user definable angles with very high speed and repeatability.
- As a traditional scrambler, the N7785C varies the output SOP smoothly in a random walk pattern.
- As a polarization stabilizer, the N7785C uses feedback via program commands to set and stabilize the SOP based on an external reference.

Programming uses a new SCPI command set and the instrument is addressed as a VISA resource. The instrument comes in a compact form factor of just one rack height unit, with LAN and USB interfaces. The instrument does not contain any moving optical parts.

Applications

- Recirculating loop experiments: loop-synchronous polarization scrambling
- System test: polarization sensitivity analysis on link/ transmission quality
- Characterization of optical components for polarization dependence
- Polarization stabilization relative to an external reference

Key benefits

- Comprehensive polarization control and management capabilities
- Wavelength options to cover entire CWDM wavelength range
- Compact size, one rack height unit
- Robust, no moving optical parts

N7786C Polarization Synthesizer

The Keysight Technologies N7786C contains a high-speed lithium-niobate based polarization controller and a polarization analyzer that monitors the output signal and provides feedback to the controller. This unit can operate in several modes:

- As a polarization stabilizer, it provides a stable output State of Polarization (SOP) even with fluctuations and drifts of the input SOP. The stabilized output signal is guided in a standard Single-Mode Fiber (SMF). The output SOP can be defined in the following ways:
    - When the set-and-forget switch in the user interface is activated, the current SOP is stored and maintained, even if polarization changes occur on the instrument input.
    - Defined Stokes: the target output SOP can be defined by the user using the Stokes parameters, which are then set using the polarization analyzer feedback.
    - Defined sequence: the device switches the SOP of the output signal in a chosen pattern with a cycling speed of up to 100 kSOPs/s.
- As an SOP switch, the N7786C cycles through a sequence of SOPs at a chosen rate up to more than 40 kHz. The internal settings for the SOP sequence are first determined with the stabilizer function for rapid direct switching. SOP switching occurs within a few microseconds. An electrical trigger input can be used to synchronize the scrambler with external events.
- As a traditional scrambler, the N7786C varies the output SOP in a random way. Full coverage of the Poincaré Sphere can be achieved within a few milliseconds.
- As a polarization analyzer, the instrument provides truly high-speed capabilities: 1 M samples can be taken with a sample rate of up to 1 M samples per second, at up to 250 kHz analog bandwidth.
- As fast-switching polarization controller for single-sweep wavelength dependent PDL measurements in combination with the Photonic Application Software suite (PAS). See the PAS literature for details: www.keysight.com/find/n7700

Many applications of the N7786C are supported by the built-in user interface. Programming uses a new SCPI command set and the instrument is addressed as a VISA resource.

Applications

- Swept-wavelength PDL measurements with tunable laser and photonic application software suite
- Polarization alignment with device axes
- Interferometry: Polarization stabilization to maximize contrast ratio
- Polarization analysis

Key benefits

- Comprehensive polarization stabilization/control
- Fast switching capability
- Enables single-sweep spectral PDL measurements with photonic application software suite
- Covers entire range from 1.3 µm window up to the L-band
- Standalone operation
- Compact and robust, no moving optical parts

N7788C Optical Component Analyzer

The N7788C optical component analyzer provides both polarization control and analysis functions in one instrument for flexible laboratory use.

The N7788C is especially used in combination with a tunable laser for measuring how an optical component changes the SOP of a signal. This measurement uses the unique single-sweep polarization dependent method to determine the parameters Polarization Mode Dispersion (PMD) or Differential Group Delay (DGD) and Polarization Dependent Loss (PDL), based on a generalization of the standardized Jones Matrix Eigenanalysis method (JME).

For these spectral measurements of polarization dependent loss and dispersion, the N7788C is combined with a tunable laser and a new N7700 software engine.

