



Network and Data Center Solution Brochure



Dear Customer,

With the progressive evolution of optical and electrical data transmission, it is a great pleasure to continuously support you personally working on these new challenges. We are pleased to take this opportunity of presenting our new published brochure, introducing Keysight's "Latest" products and solutions that will be a major contributor in accelerating innovations to connect and secure the world.

We are exceptionally thrilled to introduce Keysight's latest Arbitrary Waveform Generator to enable signals well beyond 160GBaud.

Our Highlights in this issue

- New AWG for 160 GBaud signal generation and beyond
- 1.6T and 800G optical and electrical transmission based on 200G and 100G serial interfaces is developing and requires test of the Forward Error Correction (FEC) to run error free.
- Following the IEEE 802.3db release multimode transmission expands to 100G per lane
- Integrated Photonics is enabling new optical design-ins and require comprehensive testing at wafer level as well as on singulated dies
- Verifying compliance for new standards requires careful considerations to test setup and execution as design margins continue to decrease.

Find out about

In-depth, end-to-end test solutions and product workstations, spanning from electrical to optical, optical to electrical and physical layer to protocol test:

- **1.6T and 800G R&D test solutions** for optical and electrical characterization of Tx/Rx
- **Terabit Research** – Beyond 2T Coherent Optical
- **Data Center Transceiver Design & Test** - 800G Layer 1 Test with FEC
- **Integrated Photonics** - Optical Parametric Test
- **High Speed Multimode Optics** - 100G per lane Multimode
- **Automated test solution for coherent optical transmit and receive devices** - e.g., standard conform for OIF-400ZR-01.0

Our technical experts and application engineers are available to discuss challenges in R&D, design verification and for scalable and fully automated production processes.

Reach out without hesitation to your local Keysight representative



Dr. Joachim Peerlings
Vice President and General Manager
Network & Data Center Solutions

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New Product Introduction Addressing 160 GBaud and Beyond

M8199B 256 GSa/s Arbitrary waveform generator



Key features & specifications

- Up to 256 GSa/s for 2 channels in a 2-slot AXIe module
- 8-bit resolution
- Analog bandwidth >80 GHz (enabling 160 GBaud serial data generation)
- High-voltage output amplifier enables amplitudes > 3 V_{pp}, diff
- 1 MSA/channel memory
- Synchronize up to 8 channels (across 4 modules)

Helping you develop your innovation

Keysight knows you are pushing boundaries and understands that your innovation requires next generation test equipment. That's why we continually develop solutions that keep up with the latest technology waves and applications. The M8199B Arbitrary Waveform Generator (AWG) is the latest example of this commitment.

Fastest AWG on the market

The Keysight M8199A AWG uses an external passive coupler to interleave two 128 GSa/s channels to achieve signal generation up to 256 GSa/s. The M8199B AWG follows the same interleaving approach as the M8199A, but the passive combiner and RF amplifier are integrated into a single package, greatly improving the achieved bandwidth and signal-to-noise ratio (SNR).

The Keysight M8199B AWG offers you performance never seen before. It has a built-in frequency and phase response calibration, which ensures generating the most accurate signal possible. It is ready to use out-of-the-box, which means you spend less time setting up your test equipment and more time running your tests. Brand-new Keysight custom technology ensures highest signal quality and maximum flexibility.

Support for leading-edge applications

The M8199B AWG allows you to generate signals up to 256 GSa/s with sufficient signal integrity, perfect for applications like 1.6 Tb/s coherent transmissions or beyond 224 Gbit/s/lane intensity-modulation/direct-detect (IM/DD) transmissions.

The M8199B AWG is the unique solution in the market allowing R&D teams in the telecom and datacom industry, developing components, prototypes or products for coherent and IM/DD optical transmission systems operating at data rates up to 160 GBaud and beyond.

The M8199B AWG provides a stimulus signal with flexible modulation schemes (NRZ, PAM-n, QPSK, QAM-n). In addition, it allows you to apply offline customized digital-signal processing before loading the signal into the memory of the AWG.

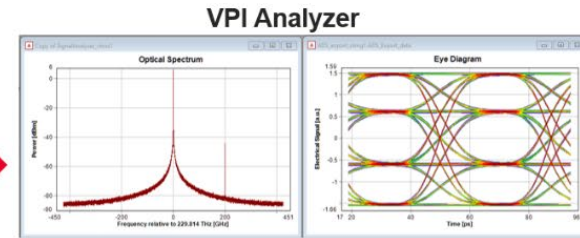
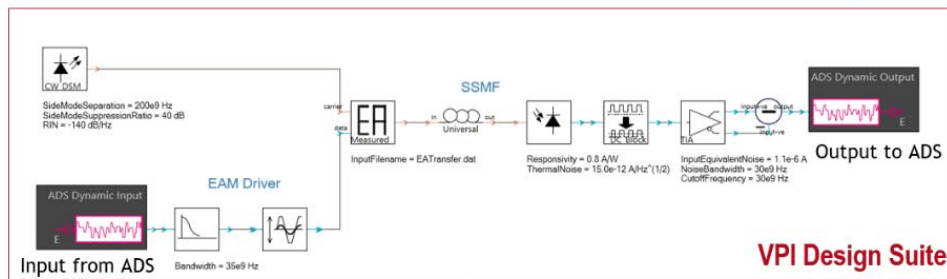
Design

PAM4 system analysis

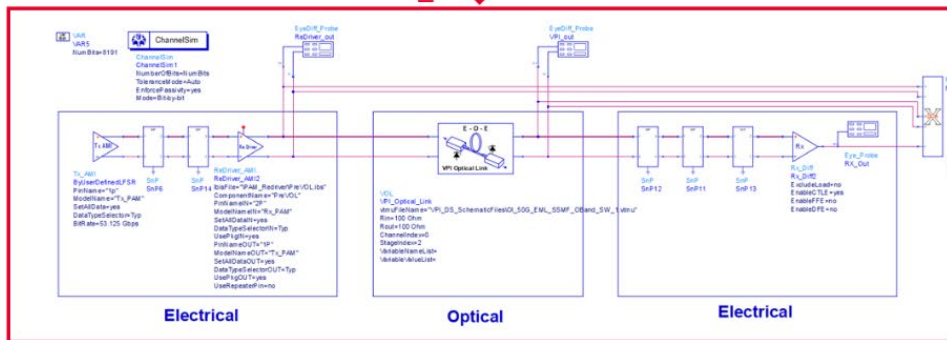
Keysight has a full PAM4, E-O-E (Electrical – Optical – Electrical) end-to-end link simulation example in PathWave ADS 2020, including modeling of the optical channel using VPIphotonics' VPItransmissionMaker™. The connected solution to FlexDCA feature allows fast and accurate insights of PAM4 measurements and comparison with measured results including transmitter dispersion and eye closure quaternary (TDECQ).

Facing today's high-speed design challenges.

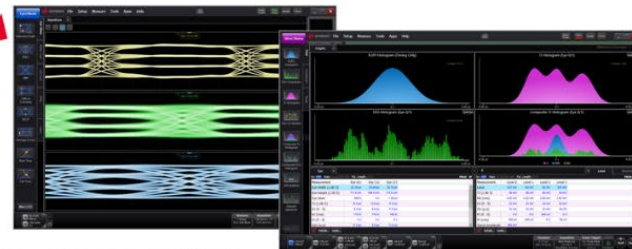
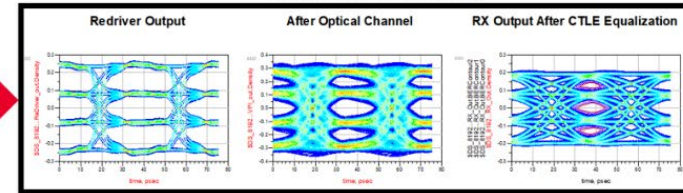
When digital signals reach multigigabit speeds, the unpredictable becomes the norm. Keysight's PathWave ADS will help you cut through these challenges by state-of-the-art high speed digital design simulation solutions. PathWave ADS delivers industry leading time-, frequency-domain, and channel simulation technologies, within a cohesive design-to-test workflow, to help you overcome signal integrity and power integrity issues for SerDes and memory interface designs, while ensuring the design for compliance.



