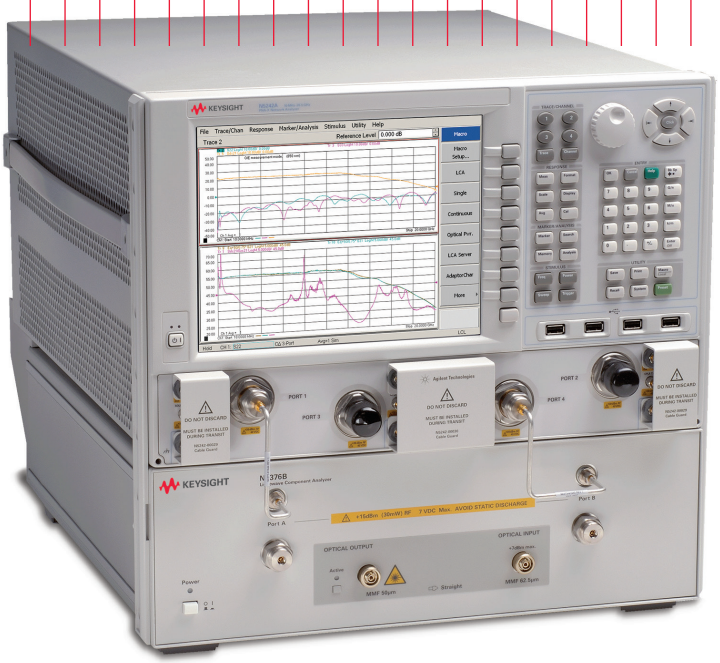
Keysight Technologies
26.5 GHz Multimode Lightwave Component Analyzer

Data Sheet



KEYSIGHT TECHNOLOGIES

General Information

The Keysight Technologies, Inc. N4376D Lightwave Component Analyzer (LCA) is the instrument of choice to test short wavelength 10G Ethernet, Fibre Channel FCx8, FCx10 and FCx16 electro-optical components, with up to 26.5 GHz modulation range. The N4376D also supports the test of transmitter and receivers for optical computer backplanes and optical chip-to-chip connections in high speed computers and server applications.

Modern optical transmission and datacom systems require fast, accurate and repeatable characterization of the core electro-optical components. These core subcomponents (lasers, modulators and detectors) have significant impact on the performance of the transmitter and the receiver with respect to modulation bandwidth, jitter, gain, and distortion of the final transceiver.

For frequency dependent responsivity measurements the N4376D extends opto-electronic S-parameter measurements to multimode devices in the 850 nm wavelength range.

With the latest PNA family of network analyzers, the N4376D guarantees excellent electro-optical measurement performance. In addition a unique new calibration concept significantly reduces time from powering up the LCA until the first calibrated measurement can be made. This increases productivity in R&D and on the manufacturing floor.

The fully integrated “turnkey” solution reduces time to market, compared to the time-consuming development of a self-made setup.

The electrical and optical design of the N4376D is optimized for lowest noise and ripple. IIn addition, this design makes the accuracy independent of the electrical reflextion coefficient. It’s the excellent accuracy that improves the yield from tests performed with the N4376D, by narrowing margins needed to pass the tested devices. Traceability ensures world-wide comparability of test results.

The advanced optical design together with temperature-stabilized transmitter and receiver ensures repeatable measurements over days without recalibration.

Using the advanced measurement capabilities of the network analyzer, all S-parameter related characteristics of the device under test, like responsivity, ripple and 3 dB-cutoff frequency, can be qualified with the new N4376D Lightwave Component Analyzer from 10 MHz to 26.5 GHz.

The network analyzer

The N4376D is based on the new 2- and 4-port N5222A PNA Series microwave network analyzer with an identical and well known user interface across all Keysight network analyzers. Versions with configurable test set and bias-T integrated in the network analyzer are available. The High RF output power ensures a higher optical modulation index (OMI). This gives you the freedom to change between small signal analysis and large signal analysis of your device under test. True mode balanced measurements are possible with 4-port, dual source network analyzers.

