Keysight N4391B
Optical Modulation Analyzer

General Information

The N4391B is the next generation Optical Modulation Analyzer based on the UXR Oscilloscope series with two bandwidth options, one ranging from 40 GHz to 70 GHz and the second one ranging from 80 GHz to 110 GHz.

It is the most compact OMA solution of its class and combines industry-leading noise performance with a proven architecture and Keysight's well-known, reliable and flexible vector signal analysis (VSA) software.

Applications

The ever-growing demand for higher transmission capability drives symbol rates to 64 GBaud in near future, and to the 100 GBaud range in the long term. To keep up with this symbol rate increase, a test instrument is required that can handle the symbol rate classes of transceivers for 600 Gb/s, 1.2 Tb/s and beyond, from the first day in advanced research through the development phase.

Not only symbol rates are challenging, but also modulation formats are getting more demanding due to the higher-order quadrature amplitude modulation which require a step forward in noise performance.

The N4391B, based on the latest industry-leading UXR Oscilloscope series, is the best-suited optical modulation analyzer to support these application requirements.

It provides an operating bandwidth up to 110 GHz and endless options for selecting modulation formats. Even user-defined modulation formats are supported through an additional option, and all at an outstanding high ENOB at highest bandwidths.

KEYSIGHT TECHNOLOGIES

Product Offer

The new optical modulation analyzer based on Keysight's latest UXR oscilloscopes is available in in two bandwidth classes: an optical coherent receiver with a calibrated operating bandwidth of 70 GHz (Option 007), and one with 110 GHz (Option 011). Within each class the system bandwidth is determined by the oscilloscope bandwidth which can be upgraded by using a software license: option 007 can be upgraded from 40 GHz to 50 GHz, 59 GHz or 70 GHz; option 011 can be upgraded from 80 GHz to 100 GHz or 110 GHz without sending the Optical Modulation Analyzer to Keysight. Upgrading option 007 to option 011 requires additional hardware changes which need to be implemented by Keysight. In each configurations, the optical coherent receiver comes with an internal power monitor, internal LO, LO output and external LO input.

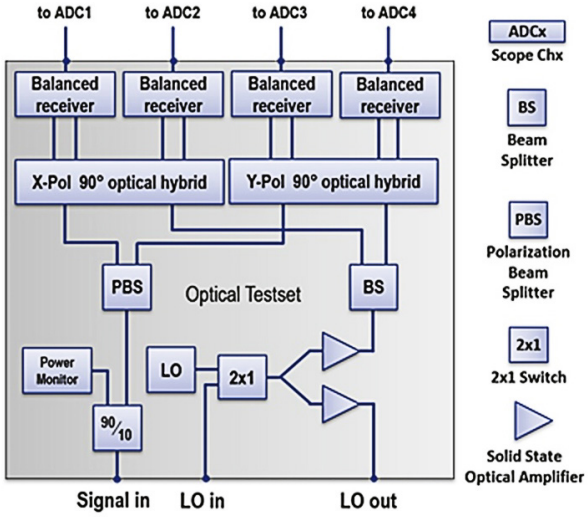

Figure 1: Block Diagram of the Optical Front End

Turn-Key Solution

Compared to the time-consuming and resource-intensive implementation of a home-grown optical modulation analysis solution, the fully integrated N4391B provides a fully specified and reliable test instrument that helps greatly reduce time-to-market. With guaranteed and characteristic specifications Keysight takes responsibility for accurate and reliable test results which can only be achieved with a turn-key solution.

Integrated Coherent Receiver Test Application with On-site Verification and Re-Calibration Software

Integrated Coherent Receiver (ICR) modules are key components in coherent transmission systems and are more challenging to test than direct-detection receiver optical sub-assemblies (ROSAs), as the ICRs have phase-sensitive signal detection and provide four electrical outputs and two optical inputs. The test instruments used in ROSA S21 testing cannot be used in a similar way for S-parameter testing of ICRs, making S-parameter testing very challenging.