Dynamic Co-Simulation



ADS Data Display

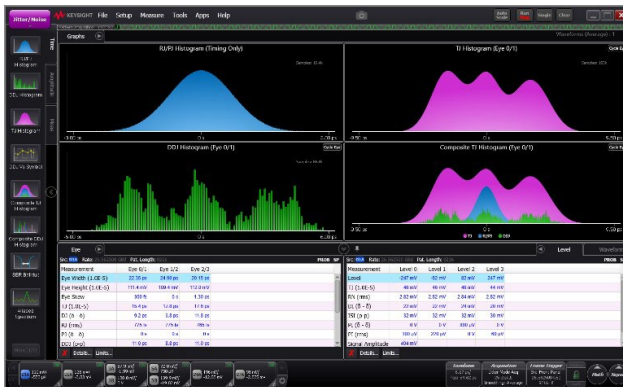


FlexDCA for TDECQ & PAM4

PathWave advanced design system (ADS)

With PathWave ADS and other tools from Keysight you can:

- Analyze complete serial link and memory interface systems
- Analyze eye diagram, eye mask, BER etc. for PAM-n (PAM3, PAM4, PAM8, PAM16, etc) signals
- Simulate AMI (Algorithmic Modeling Interface) models from any SerDes vendors and calculate ultra-low BER in seconds not days using the statistical Channel Simulator Use measured waveform for Tx AMI model
- Handles frequency-domain S-parameter models accurately in time-domain and channel simulations, using patented causality and passivity algorithms Accurate EM-based PCB channel modeling and transmission line impedance scanning
- Perform COM (Channel Operating Margin) calculation for normative channel compliance
- Connect to FlexDCA (Sampling scope) to process the simulated waveforms for advanced PAM4 measurements such as TDECQ and jitter analysis. Also connects to Infiniium (real-time scope)

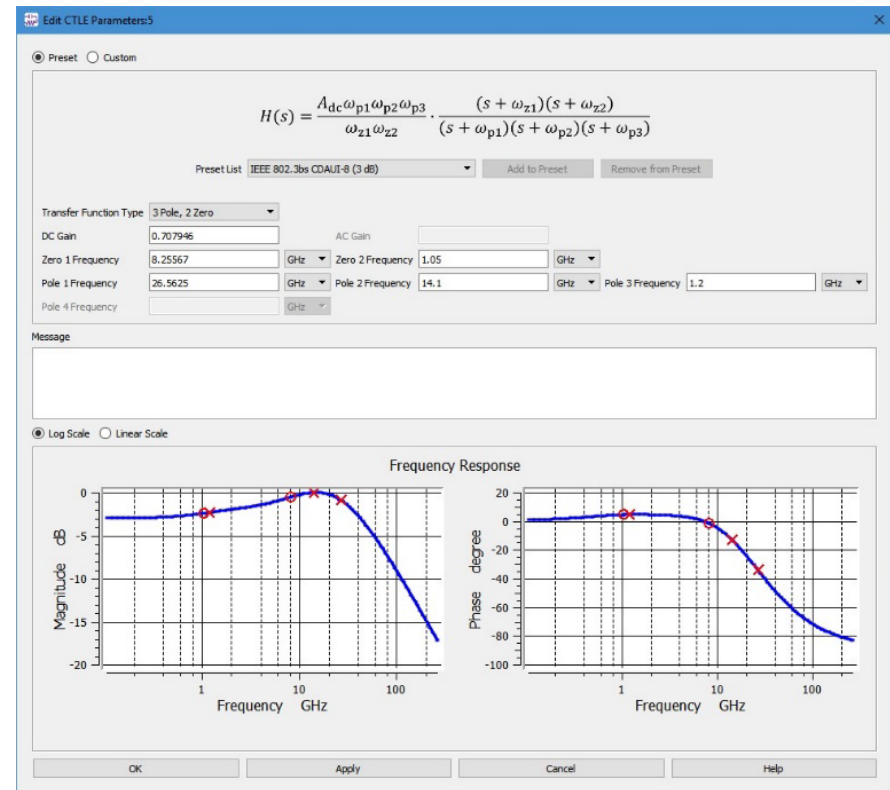


Flex DCA Software



Visualize CTLE transfer functions with poles and zeros (Many preset CTLE values are provided for 802.3bs, USB, MIPI, PCIe Gen3, Gen4 and Gen5, etc)

- IBIS-AMI Back Channel Interface – enables automatic negotiation of EQ settings between Tx and Rx models



CTLE Interface

Data Center Transceiver Test

800G R&D test solutions for optical and electrical characterization of Tx/Rx

Keysight's total solution approach

Keysight continuously make new addition to its 400G/800G R&D characterization portfolio. This will offer designers and R&D engineers clock recovery, equalization and error detection capabilities at emerging data-rates.

Test equipment and solutions for optical and electrical characterization of Tx/Rx :

- UXR1102A Infiniium series 110GHz Realtime Oscilloscope
- N7005A O/E converter for UXR
- M8040A or M8050A Bit Error Tester (BERT)
- M8199A/B or M8194A Arbitrary Waveform Generator (AWG)
- N1000A DCA-X Wide-Bandwidth Oscilloscope Mainframe
- N1032A 120 GHz optical plug-in module
- N1046A 75/85/100 GHz 1/2/4 port remote sampling heads module
- N1060A precision waveform analyzer
- G800GE OSFP/ QSFP-DD test system

DCA-X performance



The N1000A DCA-X wide-bandwidth sampling oscilloscopes provide accurate and precise measurements of high-speed digital designs from 50 Mb/s to 224 Gb/s.

Applications include:

- Optical transceiver design and production tests
- Electrical ASIC/FPGA/IC design and characterization
- Serial bus characterization, measurements and trouble-shooting via TDR/TDT and S-parameter measurements of channels, cables and PCBs.

Keysight offers wide range of solutions to target on your applications that can be combined with or used alongside the DCA-X, DCA-M, stand-alone clock recovery and N1010A FlexDCA software.

N1060A Precision waveform analyzer



N1060A Precision Waveform Analyzer with N1000A DCA-X

Key features & functions

Gain margin with high instrument performance: bandwidth to > 90 GHz, residual jitter as low as 50 fs and adjustable clock recovery peaking & loop BW.

Reduce development time through instrument flexibility: integrated clock recovery data rates to 64 GBaud (112 Gb/s) (NRZ & PAM4) and integrated pickoffs for simple one connection “triggerless” operation

Reduce validation time with analysis tools like Jitter Spectrum Analysis & SW Clock Recovery Emulation

- 2 channel / clock recovery / precision timebase combo
- 50 or 85 GHz bandwidth
- 16, 32 or 64 G NRZ and PAM4 clock recovery
- Jitter Spectrum Analysis and Clock Recovery Emulation
- Electrical inputs: 1.0 mm male (1.0 female to 1.85 female adapters incl.

N1046A 75/85/100 GHz 1/2/4 port remote sampling heads module



N1046A | 75GHz | 85GHzz | 100GHz | 1 Port | 2 Port | 4 Port | Remote sampling heads for 86100D DCA-X

Key features

The N1046A is a group of remote sampling head modules designed to characterize your highest-performance designs for 56 GBaud and beyond. The “soft roll-off” of their frequency response can capture wideband digital signals such as NRZ or PAM4, as well as narrowband.

- 1/2/4 Port, Electrical Remote Sampling Head
- 75 GHz, 85 GHz or > 100 GHz maximum available bandwidth (upgradable)
- High bandwidth and low-noise samplers, ideal for analyzing high-speed signals used in emerging designs such as 224 Gb/s

N1032A/B 90/120 GHz Single/dual channel optical module

The new N1032A/B optical module for DCA-X sampling scopes provides the world's highest optical bandwidth up to 120 GHz. The ultra-high optical bandwidth in N1032A/B module is ideally analyzing 112 GBaud (224 Gbps) optical signals or any application that require ultra-wide optical receiver > 65 GHz bandwidth (-3 dBo).



N1032A/B optical modules with N1000A DCA-X

Typical Setup for signaling rates > 64 GBaud



Key features & functions

Highest Optical Bandwidth

- Feature: World's highest optical oscilloscope at 120 GHz bandwidth
- Benefit: Helps pathfinders and researchers to see the true performance of their designs

Unique Solution for 224 Gb/s (112 Gbaud PAM4)

- Feature: Optical reference receiver range from 49.8 to 224 Gb/s
- Benefit: First optical reference receiver to enable 800G/1.6T transmission

Ultra-wide Optical Reference Receiver

- Feature: Fully calibrated and easy-to-use optical reference receiver
- Benefit: Accurate characterize subsystems used in data communications that require > 65 GHz BW

Smooth frequency response enables accurate System Impulse Response Correction (SIRC)

- Adjustable BW (-3 dBo): 35 GHz – 90 GHz (#09U) and 35 GHz – 130 GHz (#13U)
- Adjustable Frequency Response: Bessel, Gaussian, Flat, Sin(x)/(x)

G800GE - 800GE Layer 1 BERT + KP4 FEC Multiport

World's First Line-Rate 2 x 800GE Test system

Keysight's G800GE OSFP test system makes the challenge of qualifying bit error rate (BER) and forward error correction (FEC) symbol performance and stress-testing with line-rate packet traffic on 800GE electronic devices easier and affordable. Used to validate chips, optical transceivers, or the port electronics of networking equipment, the G800GE is a purpose-built BERT and FEC test system with 112Gb electrical lane signaling per port that gives you the ability to find a problem in minutes, not hours. It shows a system-level view of the BER and FEC performance of all lanes and on the ports, as desired, all at once, in real time.