General Information (continued)

Key benefits

- Traceable multimode S21 test, right at 850 nm target wavelength
- IEEE 802.3ae launched power distribution leads to test results comparable to the final application
- Fast and easy measurement setup and calibration for all standard tests
- High confidence and fast time-to-market with a 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
- Test right at target launch condition eliminates test uncertainty
- Identical LCA software and remote control across the N437xD family simplifies integration and backward compatibility to N437xB/C series

Operating frequency range
10 MHz to 26.5 GHz
Relative frequency response uncertainty @ 20 GHz
± 1.5 dB
± 1.0 dB (typical)
Absolute frequency response uncertainty @ 20 GHz
± 2.0 dB (typical) for E/O measurements
± 1.8 dB (typical) for O/E measurements
Noise floor @ 20 GHz
–69 dB W/A for E/O measurements
–68 dB A/W for O/E measurements
Transmitter wavelength
850 nm ± 10 nm
Supported connectors
LC or SC straight
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
Warranty
Select coverage
Included: 3-year warranty (return to Keysight), standard
R-51B-001-5Z: 5-year warranty assurance plan (return to Keysight): Priority warranty service includes one-time coverage for an EOS/ESD failure.

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
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)
Optical (O/O)
Passive optical components
Optical multimode fibers
Optical transmission systems

Keysight N4376D Applications

In digital photonic transmission systems, the performance is ultimately determined by bit error ratio test (BERT), as this which describes the performance of the whole system. However it is necessary to design and qualify subcomponents like modulators and receivers, which are analog by nature, with different parameters. Those parameters are core to the overall system performance.

These electro-optical components significantly influence the overall performance of the transmission system via 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.
- Electrical reflection at the RF port

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 amplified or unamplified 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 parallel the LCA also measures the electrical return loss.

In manufacturing it is important to be able to monitor the processes regularly to keep up the throughput and yield. In this case the LCA is the tool of choice to monitor transmission characteristics and absolute responsivity of the manufactured device. The remote control of the N4376D offers another tool to improve the productivity by making automated measurements and analysis of the measured data.

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 linearity. The new switched architecture offers direct access to the electrical outputs and inputs of the network-analyzers just by selecting electrical- to electrical measurement mode in the LCA user interface.

Keysight N4376D 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 N4376D 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 N4376D.

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 new calibration process implemented in the N4376D, the tasks that have to be done by the user are reduced to one pure electrical calibration. The calibration with an electrical microwave 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 N4376D'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.

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 N4376D Features (continued)

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 (ROSA's) 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.

Large signal measurements

LCA S21 measurements are typically small-signal linear transfer function measurements. If an electro-optical component must be tested under large signal conditions, normal balanced measurements might lead to wrong measurement results.

The LCAs based on the 4xx PNA options allow true balanced measurements for differential ports by providing two independent high power RF sources. With this setup the LCA measures the correct S21 transfer function of E/O components, even in the nonlinear regime.

To stimulate O/E components like PIN-TIA receivers under optical large signal conditions, the PNA based LCA offers a variable optical modulation index > 50%.

IEEE 802.3ae multimode launch condition

Multimode measurements are typical much more critical regarding repeatability and stability than single mode measuremts. To minimize these effects it is necessary to have well defined and stable mode filling of the transmitter fiber. The N4376D has typical multimode launch conditions or power-distribution in the transmitter fiber as defined by the IEEE 802.3ae standard.

The IEEE 802.3ae power-distribution compliance of the N4376D transmitter leads to application realistic and repeatable test results.

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.

