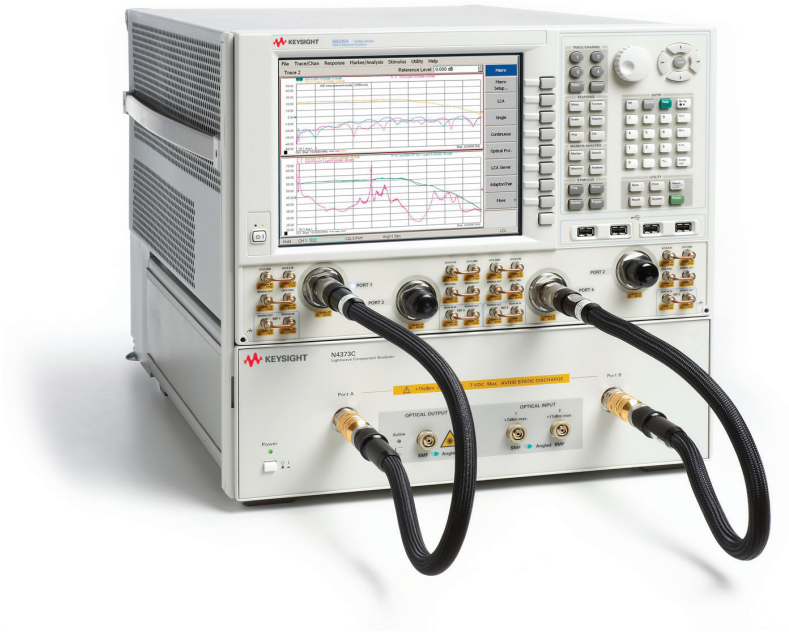
Keysight Technologies
43.5/50/67 GHz Single-Mode Lightwave Component Analyzer for 40/100G Electro-Optical Test

Data Sheet



KEYSIGHT TECHNOLOGIES

General Information

The Keysight's Technologies, Inc. N4373D Lightwave Component Analyzer (LCA), based on the new N522xA PNA Microwave Network Analyzer series offers a modulation bandwidth of 43.5/50/67 GHz which makes it the ideal choice to develop and characterize electro-optical components, for 40G/100GbE and the upcoming 400G and 1 Tbit/s transmission systems.

Accuracy

For these modern optical transmission systems with advanced modulation schemes it is key for the electro-optical components to have very flat S21 transfer function in amplitude and delay. This performance can be achieved only with electro-optical S-parameter test as provided by the N4373D LCA.

In addition fast, accurate, repeatable and traceable characterization of these electro-optical components, like lasers, modulators and detectors and integrated receivers is required, to guarantee the performance with respect to modulation bandwidth, jitter, gain, and distortion.

By optimizing the electrical and the optical design of the N4373D for lowest noise and ripple, the accuracy has been improved by more than a factor of 2, compared to the widely used, the 86030A 50GHz LCA. This increased accuracy improves the yield from tests performed with the N4373D by narrowing margins needed to pass the tested devices.

This advanced design together with temperature-stabilized transmitter and receiver ensures repeatable measurements over hours without recalibration.

Turn-key solution

The fully integrated "turn-key" N4373D helps reduce time to market, compared to the time-consuming development of a self-made setup. In addition you get a fully specified easy transferable and reliable test instrument. With guaranteed specifications Keysight takes the responsibility to provide you with accurate and traceable test results that can only be achieved in a turn-key solution.

High productivity

The N4373D achieves fast measurements by including the N522xA PNA Microwave Network Analyzer. A unique new calibration concept significantly reduces setup time to a maximum of several minutes, depending on the selected measurement parameters. This results in increased productivity in R&D or on the manufacturing floor.

Using the advanced measurement capabilities of the network analyzer, all S-parameter related characteristics of the device under test, like responsivity and 3 dB-cutoff frequency, can be qualified with the new N4373D Lightwave Component Analyzer from 10 MHz to 43.5/50/67 GHz.

Network analyzer

The N4373D LCA is based on the new N522xA PNA Series network analyzer with an identical and well known user interface across all Keysight network analyzers.

General Information (continued)

Key benefits

- High absolute and relative accuracy measurements improve the yield of development and production processes. With the excellent accuracy and reproducibility, measurement results can be compared among test locations world wide
- Traceable balanced measurements up to 67 GHz
- High confidence and fast time-to-market with a NIST-traceable turnkey solution
- Significantly increased productivity using the fast and easy measurement setup with an unique new calibration process leads to lower cost of test
- External optical source input option to test at customer selected wavelength
- Common PNA and LCA user interface across all N437xD LCA series
- Identical LCA software and remote control across the N437xB/D family simplifies integration and backward compatibility to N437xB/C series

Relative frequency response uncertainty
± 0.8 dB @ 50 GHz (typical)
± 1.3 dB @ 65 GHz (typical)
Absolute frequency response uncertainty
± 1.2 dB @ 50 GHz (typical)
± 1.8 dB @ 65 GHz (typical)
Noise floor
–60 (55) dB (A/W) for O/E measurements @ 50 (65) GHz
–64 (59) dB (W/A) for E/O measurements @ 50 (65) GHz
Typical phase uncertainty
± 2.3°
Transmitter wavelength
1550 nm ± 20 nm
1310 nm ± 20 nm
1290 to 1610 nm with external source input
Built-in optical power meter
For fast transmitter power verification
Powerful remote control
State of the art programming interface based on Microsoft .NET or COM and SCPI

General Information (continued)

Measurement capabilities
3 dB cut-off frequency (S21)
Responsivity (S21)
Electrical reflection (S11 or S22)
Group Delay vs. frequency
Insertion Loss (IL)
Transmission bandwidth
Differential and common mode parameters with 4 channel PNA
All electrical S-parameter measurements
Target test devices
Transmitter (E/O)
Mach-Zehnder modulators
Electro-absorption modulators (EAM)
Directly modulated lasers
Transmitter optical subassemblies (TOSA)
Receiver (O/E)
PIN diodes
Avalanche photodiodes (APD)
Receiver optical subassemblies (ROSA) and integrated PIN-TIA receivers
Optical (O/O)
Passive optical components
Optical transmission systems

Keysight N4373D Applications

In digital photonic transmission systems, the performance is ultimately determined by Bit Error Ratio Test (BERT). As this parameter describes the performance of the whole system, it is necessary to design and qualify subcomponents like modulators and and PIN-TIA receivers detectors, which are analog by nature, with different parameters that reflect their individual performance.