More accurate measurement using coaxial connectivity

The G800GE 1-port optical transceiver interface model is a unique benchtop test chassis that includes a 1-port electrical Tx/Rx coaxial interface. The coaxial interface is an excellent medium for electrical signals. Its use results in more accurate measurements because it offers an extremely clean signal. The coaxial interface connects with many different types of device evaluation boards to validate devices under test with the G800GE's BERT, FEC, and packet transmission capabilities.

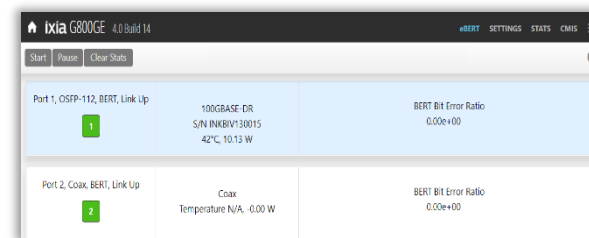
Key features & functions

- Functional testing for 400G and 800G silicon and transceiver with 100G serial interfaces.
- Validate the BER performance of high-port-count devices with 2-ports of the G800GE 800GE BERT, FEC, and packet blast capabilities with Keysight's KiOS multi-port browser application

- Perform long-duration (timed tests) and stress tests by using Keysight's KP4 FEC symbol bit error density distribution analysis—excellent for catching bursty errors that occur over time
- Simplify connection of the G800GE to Keysight's M8040A high-performance BERT analyzer for FEC-aware physical layer test
- Programmable FEC capture with external trigger to UXR Realtime scope.
- Exhaustive manufacturing solution for 800G transceiver, combined with Keysight DCA-M oscilloscope
- Available interfaces OSFP + COAX, OSFP, QSFP-DD + COAX and QSFP-DD.
- Find problems faster with KiOS browser-based single-page application (SPA), system-view of all the BERT, FEC, and packet statistics of all the lanes or ports with 1x800GE, 2x400GE, 4x200GE, and 8x100GE speed support
- Measure line-rate BER and FEC performance in minutes, not hours—evaluate optical transceiver and silicon device BER at all Ethernet speeds simultaneously by using the patented enhanced BERT option (BERT inferred FEC)



G800GE 1-port optical transceiver interface model



G800G software interface

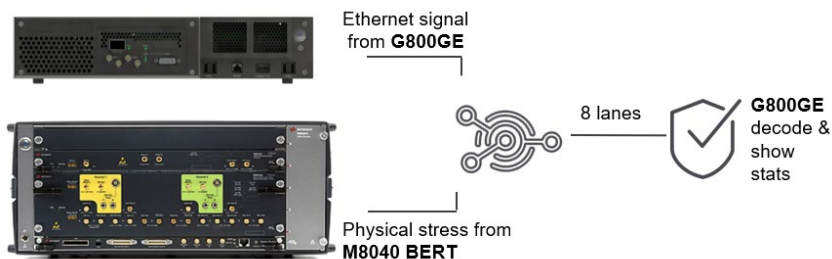
FEC- proofed designs

The combination of adaptive digital equalizers combined with forward error correction has drastically increased the level of complexity for the design, characterization, and validation process of 400G and 800G components and interfaces.

800G FEC-aware Rx conformance test

100G serial interfaces heavily rely on adaptive digital equalizer to compensate for the channel loss and reflections and on Forward Error Correction (FEC) to run error free. Unfortunately, digital equalizers and re-timers generate error bursts that strongly affect the performance of Reed Solomon FEC codes used in the 400G and 800G designs. The Solution consist of the M8040A or M8050A BERT combined with the G800GE. It is designed to integrate FEC constraints into the physical design validation.

The G800GE generates and analyzes 100G, 200, 400 or 800G traffic. Some of the electrical lanes can be replaced by those of a classical BERT system acting as victim lanes calibrated according to standards such as IEEE 802.3ck. The traffic can be PRBS-based or FEC encoded – for this the G800GE and the BERT must be synchronized.



FEC-AWARE conformance test for 100G Serial Interfaces with M8040A and G800GE

High-performance BERT analyzer synchronization

The G800GE OSFP can be upgraded in the field to support interconnection and synchronization with Keysight's M8040A or M8050A high-performance BERT analyzer. The combined system is a symbol-stripped, FEC-aware physical layer BER tester for 112G electrical lanes. It is a solution for 800GE characterization, stress, and conformance tests, and to perform physical-layer channel stress and impairment of a channel. Additionally, advanced tests such as TDECQ and optical receiver stress testing (ORST) may be performed for optical transceivers in conjunction with various Keysight Layer 1 instruments such as a real-time oscilloscope, a DCA, and other equipment and accessories depending on the application.

Key features

- Stressed signal calibrated according to IEEE 802.3ck (electrical) and IEEE 802.3cd (optical)
- 100GBASE FEC lanes from 2 sources seamlessly (PRBS possible)
- Real-time Rx performance monitoring on G800GE e.g. BER, FLR, FEC margin, and bursts capture.
- Connect a module compliance board to your device evaluation board by using the G800GE electrical coaxial cabling system

M8040A 64 GBaud High-performance BERT

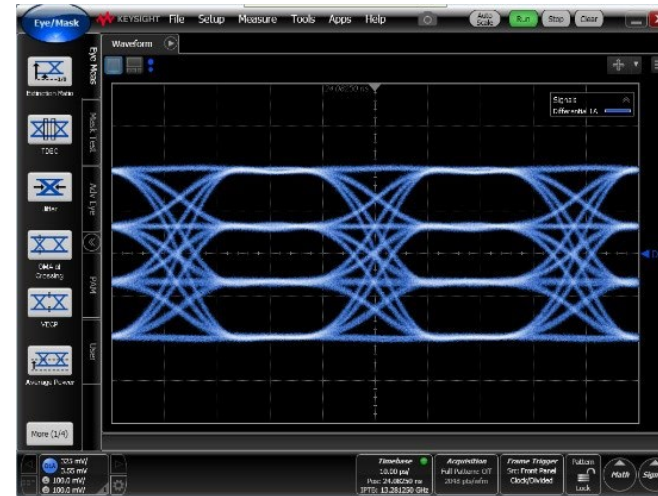


Get repeatable and accurate results with the M8040A 64 GBaud High-Performance BERT.

Master your next design

The M8040A provides clean NRZ and PAM4 signals up to 64 Gbaud with fast transitions and low intrinsic jitter. The remote head concept of the M8040A with the short 1.85 mm cables brings the performance close to the device under test, minimizing signal degradations caused by lossy channels.

The M8040A can be used for receiver (input) testing for many popular interconnect standards that use PAM4 and NRZ data formats such as: 50 / 100 / 200 / 400 / 800 GbE, OIF CEI-56G, and CEI-112G, 64G/112G Fibre Channel, PCIe 6.0 / 5.0 / 4.0, TBT3, USB3/4, SAS and Infiniband.



The pattern generator of M8040A provides a clean PAM4 signal.