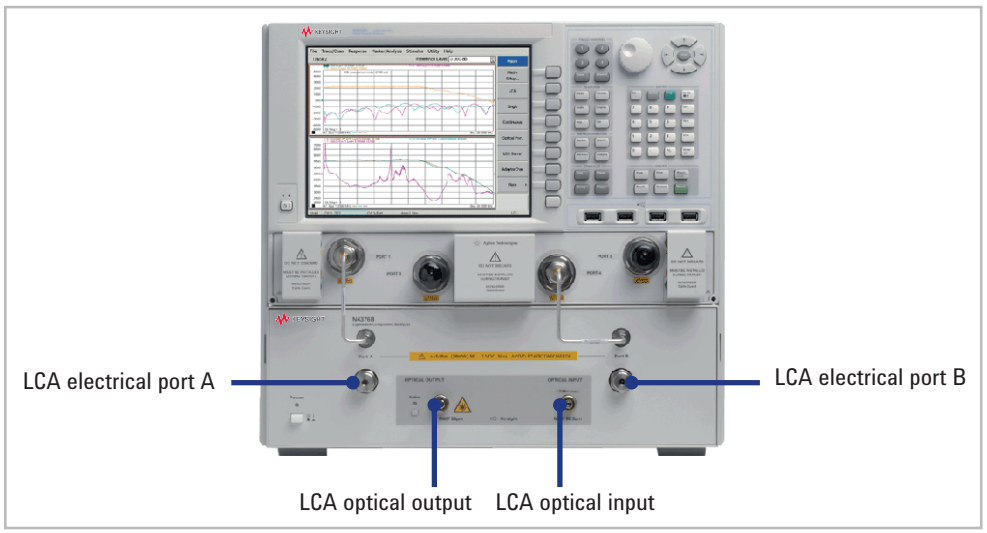
Typical values (characteristics)

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.

Definition of LCA Input and Output Names



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 at 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.

Keysight N4376D Specifications

Measurement conditions

- Modulation frequency range from 10 MHz to 26.5 GHz
- Foreward RF power +3 dBm
- Reverse RF power 0 dBm
- 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”
- All network-analyzer ports configured in standard coupler configuration (“CPLR ARM” to “RCVB B in”, “SOURCE OUT” to “CPLR THRU”)
- After full two-port electrical calibration using an Electronic Calibration Module, Keysight N4691B, at constant temperature (± 1 °C) with network analyzer set to –10 dBm electrical output power
- Modulator bias optimization set to “continous sweep”
- Measurement frequency grid equals electrical calibration grid
- 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 and RF cables in perfect condition
- 50 µm FC/APC to FC/PC patchcord at the input and output
- Launched power distribution according to IEEE 802.3ae - 2002, see figure 1
- Test performed using an optical reference source with return loss better 45 dB, spectral width FWHM < 10 MHz and InGaAs detector
- The optical test set always has angled connectors. Depending on the selected option (-023, -024, -025, -026) 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.

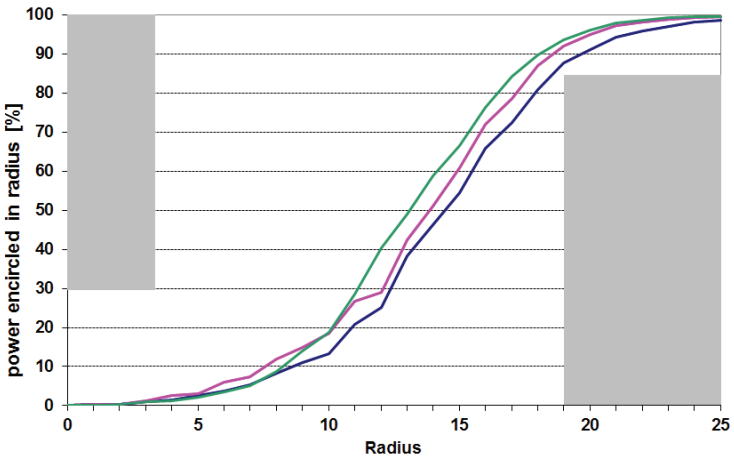


Figure 1. IEEE 802.3ae launch conditions measured with 3 examples

Transmitter and Receiver Specifications

Optical test set		
Operation frequency range		10 MHz to 26.5 GHz
Connector type (Optical test set)	Optical input	62.5 µm MMF angled with Keysight versatile connector interface
	Optical output	50 µm MMF angled with Keysight versatile connector interface
	RF	3.5 mm male
LCA optical input		
Operating input wavelength range		750 nm to 1650 nm
Maximum linear average input power [1]		Optical input: –1 dBm
Maximum safe average input power		Optical input: +3 dBm
Optical return loss (typical) [1]		> 14 dBo
Average power measurement range [1]		–25 dBm to –1 dBm
Average power measurement uncertainty (typical) [1]		± 0.7 dBo
LCA optical output		
Optical modulation index (OMI) at 10 GHz (typical)		25% @ +3 dBm RF (typical)
		31% @ +5 dBm RF (typical)
Output wavelength		(850 ± 10) nm
Lauched power distribution (typical)		According to IEEE 802.3ae - 2002
Average output power range		–5 dBm to –1 dBm
Average output power uncertainty (typical) [2]		± 0.7 dBo
Average output power stability, 15 minutes (typical)		± 0.5 dBo

Wavelength within range as specified for LCA optical output.
After modulator optimization.