These components significantly influence the overall performance of the transmission system with the following parameters:

- 3 dB bandwidth of the electro-optical transmission.
- Relative frequency response, quantifying the electro-optical shape of the conversion.
- Absolute frequency response, relating to the conversion efficiency of signals from the input to the output, or indicating the gain of a receiver.
- Differential gain and common mode rejection.
- Electrical reflection at the RF port.
- Group delay of the electro-optical transfer function.

Only a careful design of these electro-optical components over a wide modulation signal bandwidth guarantees successful operation in the transmission system.

Electro-optical components

The frequency response of detector diodes, modulators and directly modulated lasers typically depends on various parameters, like bias voltages, optical input power, operating current and ambient temperature. To determine the optimum operating point of these devices, an LCA helps by making a fast characterization of the electro-optic transfer function while optimizing these operating conditions.

In manufacturing it is important to be able to monitor the processes in regular time slots to keep up the throughput and yield. In this case the LCA is the tool of choice to monitor transmission characteristic and absolute responsivity of the manufactured device.

Electrical components

Electrical components such as amplifiers, filters and transmission lines are used in modern transmission systems and require characterization to ensure optimal performance. Typical measurements are bandwidth, insertion loss or gain, impedance match and group delay.

Keysight N4373D Features

Turnkey solution

In today's highly competitive environment, short time-to-market with high quality is essential for new products. Instead of developing a home-grown measurement solution, which takes a lot of time and is limited in transferability and support, a fully specified and supported solution helps to focus resources on faster development and on optimizing the manufacturing process.

In the N4373D all optical and electrical components are carefully selected and matched to each other to minimize noise and ripple in the measurement traces. Together with the temperature stabilized environment of the core components, this improves the repeatability and the accuracy of the overall system. Extended factory calibration data at various optical power levels ensures accurate and reliable measurements that can only be achieved with an integrated solution like the N4373D.

Easy calibration

An LCA essentially measures the conversion relation between optical and electrical signals. This is why user calibration of such systems can evolve into a time consuming task. With the calibration process implemented in the N4373D, the tasks that have to be done by the user are reduced to one pure electrical calibration. The calibration with an electrical calibration module is automated and needs only minimal manual interaction.

Built-in performance verification

Sometimes it is necessary to make a quick verification of the validity of the calibration and the performance of the system. The N4373D's unique calibration process allows the user to perform a self-test without external reference devices. This gives full confidence that the system performance is within the user's required uncertainty bands.

State-of-the-art remote control

Testing the frequency response of electro-optical components under a wide range of parameters, which is often necessary in qualification cycles, is very time consuming. To support the user in minimizing the effort for performing this huge number of tests, all functions of the LCA can be controlled remotely via LAN over the state-of-the-art Microsoft .NET or COM interface. The new D series come in addition with the very easy to use industry standard SCPI remote interface.

Based on programming examples for VBA with Excel, Keysight VEE and C++, it is very easy for every user to build applications for their requirements.

These examples cover applications like integration of complete LCA measurement sequences.

Keysight N4373D Features (continued)

Balanced measurements

When working with 4 port PNAs, offers balanced measurements up to 67 GHz to test PIN-TIA combinations and dual drive optical modulators with differential outputs in one measurement. This offers additional analysis capabilities of common mode transfer function or gain imbalance measurements.

Integrated optical power meter

In applications where optical power dependence characterization is needed, the average power meter can be used to set the exact average output power of the LCA transmitter by connecting the LCA optical transmitter output, optionally through an optical attenuator, to the LCA optical receiver input. By adjusting the transmitter output power in the LCA user interface or the optical attenuation, the desired transmitter optical power can be set.

In cases where an unexpectedly low responsivity is measured from the device under test, it is very helpful to get a fast indication of the CW optical power that is launched into the LCA receiver. The cause might be a bad connection or a bent fiber in the setup. For this reason too, a measurement of the average optical power at the LCA receiver is very helpful for fast debugging of the test setup.

Selectable output power of the transmitter

Most PIN diodes and receiver optical subassemblies need to be characterized at various average optical power levels. In this case it is necessary to set the average input power of the device under test to the desired value. The variable average optical output power of the LCA transmitter offers this feature. Together with an external optical attenuator, this range can be extended to all desired optical power levels.

Group delay and length measurements

In some applications it is necessary to determine the electrical or optical length of a device. With the internal length calibration of the electro-optical paths with reference to the electrical and optical inputs or outputs, it is possible to determine the length of the device under test.

External optical source input

For applications where test of opto-electric devices need to be done at a specific optical wavelength like proposed in the IEEE 802.3ba standard, the N4373D-050 option offers an external optical input to the internal modulator where an external tunable laser can be applied. As modulators are polarization sensitive devices, this input is a PMF input to a PMF optical switch to maintain the polarization at the internal modulator and keep loss at a minimum.

This external optical source input is required when O/E devices with integrated filter are to be characterized, or generally when the O/E converter needs to be tested at different wavelengths than the internal source.

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.

Explanation of Terms

Responsivity

For electro-optical devices (e.g. modulators) this describes the ratio of the optical modulated output signal amplitude compared to the RF input amplitude of the device.

For opto-electrical devices (e.g. photodiodes) this describes the ratio of the RF amplitude at the device output to the amplitude of the modulated optical signal input.

Relative frequency response uncertainty

Describes the maximum deviation of the shape of a measured trace from the (unknown) real trace. This specification has strong influence on the accuracy of the 3-dB cut-off frequency determined for the device under test.

Absolute frequency response uncertainty

Describes the maximum difference between any amplitude point of the measured trace and the (unknown) real value. This specification is useful to determine the absolute responsivity of the device versus modulation frequency.