Key features

- Data rates from 2 to 64 GBaud PAM4 signal
- True PAM4 error detection in real-time up to 58 GBaud
- Built-in de-emphasis, analyzer equalization and clock recovery
- Integrated and calibrated jitter injection: RJ, PJ1, PJ2, SJ, BUJ, and clk/2 jitter
- Two pattern generator channels per module to emulate aggressor lane
- Interactive link training and SKP OS filtering for 8/16/32/64 GT/s PCI Express®, SAS and USB3.2/ 4
- Algorithmic PRBS, QPRBS and memory-based patterns such as SSQRQ, pattern sequencer.
- For PAM4: Gray coding, FEC encoding and precoder an error distribution analysis
- All options and modules are upgradeable

M8050A 120 GBaud High-performance BERT

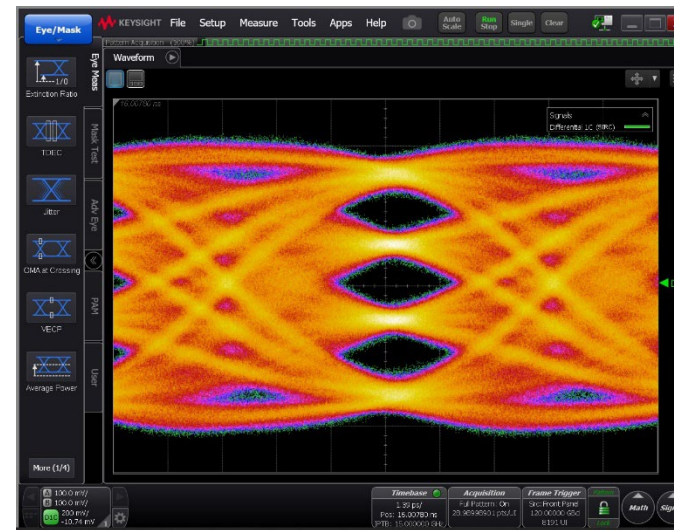


Get up to 120 GBaud pattern generation and error analysis with the M8050A.

Keysight is your partner for 1.6T

Keysight's most advanced BERT, the M8050A, ensures success in next-generation chip deployments for up to 1.6 Tbps and other leading-edge technologies by providing the unmatched combination of 120 GBaud signal generation with uncompromised signal integrity.

When you combine the M8050A with an 80 GHz UXR, you have a full 120 GBaud receiver and transmitter test solution – only available from Keysight! Succeeding in next-generation technologies is seamless when partnering with Keysight and the M8050A high-performance 120 GBaud BERT.



The M8050A provides pattern generation for up to 120 GBaud with clean open eyes.

Key features

- Pattern generation up to 120 GBaud NRZ, PAM4, PAM6/8
- Fast transition times of 5 picoseconds
- A super-clean clock with less than 100 fs random jitter @ 106 GBd
- An output amplitude up to 1.6V peak to peak differential.
- 7 tap de-emphasis with nominal 0.5% resolution provides lower distortions through better channel match and improved channel loss compensation
- Error analysis up to 120 GBaud with the SD7150A Receiver and Transmitter Test solution
- Software support from the well-known M8070B system software, which means along with additional conformance test software packages, you can easily verify you are meeting standards requirements.

High speed multimode optics solutions

Keysight's total solution for 100G/lane multimode

Keysight has a total solution approach for 100G/lane Multimode optical transceiver test. Transmitter dispersion and eye closure quaternary (TDECQ) is the primary metric to assess PAM4 optical transmitter communication quality. A solution combining the N1092A DCA-M Sampling Oscilloscope, with new N1077B Clock Recovery module is targeted on 100G per lane multimode applications defined under IEEE 802.3db.

- First-to-market 64GBaud Multimode CDR
- IEEE 802.3db compliance
- Complete Tx-test Solution

N1092A/B/C/D/E and N1094A/B DCA-M Optical and Electrical Sampling Oscilloscopes



N1092A/B/C/D/E and N1094A/B DCA-M optical and electrical sampling oscilloscopes

Get N1000A DCA accuracy with a test solution designed for manufacturing

Keysight's N1000A digital communication analyzer (DCA) family is recognized as the industry standard for verifying optical transmitter compliance to communications standards. For years engineers have trusted the DCA to provide accurate and easy measurement of digital communication waveforms. The Keysight N109X DCA-M family has built on that legacy by using the high-performance elements of both the N1000A-oscilloscope mainframe acquisition system and the optical and electrical channel hardware of the N104XA plug-in modules. The N1092 and N1094 are for use from 8.4 GBaud to 64 GBaud on NRZ and PAM4 waveform and jitter measurement.

Designed specifically for high-volume manufacturing test applications

Designed specifically for high-volume manufacturing test applications, the DCA-M provides the measurement accuracy of the N1000A, without the extra cost associated with an R&D test solution. Be confident that your test results will never be questioned when performed with an N109X because end users of your transceivers and components are likely to use similar accurate, high-quality test systems to verify component performance.

Integrated instruments built in a small form factor

Built on Keysight's digital communication analyzer (DCA) technology, the DCA-M family is recognized as the industry standard for verifying optical transmitter compliance to communications standards. With single to quad optical AND electrical channels in a compact form factor, the DCA-M is ideal for both manufacturing and R&D applications. Analyze both multi-mode and single-mode signals with the low-noise, high-sensitivity calibrated reference receivers. The variety of models along with the supporting software and compliance applications ensure you can measure with high precision, whether you analyze electrical or optical devices.

- Analyze a wide range of data rates, from 1 Gb/s through 64 GBaud
- Electrical channels are available with up to 50 GHz bandwidth
- Characteristic intrinsic jitter as low as 160 fs RMS
- Supported both multimode and single-mode for single to quad channels models

Based on the modern N1010A FlexDCA user interface

Keysight's N1010A FlexDCA is the software that runs on the Keysight DCA Series of sampling oscilloscopes. It controls measurement hardware both as a local user interface and for remote control. In addition to acquiring data and making measurements, FlexDCA has powerful tools that boost productivity and provide insights into root causes of issues with the signal or device under test.



N1010A FlexDCA user interface

N1077B 64 GBaud multimode optical/electrical clock recovery

The N1077B Optical/Electrical **Clock Recovery** provides instrument-grade clock recovery with adjustable loop bandwidth and peaking on both optical and electrical signals up to 64 GBaud. The N1077B clock recovery instrument is controlled via a USB connection to an N1000A DCA-X mainframe, or to a standalone PC, running N1010A FlexDCA software.



N1077B 64 GBaud Multimode Optical/Electrical Clock Recovery

Key features & functions

- 125 MBd to 64 GBaud data rate range (continuous) on optical and electrical NRZ and PAM4 data signals
- Standards-compliant clock recovery ("Golden PLL") with adjustable peaking and loop bandwidth (to 20 MHz)
- Lock onto degraded signals ("closed eyes") using a built-in variable equalizer (Option EVA)
- Gain insight into root cause(s) for jitter using Jitter Spectrum Analysis (Option JSA). Perform compliant PLL bandwidth and peaking measurements using N1010300A FlexPLL Analysis software and N1081PLCA PCI Express PLL Test Application

100/400GE Optical receiver stress test solution – ensuring repeatable and reproducible results



When transceiver modules interoperability issues arise or simply when discrepancies between the measured and expected performance are observed, additional rounds of module characterization must be performed by the vendor leading to a delay in the shipment or even to product disqualification.

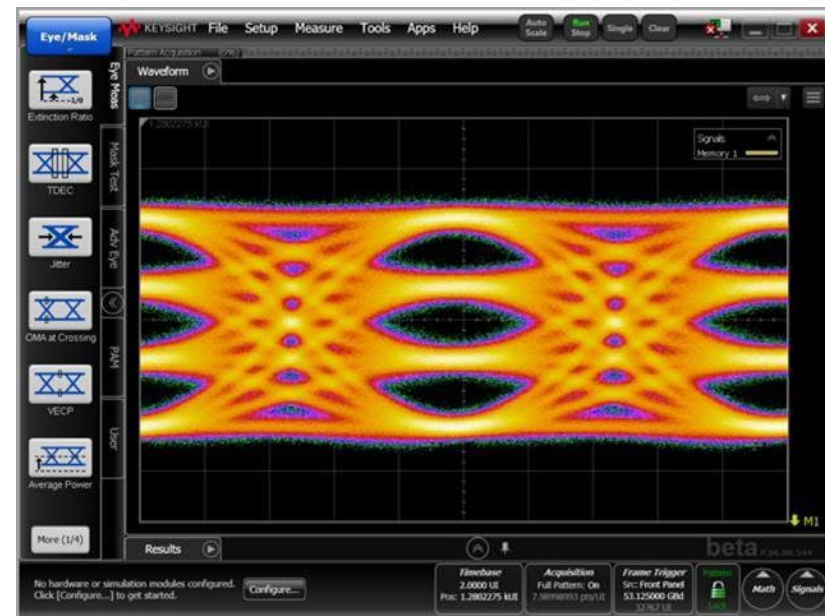
Keysight provides fully automated solutions for optical transmitter characterization and optical receiver stress testing following IEEE 100G, 400G and MSAs. Keysight optical receiver stress testing solution is the only commercially available and complete solution including an automated optical stressed eye calibration, where stress conditions are fully controlled and adjustable thus ensuring repeatable and reproducible results.