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

All specifications of the N5222A option 200, 201, 219, 400, 401, or 419 network analyzer apply depending on selected LCA option -x2z. Please see the corresponding network analyzer data sheet and user's guide.

Optical test set	
Electrical loss of optical test set	< 2.0 dBe (typical)

Specifications for Electro-Optical Measurements at 850 nm (E/O Mode)

N4376D system with network analyzer:
- N5222A-200, N5222A-201, N5222A-219
- N5222A-400, N5222A-401, N5222A-419

Specifications are valid under the stated measurement conditions.
- For wavelength: (850 ± 10) nm

System performance		0.05 GHz to 0.2 GHz	0.2 GHz to 10 GHz	10 GHz to 20 GHz	20 GHz to 26.5 GHz
Relative frequency response uncertainty	DUT response	–	–	–	–
	≥ –26 dB (W/A) [1]	± 1.0 dBe, typical	± 1.3 dBe (± 0.9 dBe, typical)	± 1.5 dBe (± 1.0 dBe, typical)	± 1.0 dBe, typical
	≥ –36 dB (W/A)	± 1.0 dBe, typical	± 0.9 dBe, typical	± 1.0 dBe, typical	± 1.2 dBe, typical
	≥ –46 dB (W/A)	± 1.1 dBe, typical	± 0.9 dBe, typical	± 1.3 dBe, typical	± 2.0 dBe, typical
Absolute frequency response uncertainty (typical)	DUT response	–	–	–	–
	≥ –26 dB (W/A) [1]	± 2.1 dBe	± 2.0 dBe	± 2.0 dBe	± 2.4 dBe, typical
Frequency response repeatability (typical)	DUT response	–	–	–	–
	≥ –26 dB (W/A) [1]	± 0.1 dBe	± 0.1 dBe	± 0.1 dBe	± 0.1 dBe, typical
	≥ –36 dB (W/A)	± 0.15 dBe	± 0.1 dBe	± 0.15 dBe	± 0.25 dBe, typical
Minimum measurable frequency response (noise floor) [2,4]		–65 dB (W/A)	–82 dB (W/A)	–69 dB (W/A)	–69 dB (W/A), typical

1. For DUT optical peak output power ≤ +0 dBm.
2. IFBW = 10 Hz.
3. Note: Average value over frequency range.

Specifications for Opto-Electrical Measurements at 850 nm (O/E Mode)

N4376D system with network analyzer:
- N5222A-200, N5222A-201, N5222A-219
- N5222A-400, N5222A-401, N5222A-419

Specifications are valid under the stated measurement conditions.
- For wavelength: (850 ±10) nm

System performance		0.05 GHz to 0.2 GHz	0.2 GHz to 10 GHz	10 GHz to 20 GHz	20 GHz to 26.5 GHz
Relative frequency response uncertainty	DUT response	–	–	–	–
	≥ –21 dB (A/W) [1]	± 1.0 dBe, typical	± 1.3 dBe (± 0.9 dBe, typical)	± 1.5 dBe (± 1.0 dBe, typical)	± 1.0 dBe, typical
	≥ –31 dB (A/W)	± 1.0 dBe, typical	±0.9 dBe, typical	± 1.1 dBe, typical	± 1.2 dBe, typical
	≥ –41 dB (A/W)	± 1.2 dBe, typical	± 0.9 dBe, typical	± 1.5 dBe, typical	± 1.2 dBe, typical
Absolute frequency response uncertainty (typical)	DUT response	–	–	–	–
	≥ –21 dB (A/W) [1]	± 1.9 dBe	± 1.7 dBe	± 1.8 dBe	± 2.0 dBe, typical
Frequency response repeatability (typical)	DUT response	–	–	–	–
	≥ –21 dB (A/W) [1]	± 0.25 dBe	± 0.1 dBe	± 0.2 dBe	± 0.25 dBe, typical
	≥ –31 dB (A/W)	± 0.3 dBe	± 0.1 dBe	± 0.25 dBe	± 0.5 dBe, typical
Minimum measurable frequency response (noise floor) [3, 4]		–58 dB (A/W)	–77 dB (A/W)	–68 dB (A/W)	–68 dB (A/W), typical