Parameters provided by this measurement include:

- DGD/PMD
- PDL
- Power/loss
- TE/TM-loss
- Jones matrices
- Mueller matrices
- 2nd-order PMD (depolarization + PCD)

Applications

- Fiber characterization: SMF, PMF, DCF
- Passive component testing: filters, isolators, circulators
- Dynamic component/module testing: WSS
- Active component testing: EDFAs, SOAs, VOAs
- Link test: In-channel measurements across amplifiers

Key benefits

- Highest accuracy in a single sweep: No averaging over multiple sweeps required.
- High measurement speed: Complete measurement across C/L-band in less than 10 s.
- Robustness against fiber movement/vibration and drift: Fixing fibers with sticky tape on the table or even operation on isolated optical table is not required! The single-scan measurement fully characterizes each wavelength point in 0.3 ms rather than after multiple sweeps over many seconds.
- No limitation on optical path length of component.
- The internal referencing scheme guarantees reliable and accurate measurements.
- High-speed operation up to 1 M samples/s
- Memory for up to 1 M samples
- Up to 250 kHz analog bandwidth
- Compact size, one rack height unit.
- Robust, no moving optical parts.

Definitions

Generally, all specifications are valid at the stated operating and measurement conditions and settings, with uninterrupted line voltage.

Specifications (guaranteed)

Describes warranted product performance that is valid under the specified conditions. Specifications include guard bands to account for the expected statistical performance distribution, measurement uncertainties, changes in performance due to environmental changes and aging of components.

Typical values (characteristics)

Characteristics describe the product performance that is usually met but not guaranteed. Typical values are based on data from a representative set of instruments.

General characteristics

Give additional information for using the instrument. These are general descriptive terms that do not imply a level of performance.

N7781C Polarization Analyzer Specifications

	N7781C
Operating wavelength range [1]	1240 nm to 1650 nm
Specification wavelength range	1270 nm to 1620 nm
SOP measurement uncertainty [2, 3]	Typical 1.5°
DOP measurement uncertainty [2]	± 2% Typical ± 1.5%
Relative power measurement uncertainty due to PDL [2]	± 0.05 dB Typical ± 0.04 dB
Relative power measurement error due to other factors [2]	Typical ± 0.1 dB
Input power range	–50 dBm to +7 dBm
Maximum safe input power	+12 dBm

1 Range of calibration data.
2 Input power > –30 dBm, averaging time > 10 µs, PDL excluding connector.
3 DOP = 100%.

N7785C Synchronous Scrambler Specifications

	N7785C		
Operating wavelength range	1240 nm to 1650 nm (Option 001) 1480 nm to 1620 nm (Option 002)		
SOP cycling time (τ_{90} [1])	< 10 µs		
Specification wavelength ranges	1270 – 1375 nm (Option 001)	1375 – 1460 nm (Option 001)	1490 – 1620 nm
Sensitivity of output power to polarization scrambling, peak to peak, typical [2]	< 1.0 dB	< 1.0 dB	< 0.4 dB (< 0.18 dB at 1550 nm)
Insertion loss including reference connectors	Typical < 4.5 dB	Typical < 4.0 dB	< 4.0 dB (< 3.75 dB at 1550 nm) Typical < 3.5 dB (< 3.25 dB at 1550 nm)
Maximum safe input power	+20 dBm		

1 Sequence with Stokes vector angles 0° – 90° – 180° – 90° – 0° with 50 kHz. Power range ≥ –10 dBm.
2 At constant input power and input state of polarization (SOP). Including output reference connector.

N7786C Polarization Synthesizer Specifications

	N7786C-115		
Operating wavelength range [1]	1240 nm to 1650 nm		
Specification wavelength ranges	1270 – 1375 nm	1375 – 1490 nm	1490 – 1620 nm
SOP cycling time [4] (τ_{90} [5])	< 10 µs		
Remaining SOP error at input SOP movement rate of [3, 6]	Typical < 5.5° at 10 rad/s		
SOP settling time [3, 8]	Typical < 50 ms		
Feedback loop time	Nominal < 150 µs		
SOP measurement uncertainty [2, 3]	Typical 1.5°		
DOP measurement uncertainty [2]	± 2.0% Typical ± 1.5%		
Insertion loss including reference connectors	Typical < 5.0 dB	Typical < 4.5 dB (1400 – 1460 nm)	< 4.5 dB (< 4.0 dB at 1550 nm) Typical < 4.0 dB (< 3.5 dB at 1550 nm)
Sensitivity of output power to changing the SOP, peak-peak [9]	Typical < 1.0 dB	Typical < 0.6 dB	Typical < 0.4 dB (< 0.2 dB at 1550 nm)
Relative output power measurement uncertainty due to PDL [9, 10]	Typical ± 0.1 dB	Typical ± 0.16 dB	Typical ± 0.16 dB
Relative output power measurement error due to other factors [2]	Typical ± 0.15 dB	Typical ± 0.15 dB	Typical ± 0.15 dB
Input power range	–38 dBm to +19 dBm		
Maximum safe input power [11]	+20 dBm (1525 – 1620 nm) +16 dBm (1270 – 1375 nm)		