Key features & benefits

- Test compliance of optical 100G & 400G transceivers with IEEE standards & MSAs
- Detect and understand interoperability issues
- One vendor turn-key solution.

Key specifications

- Controllable stress mix (ISI, jitter, noise) to address IEEE 802.3bs/cd/db test procedure and user-specific test (design characterization)
- Up to 56GBaud PAM4 in O- C-band and 850nm with 81492A-135 single mode and 81491A-085 multimode reference transmitters.
- Controllable amount of jitter-, noise- and ISI-induced penalty for both NRZ and PAM4
- Automated stress signal calibration, receiver sensitivity and jitter tolerance measurements
- Repeatable and stable calibration of optical stressed NRZ and PAM4 signals



Optical 53.125GBaud PAM4 generated using M8196A AWG and 81490A-135 reference transmitter.

Integrated Photonics and Optical Parametric Test

Silicon photonics - efficient wafer level test

Integrated photonic devices

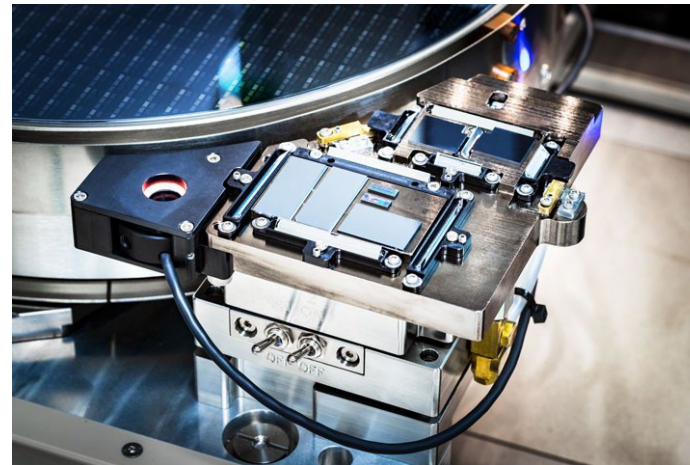
Integrated photonic devices require comprehensive testing for optical and electro-optical parameters at wafer level as well as on singulated dies both for DC and high-frequency signals. Fully automated probing of wafer structures with high precision and speed is essential for R&D and design verification. Now available with Keysight's scalable multi-channel Optical, RF, DC solutions.

Keysight's integrated photonic test solution combines wafer probing and measurement solutions for parametric testing

Fully automated probe station and instrumentation characterizing optical and electro-optic devices for optical, frequency and time domain tests which are scalable to serve also your future test challenges.

- Polarization resolved optical characterization over multiple wavelength bands (1240 – 1650 nm) with
 - Photonic Application Suite Lambda Scan software
 - N777-C tunable laser sources, N778-C polarization instrument family, N774-C multiport power meter family, N7731/4A optical switches, SMU instruments for O/E responsivity
- Scalable and modular PXI platform with
 - M9601A (1 channel highest resolution) and M9614/15 (5 channel) Precision Source/Measure Units
 - M9808A 53GHz Vector Network Analyzer with N4377A Lightwave Detector

- Up to 110GHz RF tests with Keysight N4372/3E Lightwave Component Analyzer
- Frequency, Time domain and coherent test
- Fully automated wafer and die test workflow based on Keysight PathWave Test Automation (TAP) with integrated instrument and probe station control
 - N7700210C Wafer Prober Plug-In for Test Automation
 - Test Automation Plug-In for PAS Lambda Scan SW
 - N4370P01B LCA Plug-In for Test Automation
- Partnering with FormFactor
 - Semi-automated Wafer and Single-die probing with FormFactor CM300xi probe station
 - Precise, fast and repeatable device probing on up to 300mm wafers, wafer and sub-die navigation
 - Edge/Trench and Surface / grating optical coupling with single and multi-fiber connection with high degree of flexibility
 - RF probing up to 110GHz and multi-pin DC electric ai probing



Auxiliary chuck for calibration and single die testing suitable for edge and surface probing

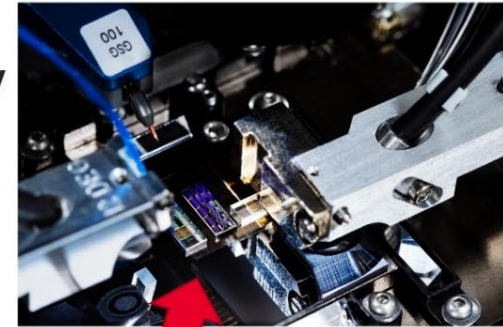
Integrated photonics test solution

RF Electro-Optical Measurement



N4372E Lightwave Component Analyzer

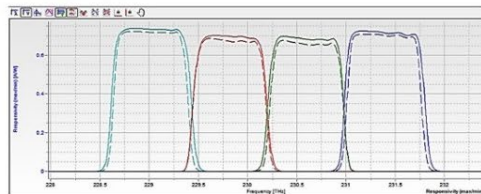
Edge & Surface Single & Fiber Array Optical & RF & DC Probes



Wafer & Die Probing and Alignment



Optical and DC Electro-Optical Measurement



N7745C Multiport Power Meter

N7786C Polarization Synthesizer

M9601A & M9615A B2900 Series Source Measure Units



N776C Tunable Laser Source



M9808A 53GHz VNA



Parametric photonic test

Keysight offers integrated solutions for measuring wavelength and polarization dependence of optical components. The new software and hardware use Keysight's unique single-sweep method for the best repeatability. New polarization alignment and stabilized polarization sweeps are especially valuable for on-wafer and PIC testing, including probe alignment. Measurement and start-up times are greatly reduced.

New generation of fiberoptic test instruments: N77-C family



Compact standard platform for N77-C instruments

For optical component development and manufacturing, these new test instruments provide the required functionality and accuracy with faster data transfer and easy connectivity. New tunable lasers, optical power meters and polarization instruments are optimized to work together making fast wavelength and polarization dependent measurements. All instruments have a browser-based GUI, so basic functionality is available simply and remotely without installing additional software, both over the LAN and USB interfaces.

www.keysight.com/find/oct

- The **N777-C tunable laser** family provides models to cover the full 1240-1650 nm range with performance classes for 2-way swept measurements at up to 200 nm/s, picometer wavelength accuracy, and economical static and stepped-wavelength applications.
- The **N774-C multiport power meters and remote heads** with 2, 4 or 8 optical ports now transfer data at up to 3x faster rate than the predecessors while logging up to 1M samples/port at up to 1 MHz sampling rate, for synchronized use with tunable lasers and other time-dependent optical measurements, supported by the new triggering on input signal events. Analog voltage output is available for alignment and feedback use, with both linear and logarithmic proportionality to the optical signal.
- The **N778-C polarization instrument family** include a polarimeter benefitting from the sampling rate and dynamic range of the N774-C electronics, a fast synchronized scrambler with new digital-feedback stabilization and combined instruments for fast deterministic polarization synthesis or component analysis including DGD/PMD.



N7749C interface for 8162-C remote power heads

Widely compatible with current instrument generations, the new N77-C instruments simplify the integration of test solutions and protect investments in earlier hardware and in software development.

Application software for wavelength & polarization dependence

The Photonic Application Suite, PAS Version 3, adds support for the N77-C instruments, adopts a new 64-bit implementation and introduces the new Lambda Scan measurement package for enhanced performance and more flexible features.

