PRELIMINARY

N4378A 220 GHz Lightwave Component Analyzer

Single-Mode Fiber Lightwave Component Analyzer for 1.6T/ 3.2T Electro-Optical Test

Introduction

The Keysight N4378A Lightwave Component Analyzer (LCA), the latest addition to the N437 family, delivers fully calibrated opto-electronic S-parameter measurements up to 220 GHz, addressing the growing test challenges of next-generation optical components used in AI and data-center applications. It combines newly designed optical test heads with the NA5305A Frequency Extender up to 170 GHz or NA5307A Frequency Extender up to 250 GHz, and the 85065A Precision Calibration Kit 0.5 mm. The configuration is completed by one of Keysight's PNA/PNA-X Vector Network Analyzers (VNA) and the N5292A Test Set Controller. The new LCA enables engineers to perform single-sweep measurements from 100 MHz to 170 GHz or 220 GHz at 1310 nm and 1550 nm wavelengths using on-board lasers. With additional laser sources, more wavelengths in the O-band and the C/L-band can be covered.

With 220 GHz bandwidth, engineers can verify the design of their 1.6/ 3.2 Tb/s optical transmitter and receiver components and refine their simulations with real-world measurements.

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Flexible Configurations

In its most complete configuration, capable of performing S-parameter measurements on photodiodes and optical modulators, the N4378A 220 GHz Lightwave Component Analyzer includes an N4378RA optical receiver, and an N4378TA optical transmitter connected to an N4378CA transmitter controller. Both optical heads come with an N4378FA mechanical fixture that ensures proper mechanical alignment between the NA5307A or NA5305A frequency extender heads which extend the bandwidth of a standard PNA/PNA-X with 26.5 GHz or 67 GHz up to 250 GHz electrical bandwidth. The LCA software is installed on the PNA and provides comprehensive user guidance for electro-optical measurements. New wizards help novice and experienced users through more complex measurement tasks. Through the new N4370AMFA software license, advanced measurement functions can be unlocked that automate Total Harmonic Distortion (THD), Relative Intensity Noise (RIN) and gain compression measurements on optoelectronic components.

A configuration specifically suitable for the measurement of optical transmitters or optical modulators consists of only the N4378RA optical receiver combined with a PNA/PNA-X, N5292A test set controller and a minimum of two NA5307A/NA5305A frequency extenders. Three frequency extenders are required for modulators with symmetrical/dual drive input.

Likewise, a configuration for the measurement of optical receivers or photodiodes consists of only the N4378TA optical transmitter, the N4378CA transmitter controller, a PNA/PNA-X, N5292A test set controller and two NA5307A/NA5305A frequency extenders.

N4378A Components

Model	Function	Description
N4378RA Optical Receiver 	The optical receiver includes a high-bandwidth photodiode that is calibrated at two wavelengths. It includes an average optical power meter that can be read out through an LED bar and numerically via the LCA software.	De-embedding data for up to two wavelengths is available: • N4378RA-131 1310 nm • N4378RA-155 1550 nm
N4378TA Optical Transmitter 	The optical transmitter is based on a high-bandwidth optical modulator with an operating wavelength range covering O-band and C/L-band. The optical input is monitored by an average power meter that can be read out through an LED bar and via the LCA software.	De-embedding data for up to two wavelengths is available: • N4378TA-131 1310 nm • N4378TA-155 1550 nm
N4378CA Transmitter Controller 	The transmitter controller provides power and control to the N4378TA optical transmitter. In addition, it hosts two DFB lasers to provide a high-power, stable optical signal to the optical modulator inside the N4378TA.	The built-in DFB lasers can be activated using licenses: • N4378CA-131 1310 nm • N4378CA-155 1550 nm
N4378FA Mechanical Fixture 	The fixture consists of a sliding base plate and a height-adjustable, fixed base plate, both carrying quick-release mounting plates for optical and electrical heads. Use an additional base plate for mounting on probers.	The mechanical fixture includes two mounting plates. Add more mounting plates and base plates: • N4378FA-801 Additional mounting plate • N4378FA-802 Additional base plate
N4378GA Alignment Gauge 	The alignment gauge is used to align an optical or electrical head on the mounting plate so that the 0.5 mm coaxial connector is located at the predefined position. For the adjustment, the alignment pin is screwed onto the RF port of the head.	The gauge comes with an alignment pin that is parked inside the gauge. Add more: • N4378GA-801 Additional alignment gauge • N4378GA-802 Additional alignment pin for 0.5 mm coaxial connector