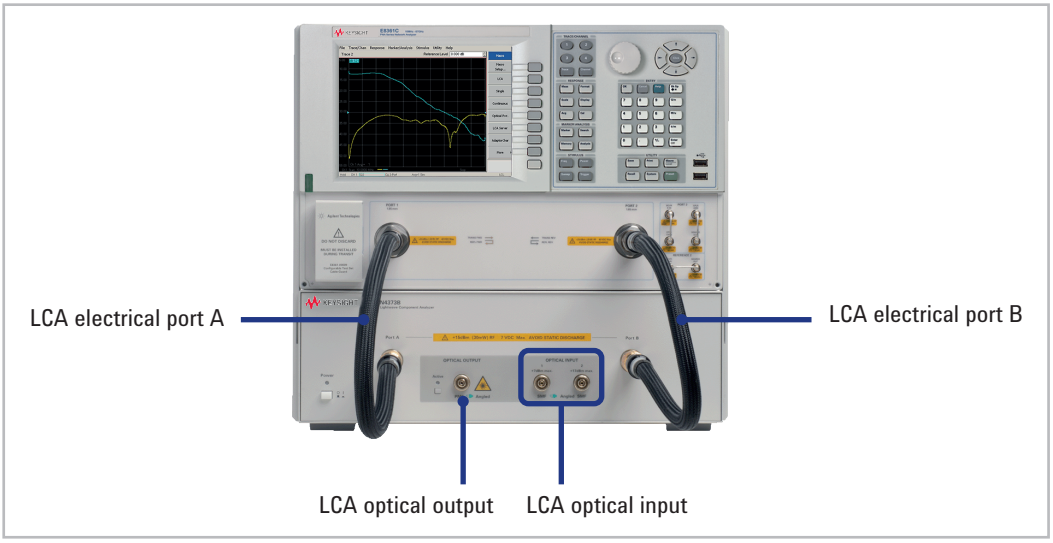
Frequency response repeatability

Describes the deviation of repeated measurement without changing any parameter or connection relative to the average of this measurements.

Minimum measurable frequency response

Describes the average measured responsivity when no modulation signal is present at the device under test. This represents the noise floor of the measurement system.

Definition of LCA Input and Output Names



Keysight N4373D Specifications

Measurement conditions

- Network analyzer set to –1 dBm electrical output power
- Modulation frequency range from 10 MHz to 43.5/50/65 GHz, depending on selected network analyzer option
- Number of averages: 1
- 100 Hz IFBW (“Reduce IF bandwidth at low frequency” enabled) with modulation frequency step size 10 MHz and measurement points on a 10 MHz raster (if not differently stated)
- Network analyzer set to “stepped sweep” – sweep moves in discrete steps”
- Network analyzer configured in reverse coupler configuration (“RCVB B in” to “CPLR THRU”, “SOURCE OUT” to “CPLR ARM”)
- After full two-port electrical calibration using an Electronic Calibration Module, Keysight N4694A, at constant temperature (± 1 °C) with network analyzer set to –15 dBm electrical output power.
- Modulation-bias optimization set to “every sweep”
- Using the supplied flexible test port cables 1.85 mm f m (Part number N4697-60200) for NA options x7z and 2.4 mm f m (Part number 85133-60017) for NA options x4z and x5z.
- Measurement frequency grid equals electrical calibration grid
- Tested from Port 1 to Port 2, respectively from Port 1 to Port 4 for 4-port PNA
- DUT signal delay ≤ 0.1/IF-BW
- Specified temperature range: +20 °C to +26 °C
- After warm-up time of 90 minutes
- Using high quality electrical and optical connectors in perfect condition
- Using internal laser source

The optical test set always has angled connectors. Depending on the selected option (-021 straight, -022 angled) the appropriate jumper cable will be delivered. This jumper cable must always be used in front to the optical test set to protect the connectors at the optical test set and is required for performance tests.

Transmitter and Receiver Specifications

Optical test set		
Operation frequency range	N5227A PNA	10 MHz to 67 GHz
	N5225A PNA	10 MHz to 50 GHz
	N5224A PNA	10 MHz to 43.5 GHz
Connector type	Optical input	SMF angled with Keysight versatile connector interface
	Optical output	
	Optical source input (rear)	PMF angled, with Keysight versatile connector interface, polarization orientation aligned with connector key
	RF	1.85 mm male
LCA optical input		
Operating input wavelength range		1290 nm to 1610 nm [3]
Maximum linear average input power [1]	Optical input 1	+4 dBm @ 1310 nm
		+5 dBm @ 1550 nm
	Optical input 2	+14 dBm @ 1310 nm
		+15 dBm @ 1550 nm
Maximum safe average input power	Optical input 1	+7 dBm
	Optical input 2	+17 dBm
Optical return loss (typical) [1]		> 25 dBo
Average power measurement range [1]	Optical input 1	–25 dBm to +5 dBm on optical input 1
	Optical input 2	–15 dBm to +15 dBm on optical input 2
Average power measurement uncertainty (typical) [1]		± 0.5 dBo
LCA optical output (Internal source)		
Optical modulation index (OMI) at 10 GHz (typical)...		> 27% @ +5 dBm RF
		> 47% @ +10 dBm RF power
Output wavelength	Option -100, -102	(1310 ± 20) nm
	Option -101, -102	(1550 ± 20) nm
Average output power range		–1 dBm to +5 dBm @ 1550 nm
		–2 dBm to +4 dBm @ 1310 nm
Average output power uncertainty (typical) [2]		± 0.5 dBo
Average output power stability, 15 minutes (typical)		± 0.5 dBo

1. Wavelength within range as specified for LCA optical output.
2. After modulator optimization.
3. Excluding water absorption wavelength.

Transmitter and Receiver Specifications (continued)

Optical test set	
External optical source input (-050)	
Recommended optical input power [4]	+8 to +15 dBm
Optical input power damage level	+20 dBm
Typical loss at quadrature bias point	9 dB
Operating input wavelength range	1290 nm to 1610 nm [3]
LCA RF test port input	
Maximum safe input level at port A or B	+15 dBm RF, 7V DC

3. Excluding water absorption wavelength.
4. Required source characteristics: SMSR > 35 dB, line width < 10 MHz, power stability < 0.1 dB pp, PER > 20 dB, unmodulated, single mode.

Specifications for Electrical to Optical Measurements at 1310 nm (E/O Mode)

N4373D system with network analyzer: N5224A, N5225A, N5227A option 200, 201, 219, 400, 401, or 419.

Specifications are valid under the stated measurement conditions.

- At optical input 1 ("+ 7 dBm max"). At optical input 2 ("+ 17 dBm max"), specifications are typically the same for 10 dB higher incident average and modulated optical power.
- For wavelength: (1310 ± 10) nm (Option -100, 102).
- Specifications apply to the frequency range of the used PNA. For N5225A specifications are typical for frequency range 47 GHz to 50 GHz.