Software packages

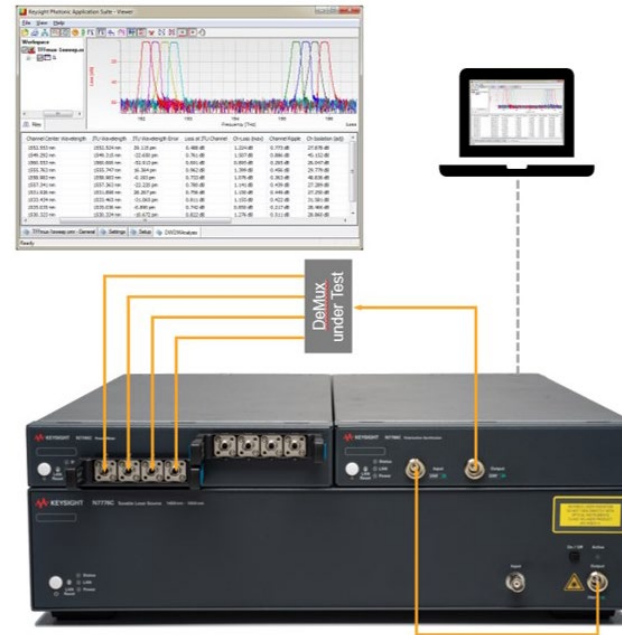
- **New LS Engine:** enhanced and extended functionality for lambda scans with or without polarization functionality, for IL, PDL, and also responsivity for integrated detector devices, supporting integration of a wide range of instruments, including optical power meters and remote heads, source measure units like the new PXI M9601A, M9614A and M9615A for photocurrent detection, and the N7788C component analyzer for DGD and PMD measurement.
- **Legacy FSIL Engine:** calibrate and adjust devices at highest repetition rates using N774x power meters
- **Legacy IL/PDL Engine:** measure IL and PDL vs. wavelength using the N7786B, also for integrated detector devices

For details, see: www.keysight.com/find/n7700

Licenses

- N7700100C Polarization Lambda Scan (PLS) for single-sweep multichannel measurement using the LS or IL/PDL engine
- N7700101C DWDM Channel Analysis (DWDM) for specified component parameters from the spectral measurements
- N7700102C Fast Lambda Scan (FLS) for multichannel wavelength-dependence using the LS or FSIL engine.
- N7700103C PMD Lambda Scan (PMD) for single channel measurements of devices and fiber for differential group delay and PMD parameters as well as insertion loss and PDL, using the N7786C with 1 or more tunable lasers.

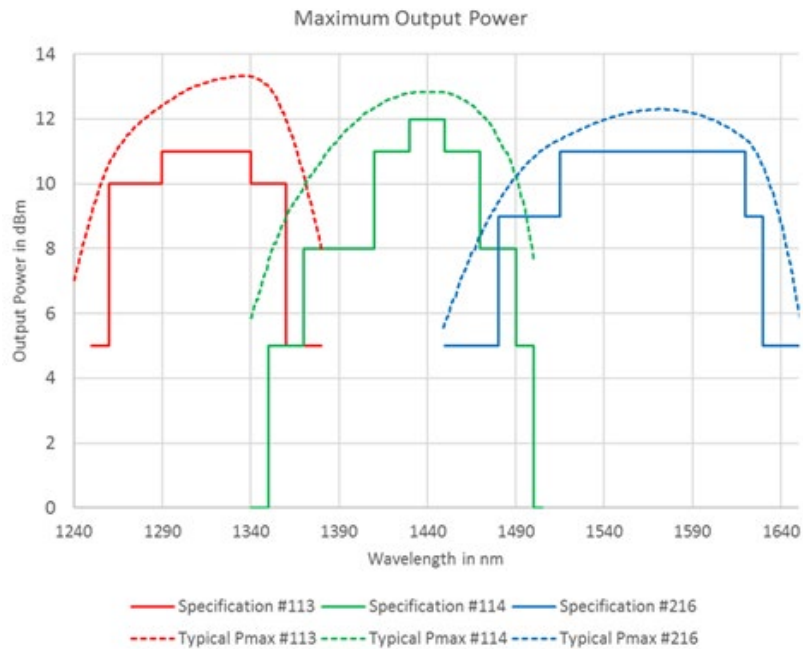
Swept-wavelength measurement solution for integrated photonics



Basic configuration for single-sweep IL and PDL multiport measurements

Keysight's single-sweep technique measures polarization dependence without repeating sweeps for much better repeatability and stability against temperature drift and fiber movement. Automatic resolution of spectra for the TE and TM modes of planar integrated devices avoids time-consuming polarization alignment prior to the measurement. New IL de-embedding of setup elements like optical switch paths simplifies measurement calibration. The Static-Mode function stabilizes the polarization to the device axis, based on the swept measurement to support probe alignment and adjustment processes, especially when performing wafer-level testing. With the LS engine and N7786C polarization synthesizer, wavelength scans can be performed at these stabilized polarizations.

All-band coverage with new wavelength option for tunable laser family



Optical power spectrum of N777-C tunable lasers

In both forms, as stand-alone N777-C or as 8160xA module, the laser family has options for complete coverage of the single-mode fiber telecom bands, from 1240 nm to 1650 nm. The combination of an O-band and an E-band laser (options 113 and 114) for example, enables the measurement of multiplexers/demultiplexers and receiver subassemblies for the 400G CWDM8 MSA, while the full CWDM spectrum is covered by the combination of three wavelength options: 113, 114 and 116 or 216. The PAS LS software makes it particularly easy to make measurements combining multiple lasers with automated switching of the laser ports.

Multi-wavelength meters



86122C multi-wavelength meter

With two models, Keysight's family of multi-wavelength meters addresses the test of tunable transmitters for DWDM systems at ± 0.2 ppm in the range of 1270 nm to 1650 nm (model 86122C, 0.3 sec cycle time), as well as the measurement of lasers for the new SWDM and CWDM MSAs at typ. ± 1 ppm in the extended range of 700 nm to 1700 nm (model 86120D, specified: 700 nm to 1650 nm, 0.6 sec cycle time). Both models in the family of multi-wavelength meters can acquire up to 1000 laser lines in a single sweep. The high-end model 86122C comes with 5 years factory warranty, including coverage of reference laser exchange.

High frequency parametric testing for silicon photonics and electro-optic device testing

N4372E Lightwave Component Analyzer up to 110GHz



N4372E Lightwave Component Analyzer up to 110GHz

The N4372E 110GHz Lightwave Component Analyzer (LCA) extends Keysight's LCA family for high frequency parametric testing of optical transmitters and receivers up to 110GHz. Based on the N5290A/N5291A 900 Hz to 110/120 GHz PNA mm-Wave System, the N4372E is the only electro-optic vector network analyzer system realizing S-Parameter measurements for both E-to-O and O-to-E devices up to 110GHz.

Key features of LCA family:

- Optical transmitter and -receiver test: responsivity, electrical return loss
- Single mode component test up to 110 GHz, 1260 - 1620 nm range
- Multimode component test up to 50 GHz, 820 – 980 nm range
- Absolute and relative electro-optic response (magnitude and phase)

- Expansion of measurement capabilities through combination with PNA measurement classes (e.g. for THD and gain compression measurements)
- NIST traceable
- Integrated optical power meter

N4377A calibrated lightwave detector



N4377A calibrated lightwave detector

The N4377A is a self-contained, USB-powered Lightwave Detector with **optical power meter capability** for **frequency domain applications** to be used with

- Vector network analyzers
- Spectrum analyzers
- Powered and connected via USB interface:
 - Calibration data stored as S2P files on module and accessible as USB drive
 - SCPI remote programming via USBTMC
- (Re-)Calibration independent from network analyzer
- Available Options:
 - S70: 70 GHz operating range at 1310 nm/ 1550 nm; single mode fiber
 - S40: 40 GHz operating range at 1310 nm/ 1550 nm; single mode fiber
 - M40: 40 GHz operating range at 850 nm; multimode fiber

N5291A 900 Hz to 120 GHz PNA Millimeter-wave system



N5291A 900 Hz to 120 GHz PNA mm-Wave System

Gain confidence with an off-the-shelf solution

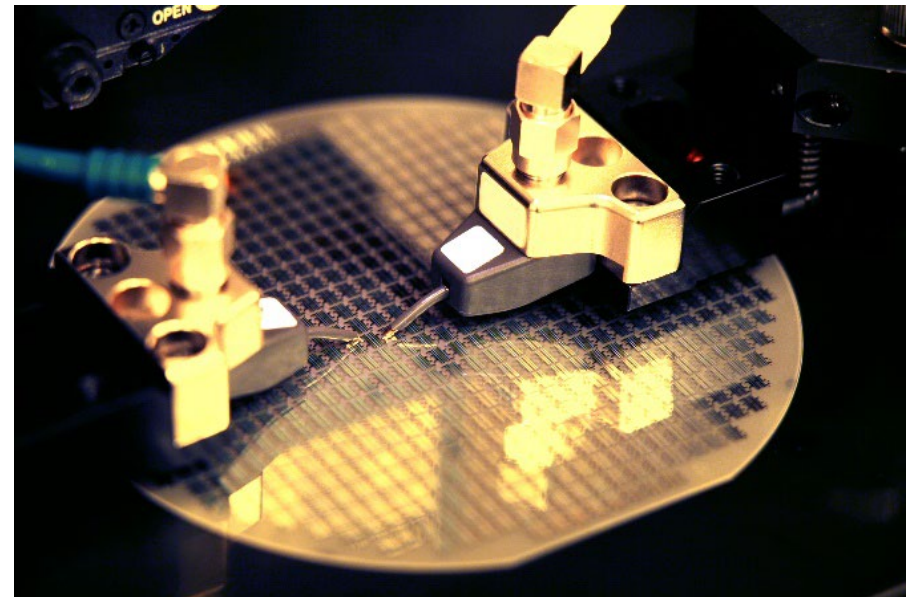
Assembling a “roll your own” millimeter-wave network analyzer can be challenging and time-consuming. Worse, there are no guaranteed specifications for stability or accuracy.