N4378RA 220 GHz Optical Receiver

The N4378RA optical receiver is equipped with a single-mode fiber input and a 0.5 mm coaxial RF output. It is connected to an NA5307A or NA5305A frequency extender using the included 0.5 mm ruggedized female to female adapter Y1920K. Powered and controlled by the PNA via USB-C connection, the N4378RA has calibration data on board that is used by the LCA software to de-embed the receiver from the measurement, defining the reference plane to be at the optical connector. The N4378RA can be ordered with de-embedding data for wavelengths 1310 nm and 1550 nm. Its operating wavelength range covers the O-band as well as the C/L-band; its frequency range spans from 100 MHz to 220 GHz.

To warn about input power overload, and to ease measurement handling and debugging, the N4378RA includes an average optical power meter function that can be read from an LED chain on top of the head, or digitally by the LCA software.

Figure 1. N4378RA Optical receiver

N4378TA 220 GHz Optical Transmitter and N4378CA Transmitter Controller

The N4378TA optical transmitter has a laser input and an optical output, both equipped with polarization maintaining single-mode fiber. Its 0.5 mm coaxial RF input must be connected to an NA5307A or NA5305A frequency extender via the included Y1920K adapter. The N4378TA is powered and controlled by the N4378CA transmitter controller, a half-19-inch, one-height-unit instrument that also hosts two high-power DFB lasers operating at 1310 nm and 1550 nm. Connected to the optical transmitter input via Polarization Maintaining Fiber (PMF), these lasers provide a highly stable Continuous Wave (CW) signal to the optical modulator inside the N4378TA. The N4378TA optical transmitter has a frequency range of 100 MHz to 220 GHz. It can be ordered with de-embedding data for wavelengths 1310 nm and 1550 nm. The two lasers in the N4378CA transmitter controller are always included and can be individually activated via a license code. Using additional laser sources, the N4378TA can be operated at more wavelengths in the O-band and in the C/L-band.

Like the optical receiver, the N4378TA is equipped with an LED chain that indicates the input power level, and warns about overloading the optical input, an indispensable tool to avoid costly damage and to warn of degraded or forgotten fiber connections.

Figure 2. Frequency extender (left) and N4378TA optical transmitter (right) on mechanical fixture

Figure 3. Transmitter controller with two built-in DFB lasers

N4378FA Mechanical Fixture Makes 0.5 mm Coaxial Connections Easy

The high bandwidth of the NA5307A and NA5305A frequency extender heads demanded the development of a new, 0.5 mm coaxial connection, as well as a new 85065A 0.5 mm calibration kit. To deliver complete measurement capabilities, Keysight has collaborated with top-tier industry solution partners for RF probes, coaxial adapters and test cables for the 0.5 mm coaxial eco system.

To minimize stress on the 0.5 mm coaxial connections, the N4378FA mechanical fixture enables accurate and repeatable mechanical alignment between the coaxial ports of the optical head and the frequency extender head. Once an optical or electrical head has been initially aligned and mounted on a mounting plate, the quick-release system allows moving the heads between positions needed for user calibration or for measurements. Additional base plates can be used to extend the quick-release function to probe holders.

Figure 4. Preparing frequency extender and optical transmitter to connect, using the N4378FA mechanical fixture

Figure 5. Using the alignment gauge to adjust the transmitter position on the mounting plate

New LCA Software with Advanced Measurement Functions

With the N4378A Lightwave Component Analyzer, a new version of the LCA software will be released that is also compatible with the N4372E, N4373E, N4375E and N4376E LCAs. Improved user guidance, new measurement and verification wizards, and advanced measurement functions that can be unlocked with the N4370AMFA software license, improve ease of use for novice and expert users and reduce the probability of operator failures. The N43780AMFA license lets operators automate Total Harmonic Distortion (THD), relative intensity noise (RIN) and gain compression measurements of optical transceiver components.