System performance		0.05 GHz to 0.2 GHz	0.2 GHz to 0.7 GHz	0.7 GHz to 20 GHz	20 GHz to 50 GHz	50 GHz to 65 GHz
Relative frequency response uncertainty	DUT response	–	–	–		
	≥ –24 dB (W/A) [1]	± 0.8 dBe typical	± 1.0 dBe (± 0.7 dBe, typical)	± 1.1 dBe (± 0.8 dBe, typical)	± 1.1 dBe (± 0.8 dBe, typical)	± 2.4 dBe (± 1.7 dBe, typical)
	≥ –34 dB (W/A) (typical)	± 0.8 dBe	± 0.8 dBe	± 0.8 dBe	± 0.8 dBe	± 1.8 dBe
	≥ –44 dB (W/A) (typical)	± 0.9 dBe	± 0.9 dBe	± 0.9 dBe	± 2.2 dBe	± 4.0 dBe
Absolute frequency response uncertainty	DUT response	–	–	–	–	–
	≥ –24 dB (W/A) [1]	± 1.7 dBe typical	± 2.4 dBe (± 1.7 dBe, typical)	± 2.6 dBe (± 1.8 dBe, typical)	± 2.7 dBe (± 1.9 dBe, typical)	± 3.2 dBe (± 2.2 dBe, typical)
Frequency response repeatability (typical)	DUT response	–	–	–	–	–
	≥ –24 dB (W/A) [1]	± 0.03 dBe	± 0.03 dBe	± 0.05 dBe	± 0.15 dBe	± 0.25 dBe
	≥ –34 dB (W/A)	± 0.03 dBe	± 0.03 dBe	± 0.11 dBe	± 0.4 dBe	± 0.8 dBe
	≥ –44 dB (W/A)	± 0.03 dBe	± 0.03 dBe	± 0.6 dBe	± 1.3 dBe	± 2.2 dBe
Minimum measurable frequency response (noise floor) [2, 4, 5]		–64 dB (W/A)	–64 dB (W/A)	–64 dB (W/A)	–64 dB (W/A)	–59 dB (W/A)
Phase uncertainty (typical) [3]	DUT response	–	–	–	–	–
	≥ –24 dB (W/A) [1]	± 3.5°	± 3.0°	± 2.7°	± 3.7°	± 5.5°
	≥ –34 dB (W/A)	± 3.5°	± 3.5°	± 2.7°	± 4.8°	± 9.0°
Group delay uncertainty		Derived from phase uncertainty, see section "Group delay uncertainty". Example: ± 2.0° ☐ ± 8 ps (1 GHz aperture)				

1. For DUT response max. –13 dB (W/A).
2. IFBW = 10 Hz.
3. Except phase wrap aliasing (Example: A DUT group delay of 5 ns (1 m cable length) requires a frequency step size of ≤ 0.2 GHz to avoid phase wraps). Excluding a constant group delay offset of < ± 0.3 ns typical. (Cable length uncertainty < ± 0.06 m). A constant group delay offset leads to a phase offset $\Delta\varphi = 360° \times \Delta GD \times fmod$ (in deg).
4. Average value over frequency range.
5. In reverse coupler configuration, for normal configuration add typically 35 dB (0.05 GHz to 0.2 GHz), 12 dB (0.2 GHz to 0.7 GHz), 8 dB (> 0.7 GHz).

Specifications for Electrical to Optical Measurements at 1550 nm (E/O Mode)

N4373D system with network analyzer: N5224A, N5225A, N5227A option 200, 201, 219, 400, 401, or 419.

Specifications are valid under the stated measurement conditions.

- At optical input 1 ("+ 7 dBm max"). At optical input 2 ("+ 17 dBm max"), specifications are typically the same for 10 dB higher incident average and modulated optical power.
- For wavelength: (1550 ± 20) nm (Option -101, 102).
- Specifications apply to the frequency range of the used PNA. For N5225A specifications are typical for frequency range 47 GHz to 50 GHz.

System performance		0.05 GHz to 0.2 GHz	0.2 GHz to 0.7 GHz	0.7 GHz to 20 GHz	20 GHz to 50 GHz	50 GHz to 65 GHz
Relative frequency response uncertainty	DUT response	–	–	–		
	≥ –26 dB (W/A) [1]	± 0.7 dBe, typical	± 0.8 dBe (± 0.6 dBe, typical)	± 0.8 dBe (± 0.6 dBe, typical)	± 1.0 dBe (± 0.7 dBe, typical)	± 1.6 dBe (± 1.1 dBe, typical)
	≥ –36 dB (W/A) (typical)	± 0.7 dBe	± 0.6 dBe	± 0.6 dBe	± 0.9 dBe	± 1.3 dBe
	≥ –46 dB (W/A) (typical)	± 0.7 dBe	± 0.7 dBe	± 0.7 dBe	± 1.6 dBe	± 2.7 dBe
Absolute frequency response uncertainty	DUT response	–	–	–	–	–
	≥ –26 dB (W/A) [1]	±1.2 dBe, typical	± 1.8 dBe (± 1.2 dBe, typical)	± 1.8 dBe (± 1.2 dBe, typical)	± 1.9 dBe (± 1.2 dBe, typical)	± 2.7 dBe (± 1.8 dBe, typical)
Frequency response repeatability (typical)	DUT response	–		–	–	–
	≥ –26 dB (W/A) [1]	± 0.02 dBe	± 0.02 dBe	± 0.02 dBe	± 0.1 dBe	± 0.2 dBe
	≥ –36 dB (W/A)	± 0.02 dBe	± 0.02 dBe	± 0.02 dBe	± 0.3 dBe	± 0.5 dBe
	≥ –46 dB (W/A)	± 0.02 dBe	± 0.02 dBe	± 0.1 dBe	± 1 dBe	± 2.0 dBe
Minimum measurable frequency response (noise floor) [2, 4, 5]		–64 dB (W/A)	–64 dB (W/A)	–64 dB (W/A)	–64 dB (W/A)	–59 dB (W/A)
Phase uncertainty (typical) [3]	DUT response	–	–	–	–	–
	≥ –26 dB (W/A) [1]	± 3.5°	± 3.0°	± 2.3°	± 3.2°	± 4.5°
	≥ –36 dB (W/A)	± 5.5°	± 3.5°	± 2.3°	± 4.2°	± 6.5°
Group delay uncertainty		Derived from phase uncertainty, see section "Group delay uncertainty". Example: ± 2.0° ☐ ± 8 ps (1 GHz aperture)				

1. For DUT response max. –13 dB (W/A).
2. IFBW = 10 Hz.
3. Except phase wrap aliasing (Example: A DUT group delay of 5 ns (1 m cable length) requires a frequency step size of ≤ 0.2 GHz to avoid phase wraps). Excluding a constant group delay offset of < ± 0.3 ns typical. (Cable length uncertainty < ± 0.06 m). A constant group delay offset leads to a phase offset $\Delta\varphi = 360° \times \Delta GD \times fmod$ (in deg).
4. Average value over frequency range.
5. In reverse coupler configuration, for normal configuration add typically 35 dB (0.05 GHz to 0.2 GHz), 12 dB (0.2 GHz to 0.7 GHz), 8 dB (> 0.7 GHz).