The better alternative is a preconfigured solution that includes a two- or four-port network analyzer along with the necessary millimeter-wave cabling, frequency extenders and test-set controller. **With the N5290/91A solutions**, you can select either a PNA or PNA-X network analyzer with maximum frequency of 26.5 GHz or 67 GHz. Keysight’s **configuration guide** describes the full range of choices.

The result is a broadband millimeter-wave solution that enhances device characterization and modeling for on-wafer and connectorized measurements. To ensure accurate and repeatable on-wafer results, the N5290/91A solution is also compatible with the **wafer-level measurement solution** (WMS) created by Keysight and solution-partner Formfactor (former Cascade Microtech).

Key features & functions

- Single-sweep solution with compact frequency extenders
- Available as a single product solution
- Accurate leveled power can be applied to the device, providing the ability to sweep power
- Available various software applications for detail analysis



The combination of calibration, fixture de-embedding and fixture removal enhances the accuracy of on-wafer measurements.

Coherent Transceiver Test

220 GBaud R&D test system for coherent optical transmissions

Test advanced modulation schemes for 600 Gb/s to 2 Tb/s transmission market. The next generation of coherent transceivers will operate at symbol rates of around 160 GBaud and beyond. This test solution mimics the function of a coherent transceiver generating signals with flexible modulation formats using **Keysight's M8199 Family of Arbitrary Waveform Generators (AWG)**. For the analysis of these signals **Keysight's groundbreaking N4391B Optical Modulation Analyzer (OMA)** is used which is based on Keysight's industry leading UXR real-time oscilloscope family. This solution enables full transceiver analysis at the new speed class to verify and improve the transceiver's performance.

- Highest bandwidth
- Lowest noise floor
- Lowest noise floor

70 GHz and 110 GHz optical modulation analyzer receiver



N4391B Optical Modulation Analyzer Receiver



M8199A Arbitrary Waveform Generator, 4-ch 128GSa/s or 4-ch 256 GSa/s with interleaving

For coherent transmission test, Keysight offers instruments for the generation and analysis of complex modulated optical signals. Multichannel arbitrary waveform generators are typically used to synthesize those complex modulated signals. Use the 81195A optical modulation generator software to generate clean complex modulated signals as well as signal impairments to stress coherent receivers over multiple test scenarios.

Optical modulation analyzers provide insights into the physical layer of complex modulated optical signals to determine signal quality or evaluate components that are designed for IQ modulation and demodulation. Keysight offers the widest range of optical modulation analysis and synthesis instruments for testing up to 1.2 Tb/s – for your current and future needs.

Key features & specifications

- Maximum detectable symbol rates 80 | 100 | 118 | 140 GBd and 160 | 200 | 220 GBd depending on oscilloscope option
- 40 | 50 | 59 | 70 GHz and | 80 | 100 | 110 GHz system bandwidth options with a single oscilloscope
- 256 GSa/s Sample rate
- ADC resolution 10 bits for all bandwidth grades
- Specified typical system noise floor < 1.6% EVM rms at reference conditions
- Relative skew < ± 0.5 ps
- Optical operating wavelength range 1528 nm to 1620 nm
- Absolute wavelength accuracy +/- 2.5 pm typical

Testing the coherent 400G ecosystem

Scalable solution for R&D and Manufacturing

Interoperability and volume requirements necessitate a paradigm shift in coherent transceiver manufacturing. Keysight offers a test solution designed for the coherent 400G ecosystem, optimized for cost and size, including the M8290A Modular Optical Modulation Analyzer family (M-OMA) and the Arbitrary Waveform Generators (AWG) M8196A (92 GSa/s, 32 GHz analog bandwidth) or the M8194A (120 GSa/s, 50 GHz analog bandwidth).

M8290A optical modulation analyzer and high-speed digitizer test solution



Optimized for the 400G speed class, the M8292A optical modulation analyzer provides a compact, rack-mountable test instrument within the M8290A family, that connects to the optical output of coherent transmitters. It leverages the full feature set of Keysight's vector signal analyzer and optical modulation analyzer software ensuring a positive user experience analyzing complex modulated data signals.

Key features & specifications

- Turn-key solution for testing coherent optical transmit and receive devices
- Compact and flexible AXIe modular form factor
- Common Specs for M8292A and M8296A
 - 74 GBd maximum symbol rate
 - 83 to 92 GSa/s sample rate
 - 512k samples maximum record length
 - 8 bit ADC resolution
- M8292A Optical Receiver only:
 - 1528 to 1570 nm wavelength coverage
- M8296A Electrical Receiver (ADC) only
 - 150 mV to 400 mV Input range

Automated test solution for coherent optical transmit and receive devices

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

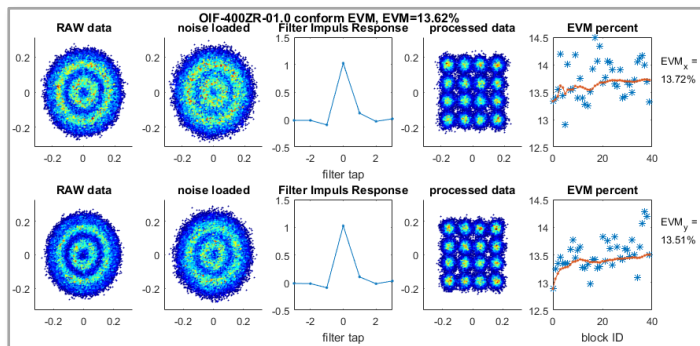
The N4391B OMA Software contains packages that use Keysight hardware to provide turn-key solutions for full characterization of coherent optical transmit and receive devices. Both hardware platforms, the M8290A as well as the N4391 family are supported.

Featured application packages in OMA software:

Standard Conform EVM measurement

Highlights:

- Transmitter test with pre-defined parameters and methodology according to ITU G.698.2 and OIF-400ZR-01.0
- Measures EVM on defined block length for all processing steps
- n-tap T-spaced adaptive equalizer
- digital noise loading (optional)

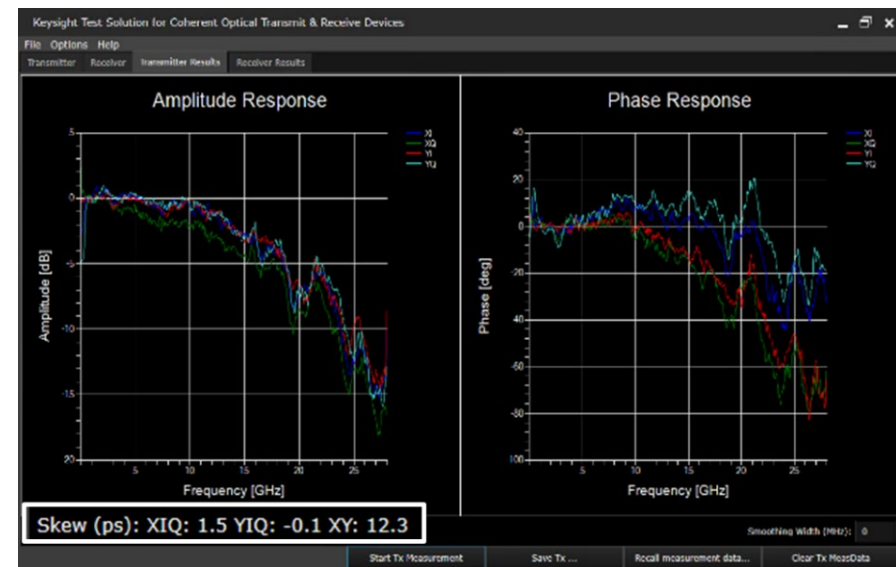


Standard-conform EVM Result screen for 400ZR transceiver

Testing of coherent optical transmit and receive devices (COD Test)

Highlights:

- single connection between fixture and instruments saves time and increases repeatability
- simultaneous measurement of all four S21 magnitude and phase responses
- De-embeds cables and fixtures
- Scalable setup to perform additional measurements
- Measures IQ skew, XY skew
- Rx IQ angles — requires heterodyne configuration