Specifications for Optical-Optical Measurements at 850 nm (O/O Mode)

N4376D system with network analyzer:
- N5222A-200, N5222A-201, N5222A-219
- N5222A-400, N5222A-401, N5222A-419

Specifications are valid under the stated measurement conditions.
- For wavelength: (850 ± 10) nm

System performance		0.05 GHz to 0.2 GHz	0.2 GHz to 10 GHz	10 GHz to 20 GHz	20 GHz to 26.5 GHz
Relative frequency response uncertainty	DUT response	–	–	–	–
	≥ –10 dBe [1, 2] (≥ –5.0 dBo)	± 0.5 dBe (± 0.25 dBo, typical)	± 0.4 dBe (± 0.2 dBo)	± 0.5 dBe (± 0.25 dBo)	± 0.5 dBe, typical (± 0.25 dBo, typical)
Absolute frequency response uncertainty (typical)	DUT response	–	–	–	–
	≥ –10 dBe [1, 2] (≥ –5 dBo)	± 1.1 dBe	± 1.0 dBe	± 1.0 dBe	± 1.0 dBe, typical
Frequency response repeatability (typical)	DUT response	–	–	–	–
	≥ –10 dBe [1, 2] (≥ –5 dBo)	± 0.15 dBe	± 0.1 dBe	± 0.15 dBe	± 0.15 dBe, typical
Minimum measurable frequency response (noise floor) [2, 3, 4]		–53 dBe (–26.5 dBo)	–70 dBe (–35 dBo)	–44 dBe (–22 dBo)	–44 dBe, typical (–22 dBo, typical)

1. For DUT response max. 0 dB.
2. Average power from LCA optical output set to –1 dBm.
3. IFBW = 10 Hz.
4. Note: Average value over frequency range.

General Characteristics

Assembled dimensions (H x W x D)	
Max, 413 mm x 438 mm x 538 mm (16.3 in x 17.3 in x 21.2 in)	
Weight	
Product net weight	
38kg (81.6 lbs) to 52 kg (114.6 lbs) depending on selected NWA	
Packaged product	
56 kg (123.5 lbs) to 54 kg (119 lbs) depending on selected NWA	
Power requirements	
100 to 240 V~, 50 to 60 Hz (2 power cables)	
N5222A	Max. 450 VA
Optical test set	Max. 40 VA
Storage temperature range	
–40 °C to +70 °C	
Operating temperature range	
+5 °C to +32 °C	
Humidity	
15% to 80% relative humidity, non-condensing	
Altitude (Operating)	
0 ... 2000 m	
Calibration	
Select Keysight calibration plan	
R-50C-011-3	3-year calibration assurance plan (return to Keysight): Priority calibration service covering all calibration costs for 3 years; 15% cheaper than buying stand-alone calibrations.
R-50C-011-5	5-year calibration assurance plan (return to Keysight): Priority calibration service covering all calibration costs for 5 years; 20% cheaper than buying stand-alone calibrations.

General Characteristics (continued)

Shipping contents
1x network-analyzer depending on selected option
1x N4376D optical test set
2x 81000 NI optical adaptor
1x 4376D-90A01 Getting Started Guide
1x N4373-61627 f 3.5 mm to f 3.5 mm RF short cut cable
1x 4373B-90CD1 LCA support CD
1x 1150-7896 keyboard
1x 1150-7799 mouse
1x 8121-1242 USB cable
1x E5525-10285 UK6 report
1x 9320-6677 RoHS addendum for photonic T&M accessories
1x 9320-6654 RoHS addendum for photonic T&M products