Specifications for Optical to Electrical Measurements at 1310 nm (O/E Mode)

N4373D system with network analyzer: N5224A, N5225A, N5227A option 200, 201, 219, 400, 401, or 419.

Specifications are valid under the stated measurement conditions.

- For external source optical input, all specifications are typical. [2, 5, 6]
- For wavelength: (1310 ± 10) nm (Option -100, 102).
- Specifications apply to the frequency range of the used PNA. For N5225A specifications are typical for frequency range 47 GHz to 50 GHz.

System performance		0.05 GHz to 0.2 GHz	0.2 GHz to 0.7 GHz	0.7 GHz to 20 GHz	20 GHz to 50 GHz	50 GHz to 65 GHz
Relative frequency response uncertainty [2]	DUT response	–	–	–	–	–
	≥ –19 dB (A/W) [1]	± 0.8 dBe, typical	± 1.0 dBe (± 0.7 dBe) [7]	± 1.1 dBe (± 0.8 dBe) [7]	± 1.7 dBe (± 1.2 dBe) [7]	± 2.2 dBe (± 1.5 dBe) [7]
	≥ –29 dB (A/W) (typical)	± 0.8 dBe	± 0.7 dBe	± 0.8 dBe	± 1.3 dBe	± 1.6 dBe
	≥ –39 dB (A/W) (typical)	± 0.9 dBe	± 0.9 dBe	± 0.9 dBe	± 1.7 dBe	± 2.8 dBe
Absolute frequency response uncertainty [2]	DUT response	–	–	–	–	–
	≥ –29 dB (A/W) [1]	(± 1.5 dBe) [7]	± 2.4 dBe (± 1.5 dBe) [7]	± 2.4 dBe (± 1.5 dBe) [7]	± 2.8 dBe (± 1.8 dBe) [7]	± 3.2 dBe (± 2.1 dBe) [7]
Frequency response repeatability (typical) [2]	DUT response	–	–	–	–	–
	≥ –19 dB (A/W) [1]	± 0.03 dBe	± 0.03 dBe	± 0.05 dBe	± 0.3 dBe	± 0.5 dBe
	≥ –29 dB (A/W)	± 0.03 dBe	± 0.03 dBe	± 0.15 dBe	± 0.5 dBe	± 0.7 dBe
	≥ –39 dB (A/W)	± 0.03 dBe	± 0.03 dBe	± 0.3 dBe	± 0.5 dBe	± 0.8 dBe
Minimum measurable frequency response (noise floor) [2, 3, 8, 9]		–60 dB (A/W)	–60 dB (A/W)	–60 dB (A/W)	–60 dB (A/W)	–55 dB (A/W)
Phase uncertainty (typical) [2, 4]	DUT response	–	–	–	–	–
	≥ –19 dB (A/W) [1]	± 3.5°	± 3.0°	± 2.7°	± 4.4°	± 6.0°
	≥ –29 dB (A/W)	± 5.5°	± 3.5°	± 2.7°	± 4.9°	± 7.5°
Group delay uncertainty		Derived from phase uncertainty, see section "Group delay uncertainty". Example: ± 2.0° → ± 8 ps (1 GHz aperture)				

1. DUT response max. –10 dB (A/W).
2. For +4 dBm average output power from LCA optical output.
3. IFBW = 10 Hz.
4. Except phase wrap aliasing (Example: A DUT group delay of 5 ns (1 m cable length) requires a frequency step size of ≤ 0.2 GHz to avoid phase wraps). Excluding a constant group delay offset of < ± 0.3 ns typical. (Cable length uncertainty < ± 0.06 m). A constant group delay offset leads to a phase offset $\Delta\varphi = 360° \times \Delta GD \times fmod.$ (in deg).
5. After CW responsivity and user calibration with external source.
6. Requires option -100 or -102.
7. Typical with internal source.
8. Average value over frequency range.
9. In reverse coupler configuration, for normal configuration add typically 35 dB (0.05 GHz to 0.2 GHz), 12 dB (0.2 GHz to 0.7 GHz), 8 dB (> 0.7 GHz).

Specifications for Optical to Electrical Measurements at 1550 nm (O/E Mode)

N4373D system with network analyzer: N5224A, N5225A, N5227A option 200, 201, 219, 400, 401, or 419.

Specifications are valid under the stated measurement conditions.

- For external source optical input, all specifications are typical. [2, 5, 6]
- For wavelength: (1550 ± 20) nm (Option -101, 102).
- Specifications apply to the frequency range of the used PNA. For N5225A specifications are typical for frequency range 47 GHz to 50 GHz.

System performance		0.05 GHz to 0.2 GHz	0.2 GHz to 0.7 GHz	0.7 GHz to 20 GHz	20 GHz to 50 GHz	50 GHz to 65 GHz
Relative frequency response uncertainty [2]	DUT response	–	–	–	–	–
	≥ –15 dB (A/W) [1]	± 0.7 dBe, typical	± 0.8 dBe (± 0.6 dBe) [7]	± 0.9 dBe (± 0.7 dBe) [7]	± 1.2 dBe (± 0.8 dBe) [7]	± 1.9 dBe (± 1.3 dBe) [7]
	≥ –25 dB (A/W) (typical)	± 0.8 dBe	± 0.7 dBe	± 0.8 dBe	± 0.9 dBe	± 1.4 dBe
	≥ –35 dB (A/W) (typical)	± 0.9 dBe	± 0.7 dBe	± 0.8 dBe	± 1.3 dBe	± 1.7 dBe
Absolute frequency response uncertainty [2]	DUT response	–	–	–	–	–
	≥ –25 dB (A/W) [1]	(± 1.1 dBe) [7]	± 1.9 dBe (± 1.1 dBe) [7]	±1.9 dBe (± 1.1 dBe) [7]	± 2.0 dBe (± 1.2 dBe) [7]	± 2.8 dBe (± 1.6 dBe) [7]
Frequency response repeatability (typical) [2]	DUT response	–	–	–	–	–
	≥ –15 dB (A/W) [1]	± 0.02 dBe	± 0.02 dBe	± 0.02 dBe	± 0.3 dBe	± 0.5 dBe
	≥ –25 dB (A/W)	± 0.02 dBe	± 0.02 dBe	± 0.02 dBe	± 0.5 dBe	± 0.7 dBe
	≥ –35 dB (A/W)	± 0.02 dBe	± 0.02 dBe	± 0.06 dBe	± 0.5 dBe	± 0.8 dBe
Minimum measurable frequency response (noise floor) [2, 3, 8, 9]		–60 dB (A/W)	–60 dB (A/W)	–60 dB (A/W)	–60 dB (A/W)	–55 dB (A/W)
Phase uncertainty (typical) [2, 4]	DUT response	–	–	–	–	–
	≥ –19 dB (A/W) [1]	± 3.5°	± 3.0°	± 2.4°	± 3.2°	± 5.0°
	≥ –29 dB (A/W)	± 5.5°	± 3.5°	± 2.4°	± 5.0°	± 7.0°
Group delay uncertainty		Derived from phase uncertainty, see section "Group delay uncertainty". Example: ± 2.0° → ± 8 ps (1 GHz aperture)				