To help users set up S-parameter tests for ICRs in significantly less time than developing their own solution, the N4391B provides an optionally-available ICR test software that measures:

- S21 magnitude responses
- IQ skew, XY skew
- IQ angle
- IQ and XY gain imbalance
- EVM noise floor
- Image suppression

Characterizing an ICR for these parameters enables the creation of a calibration data set for the coherent optical receiver of the N4391B. The software can now also be used to verify the performance of a N4391B system and perform a re-calibration if necessary. Calibrating the system in its operating environment can help to maximize system performance and minimize down-time. Assuming a current oscilloscope calibration, the additionally required equipment comprises a tunable laser source, e.g. N7711A, a variable optical attenuator, e.g. N7751A, and a polarization synthesizer, e.g. N7786B. The recommended re-calibration cycle is 1 year.

Coherent Optical Device Test Application Software

Coherent optical devices such as dual-polarization IQ modulators and intradyne coherent receivers need to be tested in their different development stages as well as qualified by the system integrators.

The optionally available coherent optical device test software provides a turn-key solution for the characterization of these devices. One user interface provides control of all instruments, i.e., an arbitrary waveform generator (AWG), the OMA, and in case of Rx devices, a polarization synthesizer, through a single software package. None of the tests requires reconnecting the DUT, saving test time and reducing the uncertainty introduced by connecting and reconnecting the device. The coherent optical device test license provides:

- S21 magnitude and phase responses
- IQ skew, XY skew

The setup can be customized in three different ways for transmit device testing, receive device testing and sequential testing of both, transmit and receive devices. Furthermore, it can be extended to perform system-level tests as well as wavelength and power calibration of the laser.

Specifications (Preliminary)

N4391B system specifications

Specification Parameter	N4391B-007	N4391B-011
Maximum detectable symbol rate	DC–80|100|118|140 Gbaud[1]	DC–160|200|220 Gbaud[1]
Sample rate	256 GSa/s	
Operating frequency range	DC–40|50|59|70 GHz[1]	DC–80|100|110 GHz[1]
Maximum record length	2 GSa max., 200 MSa standard	
ADC Resolution	10 bits	
Number of 4 channel UXR oscilloscopes	1	
Optical wavelength operating range[4]	1527.60 nm to 1630.0 nm (196.25 THz to 183.92 THz)	1527.60 nm to 1620 nm (196.25 THz to 185.06 THz)
Relative skew after correction	< ± 0.5 ps	
Image suppression[2]	> 35 dB	
EVM Noise floor[2]	< 1.6 % at 2.5 GHz	
	< 2.9 % at 10 GHz	
Sensitivity[3]	-20 dBm	

1. Depending on oscilloscope option
2. Valid at the following reference conditions
   - o Sampling rate 256 GSa/s
   - o Optical continuous wave signal at optical input port
   - o Signal power > 0 7.5 dBm, 160 mV range
   - o Optical frequency is offset by 2.5/10 GHz from local oscillator frequency
   - o Vector analyzer I-Q spectrum span set to 12.5/40 GHz
   - o QPSK demodulation
   - o 10/40 GBaud symbol rate
   - o PolStokesAlign set to “Single Polarization”
   - o KFPhaseTrack with carrier phase variance set to 1E-4
   - o Result length set to 500 symbols
   - o Raised cosine filter selected as reference filter
   - o 25 °C ± 5 K environmental temperature
3. Valid at EVM = 32.5% for 32 GBaud DP-QPSK corresponding to raw BER = 1E-3
4. Access to full wavelength range requires external LO

Absolute Maximum Ratings

Specification Parameter	N4391B-007	N4391B-011
Maximum signal input power	+14 dBm	
Maximum signal input power damage level	+20 dBm	
External local oscillator maximum input power	+20 dBm	

UXR Key Specifications (Preliminary)

For details on the Infiniium UXR-Series Oscilloscopes please refer to data sheet 5992-3132EN.

Specification Parameter	UXR0404A	UXR0504A	UXR0594A	UXR0704A
Analog input channels	4	4	4	4
Analog -3 dB bandwidth	40 GHz	50 GHz	59 GHz	70 GHz

Specification Parameter	UXR0804A	UXR1004A	UXR1104A
Analog input channels	4	4	4
Analog -3 dB bandwidth	80 GHz	100 GHz	110 GHz

N4391B Optical Receiver Specifications (Preliminary)