Additional, option dependent shipping contents	
-023	2x LC 50 µm to FC/APC 0.5 m patch cord, feedthrough
-024	2x LC 62.5 µm to FC/APC 0.5 m patch cord, feedthrough
-025	2x SC 50 µm to FC/APC 0.5 m patch cord, feedthrough
-026	2x SC 62.5 µm to FC/APC 0.5 m patch cord, feedthrough
-2yz 2-port network analyzer	1x N4373-61604 0.5 m (m) to (f) high performance RF cable
-4yz 4-port network analyzer	2x N4373-61604 0.5 m (m) to (f) high performance RF cable

LCA connector types [1]	
Optical test set	
LCA port A	3.5 mm (m)
LCA port B	3.5 mm (m)
LCA optical input	62.5 µm single-mode angled [1], with Keysight universal adapter
LCA optical output	50 µm single-mode angled [1], with Keysight universal adapter

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.

1. The optical test set always has angled connectors. For input and output, a 50 µm or 62.5 µm angled to straight LC or SC patchcord must be selected. The connection to the DUT is always either LC or SC straight. The jumper cable must always be used in front of the optical test set to protect the connectors of the optical test set.

Ordering Information

The N4376D 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 with the optical test set as listed below.

N4376D LCA ordering options	
Wavelength options	
N4376D-103	850 nm source optical test set
Network analyzer options	
N4376D-220	26.5 GHz, 2 ports, single source PNA (N5222A-200) and RF cables and RF cables
N4376D-221	26.5 GHz, 2 ports, single source PNA (N5222A-201) with configurable test set and RF cables
N4376D-222	26.5 GHz, 2 ports, single source PNA (N5222A-219) with configurable test set, extended power range, bias-tees and RF cables
N4376D-420	26.5 GHz, 4 ports, dual source PNA (N5222A-400) and RF cables
N4376D-421	26.5 GHz, 4 ports, dual source PNA (N5222A-401) with configurable test set and RF cables
N4376D-422	26.5 GHz, 4 ports, dual source PNA (N5222A-419) with configurable test set, extended power range, bias-tees and RF cables
N4376D-229	Integration of customer's 26.5 GHz, 2 port PNA (N5222A or N5242A) with any configuration and RF cables [1]
N4376D-249	Integration of customer's 26.5 GHz, 4 port PNA (N5222A or N5242A) with any configuration and RF cables [1]
Software options [2, 3]	
N4376D-S10	Time-domain measurements
Connector options	
N4376D-023	LC 50 µm connector interface (external 0.75 m patch cord)
N4376D-024	LC 62.5 µm connector interface (external 0.75 m patch cord)
N4376D-025	SC 50 µm connector interface (external 0.75 m patch cord)
N4376D-026	SC 62.5 µm connector interface (external 0.75 m patch cord)
Recommended accessories	
5063-9217	Rack mount flange kit – 265.9 mm height for installation without handles
E3663AC	Basic rail kit (for system II instruments)
N4691B	2 port microwave electrical calibration module (-00F recommended)

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

Polarization solutions
www.keysight.com/find/pol

Spectral analysis products
www.keysight.com/comms/octspectral

Electro-optical converters
www.keysight.com/find/ref

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

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

myKeysight

www.keysight.com/find/mykeysight
A personalized view into the information most relevant to you.

www.lxistandard.org

LAN eXtensions for Instruments puts the power of Ethernet and the Web inside your test systems. Keysight is a founding member of the LXI consortium.

www.pxisa.org

PCI eXtensions for Instrumentation (PXI) modular instrumentation delivers a rugged, PC-based high-performance measurement and automation system.

Three-Year Warranty
www.keysight.com/find/ThreeYearWarranty
Keysight's commitment to superior product quality and lower total cost of ownership. The only test and measurement company with three-year warranty standard on all instruments, worldwide.

Keysight Assurance Plans
www.keysight.com/find/AssurancePlans
Up to five years of protection and no budgetary surprises to ensure your instruments are operating to specification so you can rely on accurate measurements.

www.keysight.com/quality
Keysight Electronic Measurement Group
DEKRA Certified ISO 9001:2008
Quality Management System

Keysight Channel Partners
www.keysight.com/find/channelpartners
Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

www.keysight.com
www.keysight.com/find/lca

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at:
www.keysight.com/find/contactus

Americas

Canada	(877) 894 4414
Brazil	55 11 3351 7010
Mexico	001 800 254 2440
United States	(800) 829 4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
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