1. For DUT response max. –10 dB (A/W).
2. For +5 dBm average output power from LCA optical output.
3. IFBW = 10 Hz.
4. Except phase wrap aliasing (Example: A DUT group delay of 5 ns (1 m cable length) requires a frequency step size of ≤ 0.2 GHz to avoid phase wraps). Excluding a constant group delay offset of < ± 0.3 ns typical. (Cable length uncertainty < ± 0.06 m). A constant group delay offset leads to a phase offset $\Delta\varphi = 360° \times \Delta GD \times fmod.$ (in deg).
5. After CW responsivity and user calibration with external source.
6. Requires option -101 or -102.
7. Typical with internal source.
8. Average value over frequency range.
9. In reverse coupler configuration, for normal configuration add typically 35 dB (0.05 GHz to 0.2 GHz), 12 dB (0.2 GHz to 0.7 GHz), 8 dB (> 0.7 GHz).

Specifications for Optical to Optical Measurements at 1310 nm (O/O Mode)

N4373D system with network analyzer: N5224A, N5225A, N5227A option 200, 201, 219, 400, 401, or 419.

Specifications are valid under the stated measurement conditions.

- At optical input 1 ("+7 dBm max"). At optical input 2 ("+17 dBm max"), specifications are typically the same for 10 dB higher incident average and modulated optical power.
- For external source optical input, all specifications are typical. [2, 5, 6]
- For wavelength: (1310 ± 10) nm (Option -100, 102).
- Specifications apply to the frequency range of the used PNA. For N5225A specifications are typical for frequency range 47 GHz to 50 GHz.

System performance		0.05 GHz to 0.2 GHz	0.2 GHz to 0.7 GHz	0.7 GHz to 20 GHz	20 GHz to 50 GHz	50 GHz to 65 GHz
Relative frequency response uncertainty [2]	DUT response	–	–	–	–	–
	≥ –3 dBe (≥ –1.5 dBo) [4]	± 0.4 dBe, typical (± 0.2 dBo)	± 0.4 dBe (± 0.2 dBo)	± 0.4 dBe (± 0.2 dBo)	± 0.5 dBe (± 0.25 dBo)	± 0.6 dBe (± 0.3 dBo)
	≥ –13 dBe (≥ –6.5 dBo, typical)	± 0.2 dBe (± 0.1 dBo)	± 0.2 dBe (± 0.1 dBo)	± 0.2 dBe (± 0.1 dBo)	± 0.7 dBe (± 0.35 dBo)	± 1.0 dBe (± 0.5 dBo)
	≥ –23 dBe (≥ –11.5 dBo, typical)	± 0.2 dBe (± 0.1 dBo)	± 0.2 dBe (± 0.1 dBo)	± 0.2 dBe (± 0.1 dBo)	± 0.9 dBe (± 0.45 dBo)	± 1.5 dBe (± 0.75 dBo)
Absolute frequency response uncertainty [2]	DUT response	–	–	–	–	–
	≥ –3 dBe (≥ –1.5 dBo) [4]	± 0.9 dBe, typical (± 0.45 dBo)	± 0.9 dBe (± 0.45 dBo)	± 0.9 dBe (± 0.45 dBo)	± 1.0 dBe (± 0.50 dBo)	± 1.2 dBe (± 0.6 dBo)
Frequency response repeatability (typical) [2]	DUT response	–	–	–	–	–
	≥ –3 dBe (≥ –1.5 dBo) [4]	± 0.02 dBe	± 0.02 dBe	± 0.02 dBe	± 0.15 dBe	± 0.3 dBe
	≥ –13 dBe (≥ –6.5 dBo)	± 0.03 dBe	±0.03 dBe	± 0.1 dBe	± 0.4 dBe	± 0.8 dBe
	≥ –23 dBe (≥ –11.5 dBo)	± 0.03 dBe	±0.03 dBe	± 0.1 dBe	± 1 dBe	± 1.5 dBe
Minimum measurable frequency response (noise floor) [1, 2, 7, 8]		–55 dBe, typical (–27.5 dBo)	–42 dBe (–21 dBo)	–42 dBe (–21 dBo)	–42 dBe (–21 dBo)	–36 dBe (–18 dBo)
Phase uncertainty (typical) [2, 3]	DUT response	–	–	–	–	–
	≥ –3 dBe [4] (≥ –1.5 dBo)	± 3.5°	± 3.0°	± 2.2°	± 2.7°	± 3.5°
	≥ –13 dBe (≥ –6.5 dBo)	± 5.5°	± 3.5°	± 2.2°	± 3.3°	± 4.0°
Group delay uncertainty		Derived from phase uncertainty, see section "Group delay uncertainty". Example: ± 2.0° → ± 8 ps (1 GHz aperture)				

1. IFBW = 10 Hz.
2. For +4 dBm average output power from LCA optical output.
3. Except phase wrap aliasing (Example: A DUT group delay of 5 ns (1 m cable length) requires a frequency step size of ≤ 0.2 GHz to avoid phase wraps).
4. For DUT response max. +6 dBe (+3 dBo) gain.
5. After CW responsivity and user calibration with external source.
6. Requires option -100 or -102.
7. Average value over frequency range.
8. In reverse coupler configuration, for normal configuration add typically 35 dB (0.05 GHz to 0.2 GHz), 12 dB (0.2 GHz to 0.7 GHz), 8 dB (> 0.7 GHz).

Specifications for Optical to Optical Measurements at 1550 nm (O/O Mode)

N4373D system with network analyzer: N5224A, N5225A, N5227A option 200, 201, 219, 400, 401, or 419.

Specifications are valid under the stated measurement conditions.

- At optical input 1 ("+7 dBm max"). At optical input 2 ("+17 dBm max"), specifications are typically the same for 10 dB higher incident average and modulated optical power.
- For external source optical input, all specifications are typical. [2, 5, 6]
- For wavelength: (1550 ± 20) nm (Option -101,102).
- Specifications apply to the frequency range of the used PNA. For N5225A specifications are typical for frequency range 47 GHz to 50 GHz.