Figure 6. LCA software with settings for O/O measurement, and power monitoring display

NA5307A 250 GHz and NA5305A 170 GHz Frequency Extenders

The N522xB PNA/N524xB PNA-X network analyzer with the N5292A test set controller and the NA5305A/NA5307A 170 GHz/250 GHz frequency extenders provide fully calibrated broadband, single-sweep S-parameter measurements from 100 kHz/10 MHz to 170/250 GHz. The NA5305/7A frequency extenders equipped with a ruggedized 0.5 mm coaxial male test port connector are designed compact and lightweight and driven and controlled with a PNA/PNA-X network analyzer and a P9500A frequency extender hub via USB. The 85065A 0.5 mm coaxial precision calibration kit includes 16 calibration standards to accurately calibrate the VNA measurement setup up to 250 GHz. You can configure a 4-port VNA to make differential measurements for characterization/modeling of semiconductor devices up to 250 GHz for various applications: 6G research and data center networks for 1.6 Tb/s, 3.2 Tb/s and beyond. Passive devices, PCBs, cables, packages, optical RF drivers and TIAs (Transimpedance Amplifiers) can also be measured.

For details on the new NA5307A, NA5305A frequency extenders, as well as supported PNA/PNA-X configurations, please see the Technical Overview.

Figure 7. 250 GHz VNA system with four frequency extenders and P9500A hub

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.

Technical Specifications (Preliminary)

Description	N4378RA Optical Receiver	N4378TA Optical Transmitter
Operating frequency range	100 MHz to 220 GHz	100 MHz to 220 GHz
Calibrated frequency range [1]	100 MHz to 220 GHz	100 MHz to 220 GHz
De-embedding wavelengths	1310 nm (Option 131), 1550 nm (Option 155)	1310 nm (Option 131), 1550 nm (Option 155)
Optical ports	**N4378RA**	**N4378TA**
Max. operating input power	+13 dBm optical	+20 dBm optical
Max. safe input power	+18 dBm optical, when exposed for max. 1 minute	+23 dBm optical, when exposed for max. 1 minute
Optical output power	n/a	≥ 0 dBm, when using the N4378CA laser
Absolute average power measurement uncertainty	Typical ≤ ± 0.5 dB	n/a
Optical ports	Single-mode fiber input, angled contact	PM fiber [2] input and output, angled contact
Optical connectivity	Accepts 81000xI connector interfaces, one 81000NI (FC/APC) included	Accepts 81000xI connector interfaces, two 81000NI (FC/APC) included
Electrical ports	**N4378RA**	**N4378TA**
Max. RF input power	No RF signal; > 0 dBm will damage the device!	+21 dBm RF, 0 V DC
RF ports	0.5 mm coaxial output, male, ruggedized	0.5 mm coaxial input, male, ruggedized

1. De-embedding data are provided across the entire operating frequency range.
2. Panda type polarization maintaining fiber; electrical field is oriented in slow axis, in line with the connector key.

Technical Specifications (Preliminary), Continued

Description	N4378TA Transmitter Controller	
Center wavelength	1310 nm ± 5 nm (Option 131), 1550 nm ± 5 nm (Option 155)	
Max. output power	+17 dBm	
Power setting range	0 dBm to +17 dBm	
Optical power stability	Typical ± 0.1 dB, 15 minutes	
Optical ports	Two PM fiber [1] outputs, angled contact	
Optical connectivity	Accepts 81000xI connector interfaces, two 81000NI (FC/APC) included	
Laser safety information	All laser sources specified by this data sheet are classified as Class 1M according to IEC 60825-1:2014 and EN 60825-1:2014/A11:2021. All laser sources comply with 21 CFR 1040.10 except for deviations pursuant to Laser Notice No. 50, dated 2007, June 24.	