1 Range of calibration data.
2 Input power > –20 dBm, averaging time > 10 µs, PDL excluding connector. The polarization analyzer readout reflects the SOP and power at the instrument output. Thus, effects caused by the internal polarization controller are included.
3 DOP = 100%.
4 The instrument adaptively finds the polarization controller settings to let the SOP cycle through user-defined polarization states (closed-loop operation). After having found these settings, the SOP can cycle through the polarization states in open loop operation.
5 Sequence with Stokes vector angles 0° – 90° – 180° – 90° – 0° with 50 kHz. Power range ≥ –10 dBm.
6 Input power > –10 dBm, wavelength 1550 nm, ambient temperature change of max. ± 1K.
7 This value is defined to be 5 times the standard deviation of the angular SOP error on the Poincaré Sphere. During fast SOP variation at the instrument input, rare excursions from the target are to be expected.
8 Time to find target SOP from an arbitrary polarization state.
9 At constant input power and input State of Polarization (SOP).
10 Excluding the effect of the internal polarization controller.
11 4 dB less if state of polarization is static.

N7788C Component Analyzer Specifications

Specified loss ranges include loss of test device and any additional switches or connections in the optical path.

	N7788C	
Operating wavelength range [1]	1240 nm to 1650 nm	
Specification wavelength ranges	1270 – 1350 nm	1450 nm – 1620 nm
DGD measurement uncertainty [2, 9]	Typical 50 fs ± 0.6% of measured DGD at 2.0 nm resolution Typical 50 fs ± 3.0% of measured DGD at 0.1 nm resolution	
DGD measurement range [9]	0 ps to 1000 ps	
PMD error [3, 9]	Typical 25 fs ± 2.0% of measured PMD	
PMD repeatability [3, 9]	Typical ± 4 fs	
PMD measurement range [3, 9]	0 ps to 300 ps	
PDL measurement uncertainty, typical [4, 9, 10]	± (0.10 dB + 4% of measured PDL)	± (0.05 dB + 4% of measured PDL)
PDL measurement repeatability [9]	Typical ± 0.01 dB	
Insertion loss measurement range [3, 9]	Typical > 41 dB (for higher TLS power levels, increase value accordingly)	

	N7788C, continued		
Specification wavelength ranges	1270 – 1375 nm	1375 – 1490 nm	1490 – 1620 nm
SOP measurement uncertainty [5, 6]	Typical 1.5°		
DOP measurement uncertainty [5]	± 2% Typical ± 1.5%		
Insertion loss including reference connectors	Typical < 6.0 dB	Typical < 5.0 dB (1375 – 1460 nm)	< 5.0 dB (< 4.5 dB at 1550 nm) Typical < 4.5 dB (< 4.0 dB at 1550 nm)
Sensitivity of output power to changing the SOP, peak-peak [8]	Typical < 1.5 dB	Typical < 1.0 dB	Typical < 0.4 dB (< 0.15 dB at 1550 nm)
Relative power measurement uncertainty due to PDL [5]	± 0.15 dB Typical ± 0.07 dB	± 0.1 dB Typical ± 0.065 dB	± 0.1 dB Typical ± 0.06 dB
Relative power measurement error due to other factors [5]	Typical ± 0.1 dB		
Input power range	–50 dBm to +7 dBm		
Maximum safe input power	+12 dBm at polarimeter input +15 dBm at scrambler input		
SOP cycling time (τ_{90} [7])	< 10 µs		