System performance		0.05 GHz to 0.2 GHz	0.2 GHz to 0.7 GHz	0.7 GHz to 20 GHz	20 GHz to 50 GHz	50 GHz to 65 GHz
Relative frequency response uncertainty [2]	DUT response	–	–	–	–	–
	≥ –3 dBe (≥ –1.5 dBo) [4]	± 0.3 dBe, typical (± 0.15 dBo)	± 0.3 dBe (± 0.15 dBo)	± 0.3 dBe (± 0.15 dBo)	± 0.4 dBe (± 0.2 dBo)	± 0.6 dBe (± 0.3 dBo)
	≥ –13 dBe (≥ –6.5 dBo), (typical)	± 0.2 dBe (± 0.1 dBo)	± 0.2 dBe (± 0.1 dBo)	± 0.2 dBe (± 0.1 dBo)	± 0.6 dBe (± 0.3 dBo)	± 1.0 dBe (± 0.5 dBo)
	≥ –23 dBe (≥ –11.5 dBo), (typical)	± 0.2 dBe (± 0.1 dBo)	± 0.2 dBe (± 0.1 dBo)	± 0.3 dBe (± 0.15 dBo)	± 0.7 dBe (± 0.35 dBo)	±1.3 dBe (± 0.65 dBo)
Absolute frequency response uncertainty [2]	DUT response	–	–	–	–	–
	≥ –3 dBe (≥ –1.5 dBo) [4]	± 0.4 dBe, typical (± 0.2 dBo)	± 0.4 dBe (± 0.2 dBo)	± 0.4 dBe (± 0.2 dBo)	± 0.7 dBe (± 0.35 dBo)	± 0.9 dBe (± 0.45 dBo)
Frequency response repeatability (typical) [2]	DUT response	–	–	–	–	–
	≥ –3 dBe (≥ –1.5 dBo) [4]	± 0.02 dBe	± 0.02 dBe	± 0.02 dBe	± 0.1 dBe	± 0.2 dBe
	≥ –13 dBe (≥ –6.5 dBo)	± 0.02 dBe	± 0.02 dBe	± 0.02 dBe	± 0.3 dBe	± 0.5 dBe
	≥ –23 dBe (≥ –11.5 dBo)	± 0.02 dBe	± 0.02 dBe	± 0.1 dBe	±1.0 dBe	± 2.0 dBe
Minimum measurable frequency response (noise floor) [1, 2, 7, 8]		–55 dBe, typical (–27.5 dBo)	–42 dBe (–21 dBo)	–42 dBe (–21 dBo)	–42 dBe (–21 dBo)	–36 dBe (–18 dBo)
Phase uncertainty (typical) [2, 3]	DUT response	–	–	–	–	–
	≥ –3 dBe [4] (≥ –1.5 dBo)	± 3.5°	± 3.0°	± 2.2°	± 2.6°	± 3.0°
	≥ –13 dBe (≥ –6.5 dBo)	± 5.5°	± 3.5°	± 2.2°	± 3.0°	± 3.5°
Group delay uncertainty		Derived from phase uncertainty, see section "Group delay uncertainty". Example: ± 2.0° → ± 8 ps (1 GHz aperture)				

1. IFBW = 10 Hz.
2. For +5 dBm average output power from LCA optical output.
3. Except phase wrap aliasing (Example: A DUT group delay of 5 ns (1 m cable length) requires a frequency step size of ≤ 0.2 GHz to avoid phase wraps).
4. For DUT response max. +6 dBe (+3 dBo) gain.
5. After CW responsivity and user calibration with external source.
6. Requires option 101 or -102.
7. Average value over frequency range.
8. In reverse coupler configuration, for normal configuration add typically 35 dB (0.05 GHz to 0.2 GHz), 12 dB (0.2 GHz to 0.7 GHz), 8 dB (> 0.7 GHz).

Specifications for Electrical-Electrical Measurements (E/E Mode)

All specifications of the N5224A, N5225A, N5227A option 200, 201, 219, 400, 401, or 419 Network Analyzer apply depending on selected LCA option -x4z, -x5z, -x7z. Please see the corresponding Network Analyzer data sheet and User's Guide.

Group delay uncertainty

For more details see specifications of the N5224A, N5225A, N5227A option 200, 201, 219, 400, 401, or 419.

Group delay

Group delay is computed by measuring the phase change within a specified aperture (for aperture see below):

$$GD\,[s] = \frac{\text{Phase change [deg]}}{\text{Aperture [Hz]} * 360} \qquad \text{(Equation 1)}$$

Group delay uncertainty

Is calculated from the specified phase uncertainty and from the aperture (for aperture see below):

$$GD\,[\pm s] = \frac{\text{Phase uncertainty [}\pm\text{deg]}}{\text{Aperture [Hz]} * 360} * \text{sqrt}(2) \qquad \text{(Equation 2)}$$

Aperture

Determined by the frequency span and the number of points per sweep:

Aperture: (frequency span) / (number of points–1)

GD Range

The maximum group delay is limited to measuring no more than ±180 degrees of phase change within the selected aperture (see Equation 1).

General Characteristics

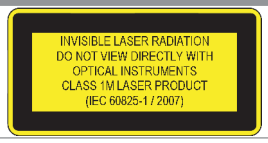
Weight	Net	Packaged
43.5 GHz LCA (2/4 port)	58/61 kg (128/135 lbs)	58/61 kg (128/135 lbs)
50 GHz LCA (2/4 port)	58/61 kg (128/135 lbs)	58/61 kg (128/135 lbs)
67 GHz LCA (2/4 port)	60/63 kg (133/139 lbs)	80/83 kg (177/183 lbs)
Assembled dimensions (H x W x D)		
43.5/50/67 GHz LCA	413 mm x 438 mm x 605 mm (16.3 in x 17.3 in x 23.8 in)	
Power requirements		
43.5/50/67 GHz LCA	100 to 240 V~, 50 to 60 Hz max. 400 VA	