1. Panda type polarization maintaining fiber; electrical field is oriented in slow axis, in line with the connector key.

Ordering Information, Optical Front End

Product/Option	Description
N4378A	220 GHz Lightwave Component Analyzer
N4370AMFA	Advanced measurement functions software license
N4378RA	**LCA Optical Receiver (for EO Measurements)**
N4378RA-500	LCA Optical receiver 0.5mm (for EO measurements) incl. 0.5mm to 0.5mm adapter Y1920K
N4378RA-F22	Operating frequency range 220 GHz
N4378RA-131	Enable de-embedding at 1310 nm for receiver
N4378RA-155	Enable de-embedding at 1550 nm for receiver
N4378TA	**LCA Optical Transmitter (for OE Measurements)**
N4378TA-500	LCA Optical transmitter 0.5mm (for OE measurements) incl. 0.5mm to 0.5mm adapter Y1920K
N4378TA-F22	Operating frequency range 220 GHz
N4378TA-131	Enable de-embedding at 1310 nm for receiver
N4378TA-155	Enable de-embedding at 1550 nm for receiver
N4378CA	**LCA Transmitter Controller (required to operate N4378TA)**
N4378CA-102	LCA TX controller with 1310 nm and 1550 nm laser sources
N4378CA-131	Enable 1310 nm laser
N4378CA-155	Enable 1550 nm laser
N4378FA/ N4378GA	**LCA Mechanical Fixture and Alignment Tool**
N4378FA	LCA Mechanical fixture, with 2 mounting plates and 2 base plates (one N4378FA required per N4378RA and N4378TA)
N4378GA-G01	Alignment gauge (one N4378GA required per N4378A system)
N4378GA-P05	Alignment pin, for 0.5 mm connector
N4378GA-P10 [1]	Alignment pin, for 1 mm connector

1. N4378FA and N4378GA can also be used with N4372E and N5293AX and N5295AX series frequency extender heads which are equipped with 1.0 mm coaxial connectors.

Ordering Information, RF Section (PNA, PNA-X)

Product/Option	Description
Option	**RF Frequency Extender Head Selection (min. 2, max. 4)**
N4378A-F51	Frequency extender, 250 GHz (NA5307A-012, 0.5 mm, 1.2 m cable, no bias-tee)
N4378A-F52	Frequency extender, 250 GHz (NA5307A-T12, 0.5 mm, 1.2 m cable, with bias-tee)
N4378A-F53	Frequency extender, 250 GHz (NA5307A-018, 0.5 mm, 1.8 m cable, no bias-tee)
N4378A-F54	Frequency extender, 250 GHz (NA5307A-T18, 0.5 mm, 1.8 m cable, with bias-tee)
N4378A-F55	Frequency extender, 170 GHz (NA5305A-012, 0.5 mm, 1.2 m cable, no bias-tee)
N4378A-F56	Frequency extender, 170 GHz (NA5305A-T12, 0.5 mm, 1.2 m cable, with bias-tee)
N4378A-F57	Frequency extender, 170 GHz (NA5305A-018, 0.5 mm, 1.8 m cable, no bias-tee)
N4378A-F58	Frequency extender, 170 GHz (NA5305A-T18, 0.5 mm, 1.8 m cable, with bias-tee)
Option	**Choice of 2-Port PNA/ PNA-X (one PNA/ PNA-X is required per system)**
N4378A-221	PNA, 2 Port, 26.5GHz (N5222B-201, -020) with config. test set, IF inputs
N4378A-222	PNA, 2 Port, 26.5GHz (N5222B-205, -020) with config. test set, IF inputs, LFE, bias-tee
N4378A-223	PNA, 2 Port, 26.5GHz (N5222B-220, -020) with config. test set, IF inputs, LFE, bias-tee, attenuators
N4378A-224	PNA-X, 2 Port, 26.5GHz (N5242B-201, -020) with config. test set, IF inputs
N4378A-225	PNA-X, 2 Port, 26.5GHz (N5242B-205, -020) with config. test set, IF inputs, LFE
N4378A-226	PNA-X, 2 Port, 26.5GHz (N5242B-219, -020) with config. test set, IF inputs, LFE, bias-tee, attenuators
N4378A-271	PNA, 2 Port, 67GHz (N5227B-201, -020) with config. test set, IF inputs
N4378A-272	PNA, 2 Port, 67GHz (N5227B-205, -020) with config. test set, IF inputs, bias-tee, LFE
N4378A-273	PNA, 2 Port, 67GHz (N5227B-220, -020) with config. test set, IF inputs, bias-tee, LFE, attenuators
N4378A-274	PNA-X, 2 Port, 67GHz (N5247B-201, -020) with config. test set, IF inputs
N4378A-275	PNA-X, 2 Port, 67GHz (N5247B-219, -020) with config. test set, IF inputs, bias-tee, attenuators