1 Range of calibration data.
2 DUT properties: Insertion loss < 30 dB, PDL < 1 dB, DGD < 150 ps. PER of source > 23 dB.
3 DUT properties: Insertion loss < 41 dB, PDL < 3 dB. Specification is typical for PMD > 50 ps. Applies for highly mode-coupled devices such as single mode fibers. Specification applies for PMD being averaged DGD over a wavelength span of max. 100 nm.
4 DUT properties: Insertion loss < 25 dB, PDL < 6 dB. Note: DUT connectors are considered as being part of the DUT. Thus, angled connectors will add to the device's PDL.
5 Using polarimeter input for measurement. Input power > –30 dBm, averaging time > 10 µs, PDL excluding connector.
6 DOP = 100%.
7 Sequence with Stokes vector angles 0° – 90° – 180° – 90° – 0° with 50 kHz. Power range ≥ –10 dBm.
8 At constant input power and input State of Polarization (SOP).
9 Valid only with Keysight 81600B, 8160xA and N777xC tunable laser sources: TLS power set to –6 dBm or higher; sweep over specification wavelength range.
10 Verified at PDL of 0.4 dB.

General Specifications

Line power	AC 100 to 240 V ± 10%, 50/60 Hz, 60 VA max.
Operating temperature	+5°C to +40°C
Operating humidity	15% to 85%, non-condensing
Maximum operating altitude	2000 m (6600 ft)
Pollution protection	Pollution degree 2
Storage temperature	–40°C to +70°C
Warm-up time	20 minutes
Recommended recalibration period	2 years
Dimensions	420 mm × 212 mm × 43 mm (excluding front and back rubber cushions and connectors)
Weight	4 kg (8 lb)
Max. sampling rate	1 M samples/s (N7781C, N7786C, N7788C)
Memory	Up to 1 M samples
Trigger	BNC input port, BNC output port
User interface	**N7781C, N7785C, N7786C, N7788C**
LAN access	Host name (printed on instrument label) or IP address via browser, 1000BASE-T, DHCP optional
USB access	Remote NDIS access via browser, USB 2.0

Ordering Information

Option	N7781C Polarization Analyzer
N7781C-001	Polarization Analyzer, 1240 nm to 1650 nm
N7781C-021	Straight contact connector
N7781C-022	Angled contact connector

Option	N7785C Synchronous Scrambler
N7785C-001	Synchronous Scrambler, 1240 nm to 1650 nm
N7785C-002	Synchronous Scrambler, 1480 nm to 1620 nm
N7785C-022	Angled contact connectors

Option	N7786C Polarization Synthesizer
N7786C-115	Polarization Synthesizer, 1240 nm to 1650 nm
N7786C-022	Angled contact connectors

Option	N7788C Optical Component Analyzer
N7788C-001	Optical Component Analyzer, 1240 nm to 1650 nm
N7788C-031	Straight contact connector at polarimeter input, all other ports are angled
N7788C-032	Angled connect connector at polarimeter input, all other ports are angled

Ordering Information, continued

Option	Recommended Accessories
81000FI	Connector interface FC/PC/SPC
81000HI	Connector interface E-2000 (physical contact)
81000KI	Connector interface SC
81000LI	LC Connector interface for source modules
81000NI	Connector interface, connector type FC - narrow key way
81000SI	Connector interface DIN 47256/4108
N7799C-1CM	Rack Mount Kit for 2 half-width instruments, 1 Rack Height Unit, including low-profile rails. Requires Filler Kit N7799C-0CM for mounting single instrument
N7799C-0CM	Filler Kit for N7799C-1CM. Required for single half-width instrument; includes front panel and base plate
N7799C-DOC	Documentation of N77xxC Platform, Physical Medium

Optical Instruments Online Information

Optical test instruments: www.keysight.com/find/oct

Optical multiport power meters: www.keysight.com/find/MPPM

Polarization solutions: www.keysight.com/find/pol

Optical test instruments accessories: www.keysight.com/comms/oct-accessories

Firmware and driver download: www.keysight.com/find/octfirmware

Keysight photonic discussion forum: www.keysight.com/find/photonic_forum

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