Shipping contents	
43.5/50 GHz LCA	**67 GHz LCA**
N5224/5A NA according to ordered option	N5227A NA according to ordered option
3x 85133-60017 f-m flexible test port MW cable (4-port network analyzer) or 2x 85133-60017 f-m flexible test port MW cable (2-port network analyzer)	3x N4697-60200 f-m flexible test port MW cable (4-port network analyzer) or 2x N4697-60200 f-m flexible test port MW cable (2-port network analyzer)
1x 85056-60006 (2.4 mm f-f adapter)	1x N5520B-FG (1.85 mm f-f adaptor)
1x N4373D optical test set	1x N4373D optical test set
2x 85058-60121 test port adapter (f)-(f)	
3x 81000NI optical adaptor (1x additional 81000NI optical adaptor for external input option #050)	
1x 8121-1242 USB cable	
1x 1150-7896 keyboard	
1x 1150-7799 mouse	
1x E5525-10285 UK6 report	
1x getting started guide	
1x LCA support CD	
2x local power cord	
1x RoHS addendum for photonic T&M products	
1 x N4373-88700 mounting kit	

Connectivity	
LCA electrical input	**LCA electrical output**
1.85 mm (m)	1.85 mm (m)
LCA optical input 1	**LCA optical input 2**
9 µm single-mode angled with Keysight universal adapter	9 µm single-mode angled with Keysight universal adapter
LCA external source input (Option -050 only)	**LCA optical output**
9 µm polarization maintaining single-mode angled, with Keysight universal adapter	9 µm single-mode angled with Keysight universal adapter

General Characteristics (continued)

Storage temperature range
–40 °C to +70 °C
Operating temperature range
+5 °C to +35 °C
Humidity
15% to 80% relative humidity, non-condensing
Altitude (Operating)
0 ... 2000 m
Recommended recalibration period
1 year
Laser safety information
All laser sources listed above are classified as Class 1M according to IEC 60825-1/2007. All laser sources comply with 21 CFR 1040.10 except for deviations pursuant to Laser Notice No. 50, dated 2007-06-24.



Ordering Information

The N4373D consists of an optical test set and an electrical network analyzer which are mechanically connected. To protect your network analyzer investment, Keysight offers the integration of an already owned PNA/PNA-X with the optical test set as listed below.

LCA N4373D family options	
Wavelength options	**Description**
N4373D-100	1310 nm source optical test set
N4373D-101	1550 nm source optical test set
N4373D-102	1300 nm and 1550 nm source optical test set
Network analyzer options	**Description**
N4373D-240	43.5 GHz, 2 ports, single source PNA (N5224A-200) and RF-cables
N4373D-241	43.5 GHz, 2 ports, single source PNA (N5224A-201) with configurable test set and RF-cables
N4373D-242	43.5 GHz, 2 ports, single source PNA (N5224A-219) with configurable test set, extended power range, bias-tees and RF-cables
N4373D-250	50 GHz, 2 ports, single source PNA (N5225A-200) and RF-cables
N4373D-251	50 GHz, 2 ports, single source PNA (N5225A-201) with configurable test set and RF-cables
N4373D-252	50 GHz, 2 ports, single source PNA (N5225A-219) with configurable test set, extended power range, bias-tees and RF-cables
N4373D-270	67 GHz, 2 ports, single source PNA (N5225A-200) and RF-cables
N4373D-271	67 GHz, 2 ports, single source PNA (N5227A-201) with configurable test set and RF-cables
N4373D-272	67 GHz, 2 ports, single source PNA (N5227A-219) with configurable test set, extended power range, bias-tees and RF-cables
N4373D-440	43.5 GHz, 4 ports, dual source PNA (N5224A-400) and RF-cables
N4373D-441	43.5 GHz, 4 ports, dual source PNA (N5224A-401) with configurable test set and RF-cables
N4373D-442	43.5 GHz, 4 ports, dual source PNA (N5224A-419) with configurable test set, extended power range, bias-tees and RF-cables
N4373D-450	50 GHz, 4 ports, dual source PNA (N5225A-400) and RF-cables
N4373D-451	50 GHz, 4 ports, dual source PNA (N5225A-401) with configurable test set and RF-cables
N4373D-452	50 GHz, 4 ports, dual source PNA (N5225A-419) with configurable test set, extended power range, bias-tees and RF-cables
N4373D-470	67 GHz, 4 ports, dual source PNA (N5227A-400) and RF-cables
N4373D-471	67 GHz, 4 ports, dual source PNA (N5227A-401) with configurable test set and RF-cables
N4373D-472	67 GHz, 4 ports, dual source PNA (N5227A-419) with configurable test set, extended power range, bias-tees and RF-cables
N4373D-249	Integration of customer's 43.5 GHz, 2 port PNA (N5224A or N5244A) with any configuration and RF-cables [1]
N4373D-259	Integration of customer's 50 GHz, 2 port PNA (N5225A or N5245A) with any configuration and RF-cables [1]
N4373D-279	Integration of customer's 67 GHz, 2 port PNA (N5227A or N5247A) with any configuration and RF-cables [1]
N4373D-449	Integration of customer's 43.5 GHz, 4 port PNA (N5224A or N5244A) with any configuration and RF-cables [1]
N4373D-459	Integration of customer's 50 GHz, 4 port PNA (N5225A or N5245A) with any configuration and RF-cables [1]
N4373D-479	Integration of customer's 67 GHz, 4 port PNA (N5227A or N5247A) with any configuration and RF-cables [1]

1. Guaranteed specification applies only for the above mentioned network analyzer options.

Ordering Information (continued)

LCA N4373D family options (continued)	
Software options [2,3]	**Description**
N4373D-S10	Time-domain measurements
Connector options	**Description**
N4373D-021	Straight FC/PC SM
N4373D-022	Angled FC/APC SM
Test set options	**Description**
N4373D-050	External optical input
Recommended accessories	
Rack mount kit for network analyzer	**Description**
5063-9217	Rack mount flange kit - 265.9 mm height for installation without handles
E3663AC	Basic rail kit (for system II instruments)
Rack mount kit for LCA test set	**Description**
5063-9214	Rack mount flange kit - 132.6 mm height for installation without handles
E3663AC	Basic rail kit (for system II instruments)

2. For detailed ordering requirements for software options please refer to the LCA configuration guide.
3. Other network analyzer software options can be added though network analyzer upgrades N522xAU-xyz. To be ordered separately.

Optical Instruments Online Information

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

Lightwave component analyzers
www.keysight.com/find/lca

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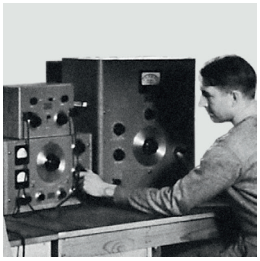

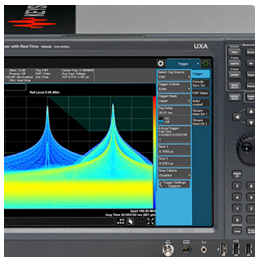

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