Product/Option	Description
Option	**Choice of 4-Port PNA/ PNA-X (one PNA/ PNA-X is required per system)**
N4378A-421	PNA, 4 Port, 26.5GHz (N5222B-401, -020) with config. test set, IF inputs
N4378A-422	PNA, 4 Port, 26.5GHz (N5222B-405, -020) with config. test set, IF inputs, LFE
N4378A-423	PNA, 4 Port, 26.5GHz (N5222B-420, -020) with config. test set, IF inputs, LFE, bias-tee, attenuators
N4378A-424	PNA-X, 4 Port, 26.5GHz (N5242B-401, -020) with config. test set, IF inputs
N4378A-425	PNA-X, 4 Port, 26.5GHz (N5242B-419, -020) with config. test set, IF inputs, bias-tee, attenuators
N4378A-426	PNA-X, 4 Port, 26.5GHz (N5242B-425, -020) with config. test set, IF inputs, bias-tee, attenuators, LFE
N4378A-471	PNA, 4 Port, 67GHz (N5227B-401, -020) with config. test set, IF inputs
N4378A-472	PNA, 4 Port, 67GHz (N5227B-405, -020) with config. test set, IF inputs, LFE
N4378A-473	PNA, 4 Port, 67GHz (N5227B-420, -020) with config. test set, IF inputs, LFE, bias-tee, attenuators
N4378A-474	PNA-X, 4 Port, 67GHz (N5247B-401, -020) with config. test set, IF inputs
N4378A-475	PNA-X, 4 Port, 67GHz (N5247B-419, -020) with config. test set, IF inputs, bias-tee, attenuators
N4378A-476	PNA-X, 4 Port, 67GHz (N5247B-425, -020) with config. test set, IF inputs, bias-tee, attenuators. LFE
Option	**Millimeter-Wave Controller (must choose one)**
N4378A-TA2	2 channels (N5292A-200)
N4378A-TA4	4 channels (N5292A-400)
Option	**Interconnect Kit (must choose one)**
N4378A-IK1	Interconnect Kit for 2 Port PNA(-X) with 3.5 mm Ports (N5292A-501)
N4378A-IK2	Interconnect Kit for 2 Port PNA(-X) with 2.4 mm or 1.85 mm Ports (N5292A-502)
N4378A-IK3	Interconnect Kit for 4 Port PNA(-X) with 3.5 mm Ports (N5292A-505)
N4378A-IK4	Interconnect Kit for 4 Port PNA(-X) with 2.4 mm or 1.85 mm Ports (N5292A-506)
Option	**Millimeter-Wave Hub (min. one required)**
N4378A-HUB	Extender hub (P9500A) needed for N52xx PNAs. Also needed for NA52xx PNAs if this is a 4-port system.

Ordering Information, Accessories

Product/Option	Description
N4378A-8A1	Calibration kit, 1 mm, DC to 120 GHz (85059B)
N4378A-8A2	USB thermocouple power sensor, DC to 120 GHz (U8489A)
N4378A-8A3	Verification kit, 1 mm (85059V)
N4378A-851	Calibration kit, 0.5 mm (85065A)
N4378FA-801	Additional head mounting plate
N4378FA-802	Additional base plate to carry head mounting plate
N4378GA-801	Additional alignment gauge
N4378GA-802	Additional alignment pin, for 0.5 mm connector
N4378GA-803 [1]	Additional alignment pin, for 1 mm connector

1. N4378FA and N4378GA can also be used with N4372E and N5293AX and N5295AX series frequency extender heads which are equipped with 1.0 mm coaxial connectors.

Included Accessories and Cables

Product	Included Accessories
N4378CA	2 x 81000NI connector interface, FC/APC, narrow key Optical patch cord, PM fiber, FC/APC to FC/APC USB-A to USB-B cable, connects to PNA(-X)
N4378TA	2 x 81000NI connector interface, FC/APC, narrow key Optical patch cord, PM fiber, FC/APC to FC/APC Optical patch cord, PM fiber, FC/APC to FC/PC Y1920K adapter, 0.5 mm female – 0.5 mm female, ruggedized USB-A to USB-C cable, for calibration data download, connects to PNA(-X)
N4378RA	81000NI connector interface, FC/APC, narrow key Optical patch cord, SM fiber, FC/APC to FC/APC Optical patch cord, SM fiber, FC/APC to FC/PC Y1920K adapter, 0.5 mm female – 0.5 mm female, ruggedized USB-C to USB-C cable, for power delivery and control, connects to P9500A mmWave extender hub

An 81000NI FC/APC connector interface is included for every optical port. For other connector types, please order additional 81000xI interfaces as appropriate.

For More Information

To find more optical test instruments, check the following links:

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

Read step-by-step instructions how to perform gain compression measurements with LCA

PNA network analyzer family: www.keysight.com/find/pnax

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