General Parameters	N4391B-007	N4391B-011
Analog bandwidth (-3dB)	> 58 GHz	> 90 GHz
Analog bandwidth (-10 dB)	> 70 GHz	> 110 GHz
Signal input wavelength range[1]	1527.60 nm to 1630 nm (196.25 THz to 183.92 THz)	1527.60 nm to 1620 nm (196.25 THz to 185.06 THz)
Receiver polarization extinction ratio	> 40 dB	
Average input power monitor accuracy	± 0.5 dB	
Internal Local Oscillator and Local Oscillator Output		
Frequency (wavelength) range	1527.6 nm to 1570.0 nm (196.25 THz to 190.95 THz)	
Frequency (wavelength) uncertainty	± 560 MHz (± 4.5 pm), guaranteed ± 310 MHz (± 2.5 pm), typical	
Frequency resolution	100 MHz (0.8 pm at 1550 nm)	
Linewidth	< 100 kHz	
Sidemode suppression ratio	> 50 dB	
RIN	-145 dB/Hz (10 MHz to 40 GHz)	
Wavelength settling time	< 30 s	
Optical CW output power	> + 14 dBm	
Local Oscillator Input		
External local oscillator input power range	0 dBm to +14 dBm	
Small signal gain, external laser input to local oscillator output (–20 dBm LO input power)	28 dB at 1550 nm	
Saturation output power at –3 dB compression	+15 dBm	

1. Access to full wavelength range requires external LO

General Characteristics (Preliminary)

	N4391B-007	N4391B-011
Dimensions (Wide x Height x Deep)		
Oscilloscope	43.5 cm (17.1") x 31,1 cm (12.24") x 56.1 cm (22.05")	
Optical Coherent Receiver	43.1 cm (17") x 17 cm (6.7") x 55.2 cm (21.7")	
Complete Instrument	53 cm (20.9") x 48 cm (18.9") x 55.2 cm (21.8")	
Weight		
Oscilloscope	40.8 kg (90 lbs)	
Optical Coherent Receiver	11.2 kg (24.7 lbs)	
Environmental		
Storage temperature range	–40° C to +70° C	
Operating temperature range	+5° C to +35° C	
Humidity	15% to 80% relative humidity, non-condensing	
Operating altitude	0 to 2000 m	
Power		
UXR Oscilloscope voltage	220V AC, 50 to 60 Hz	
Power	2615 VA	
Optical Receiver voltage	100 to 240V AC, 50 to 60 Hz	
Power	300 VA	
Safety designed to and tested to	IEC61010-1, UL61010, CSA22.2 61010.1	
EMC tested to	IEC61326-1	
Warm-up time	30 minutes	
Recommended re-calibration interval	1 year	

Explanation of Terms

Operating frequency range

The operating frequency range is the frequency range of corrected signal spectral components by deembeding for frequency and phase characteristics of the individual hardware.

Analog bandwidth

The analog bandwidth describes the 3 dB bandwidth of the full opto-electronic input path without any frequency or phase corrections.

Sensitivity

The sensitivity limit corresponds to the received signal Power at the input interface for which a 32 GBaud DP-QPSK exhibits an EVM of 32.5% or less. An EVM of 32.5% corresponds to a BER of 1E-3 for assumed added Gaussian white noise (AWGN).

Ordering Information for New Product

1) Configure system setup	
N4391B-007	70 GHz Optical Modulation Analyzer Receiver including 1 license for OMA software
Select one of these UXR oscilloscopes or integration option together with N4391B-007	
N4391B-040	Infiniium UXR0404A Real-Time Oscilloscope, 40 GHz, 256 GSa/s, 4Ch, 200 MSa/Ch, 1.85 mm
N4391B-050	Infiniium UXR0504A Real-Time Oscilloscope, 50 GHz, 256 GSa/s, 4Ch, 200 MSa/Ch, 1.85 mm
N4391B-059	Infiniium UXR0594A Real-Time Oscilloscope, 59 GHz, 256 GSa/s, 4Ch, 200 MSa/Ch, 1.85 mm
N4391B-070	Infiniium UXR0704A Real-Time Oscilloscope, 70 GHz, 256 GSa/s, 4Ch, 200 MSa/Ch, 1.85 mm
N4391B-M00	Integration of customer owned UXR0404A, UXR0504A, UXR0594A or UXR0704A Oscilloscope
N4391B-011	110 GHz Optical Modulation Analyzer Receiver including 1 license for OMA software
Select one of these UXR oscilloscopes or integration option together with N4391B-011	
N4391B-080	Infiniium UXR0804A Real-Time Oscilloscope, 80 GHz, 256 GSa/s, 4Ch, 200 MSa/Ch, 1.0 mm
N4391B-100	Infiniium UXR1004A Real-Time Oscilloscope, 100 GHz, 256 GSa/s, 4Ch, 200 MSa/Ch, 1.0 mm
N4391B-110	Infiniium UXR1104A Real-Time Oscilloscope, 110 GHz, 256 GSa/s, 4Ch, 200 MSa/Ch, 1.0 mm
N4391B-M01	Integration of customer owned UXR0804A, UXR1004A or UXR1104A Oscilloscope
Mandatory software	
89601B-200	Basic vector signal analysis and hardware connectivity, transportable license
89601B-AYA	Vector modulation analysis, transportable license
2) Optional software	
89601B-BHF	Custom OFDM modulation analysis
89601B-BHK	Custom IQ modulation analysis
M8290430A	Integrated Coherent Receiver Test Application with On-Site Verification and Re-Calibration Software
M8290440A	Coherent Optical Device Test Application Software

Ordering Information for Upgrades

1) Configure system setup, select one of the two upgrade options	
N4391B-UG1[1]	Upgrade customer's N4391A-110 to N4391B-007 including latest OMA software
N4391B-UG2[1]	Upgrade customer's N4391A-120 to N4391B-007 including latest OMA software
Select one of these UXR oscilloscopes or integration option	
N4391B-040	Infiniium UXR0804A Real-Time Oscilloscope, 40 GHz, 256 GSa/s, 4Ch, 200 MSa/Ch, 1.85 mm
N4391B-050	Infiniium UXR1004A Real-Time Oscilloscope, 50 GHz, 256 GSa/s, 4Ch, 200 MSa/Ch, 1.85 mm
N4391B-059	Infiniium UXR1104A Real-Time Oscilloscope, 59 GHz, 256 GSa/s, 4Ch, 200 MSa/Ch, 1.85 mm
N4391B-070	Infiniium UXR0704A Real-Time Oscilloscope, 70 GHz, 256 GSa/s, 4Ch, 200 MSa/Ch, 1.85 mm
N4391B-M00	Integration of customer owned UXR0404A, UXR0504A, UXR0594A, or UXR0704A Oscilloscope
2) Optional software	
89601B-BHF	Custom OFDM modulation analysis
89601B-BHK	Custom IQ modulation analysis
M8290430A	Integrated Coherent Receiver Test Application with On-Site Verification and Re-Calibration Software
M8290440A	Coherent Optical Device Test Application Software

1. Software licenses will be transferred to the N4391B system

For upgrades from N4391B-007 to N4391B-011, or from N4391A to N4391B-011 please contact your Keysight representative.

Shipping Content (Preliminary)

	N4391B-007	N4391B-011
1 x Oscilloscope depending on ordered option	UXR004A/0504A/ 0594A/0704A	UXR0804A/1004A/ 1104A
1 x Optical coherent receiver		
4 x Rigid RF cable assembly	1.85 mm (m)	1.0 mm (m)
1 x Optical mouse, USB		
1 x 104 key standard keyboard with USB connector		
1 x Quick start guide (English)		
3 x 81000NI Fiber Connector Adapter FC /APC		
1 x Calibration certificate		
1 x Test Data Sheet		
3 x License Certificates OMA and VSA Software (additional Certificates depending on additional ordered software)		
1 x China RoHS Addendum for Photonic Test and Measurement Products		
1 x Cable-Assembly USB-Plug A TO B 4-COND 0.5 m		
1 x Wrench – 2 mm thick dual	6 and 7 mm	
1 x Wrench-Torque	8-in-lb, 5/16 inch	4-in-lb 6 mm
4 x Adapter, Ruggedized Female	1.85 mm	1.0 mm
1 x Wrench-Torque Special Double-end		14 mm-open end 4-in-lb and 10-in-lb
1 x Heel Ground Strap		
1 x ESD MAT Cord		
1 x ESD Warning Sticker Sheet		
1 x China RoHS Addendum for Oscilloscope		
1 x Keysight Safety Leaflet		
1 x Tips for Preventing Damage to Oscilloscopes		
2 x Local Power Cords		

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

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

Optical test instruments accessories
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