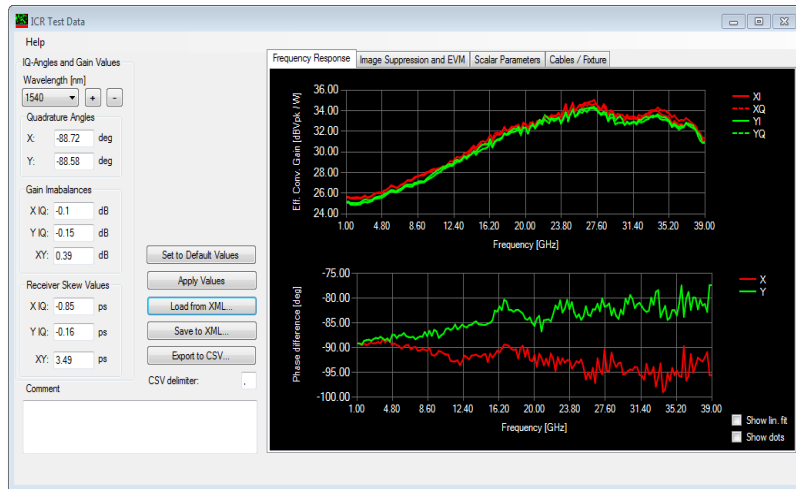


COD Test Result: Tx Amplitude & Phase Response with zoomed-in skew results

Integrated Coherent Receiver (ICR) testing

Highlights

- EVM noise floor
- Image suppression
- Simultaneous measurement of all four S21 magnitude responses saves test time
- Measures IQ skew, XY skew, and Rx IQ angle
- IQ and XY gain imbalance



ICR Test result screen with Phase & Frequency Response

Terabit Research – Precision tests at terabit speeds

To test the transmission speeds for tomorrow Keysight offers the latest industry leading signal generation and analysis technology based on the M8199A AWG and Infiniium UXR Realtime oscilloscope.

The M8199A and M8199B AWG provide the combination of speed (256 GSa/s), bandwidth and channel density (up to 4 differential channels). The UXR is the first series of real-time oscilloscopes featuring ultra-low noise and high signal fidelity with 10 bits of high-definition resolution and four channels of simultaneous 13-110 GHz of bandwidth, each concurrently sampling at 256 GSa/s.

- Industry's fastest AWG
- Ultra-low noise 110 GHz scope
- 100 GBaud/1 Tb research

UXR1104A Infiniium UXR-series oscilloscope: 110GHz, 4 channels

Infiniium UXR-series real-time oscilloscopes

The Infiniium UXR is the first series of real-time oscilloscopes to offer ultra-high-performance acquisition with 10 bits of high-definition resolution. With four channels of simultaneous 110 GHz of bandwidth, each concurrently sampling at a staggering 256 GSa/s, Infiniium UXR delivers the world-leading performance, ultra-low noise and high signal fidelity necessary for engineers and scientists to truly see and understand even the fastest phenomena – enabling you in accelerating the development of the next generation of technology and research.

Do what has never been done

- Achieve next-generation technology breakthroughs with 40 to 110 GHz of real-time bandwidth
- Enable higher order modulation standards with 10-bit ADC and superior ENOB performance
- See the truest representation of your signal with ultra-low noise floor



UXR1104A Infiniium UXR-series oscilloscope: 110GHz, 4 channels

Performance beyond the extremes of greater visibility, improved accuracy and faster testing

- 40 to 110 GHz of real-time oscilloscope bandwidth
- High definition 10 bit analog-to-digital converter (ADC)
- Full bandwidth and channel upgradability
- The industry's highest ENOB at bandwidths up to 110 GHz
- Industry's lowest noise floor with less than 1 mVrms of noise
- Industry's lowest jitter with less than 25 fs (rms) of intrinsic jitter and less than 10 fs (rms) of inter-channel jitter

Key features

- Models from 40 to 110 GHz of industry best real-time analog bandwidth → Up to 256 GSa/s sampling rate
- 2-channel and 4-channel models □ Unrestricted full bandwidth and sampling per channel
- 10-bit Analog to Digital Converter (ADC)
- Industry-leading deep memory □ Up to 2 Gpts per channel

M8199A 128/256 GSa/s Arbitrary waveform generator



M8199A 256 GSa/s Arbitrary Waveform Generator

Key features & specifications

- 4 channels at 128 GSa/s or 2 channels 256 GSa/s
- Up to 70 GHz nominal analog bandwidth
- Built-in frequency and phase response calibration for clean output signals
- 6 bits ENOB, DC to 50 GHz, Fs 100 GSa/s
- Intrinsic jitter: < 75 fs
- Continuous sample rate range: 100 to 128 GSa/s resp. 200 to 256 GSa/s
- Up to 1.4 Vpp differential output voltage @128 GBaud

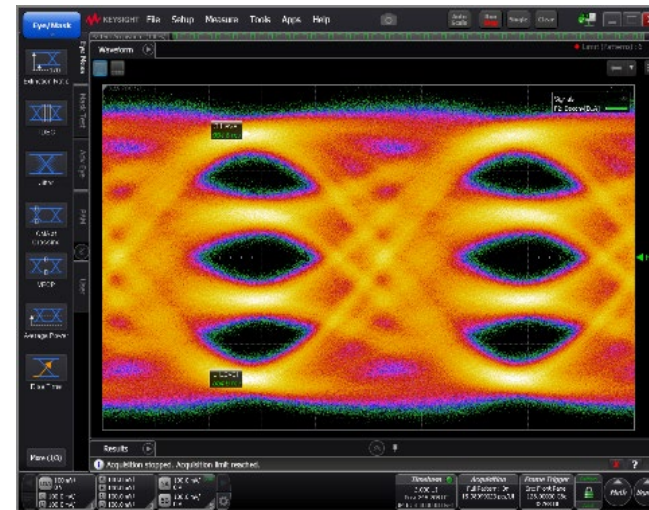
Provides research engineers a high-performance signal source for arbitrary signals, enabling development of designs up to 140 GBaud.

- Delivers twice the sampling rate of any AWG on the market today
- Integrated, ready-to-use instrument
- Operates with well-known software, like MATLAB or Keysight IQTools and SCPI programming interface based on M8070B
- High flexibility with upgrade options from 2 channels at 128 GSa/s to 4 channels at 256 GSa/s

Coherent optical applications

800G and 1 Terabit applications demand a new class of generators that provide high speed, precision, and flexibility at the same time. The M8199A is the ideal solution to test various optical systems from discrete components like optical power amplifiers to more complex dual polarization systems such as optical modulators or optical receivers. Even for tests of signal processor ASICs or algorithms, the M8199A is an excellent signal source to provide stressed signals to these devices.

With up to 4 channels per 2-slot AXIe module, each running at up to 128 GSa/s with 65 GHz of analog bandwidth, the M8199A allows dual polarization testing in a small form factor and the generation of complex signals with any modulation scheme (QPSK, nQAM, etc.) up to 128 GBaud.



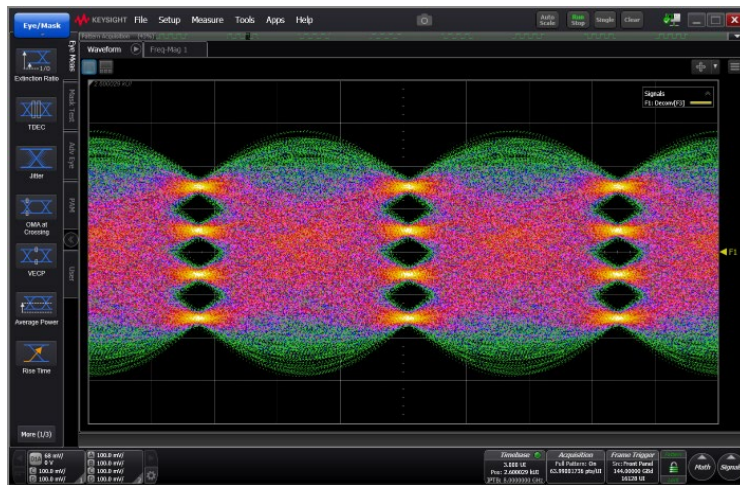
The M8199A enables 128 GBaud PAM4 (= 256 Gpbs).

Using option ILV boosts the sample rate from 128 GSa/s on 4 channels to 256 GSa/s on two channels. An optionally available remote head increases the output amplitude so that it can directly drive a modulator amplifier.

Compensation for distortions generated e.g. by cables and amplifiers can be compensated by embedding/de-embedding the S-parameters of the respective circuits or by performing an in-situ calibration using the Keysight Technologies vector signal analysis software.

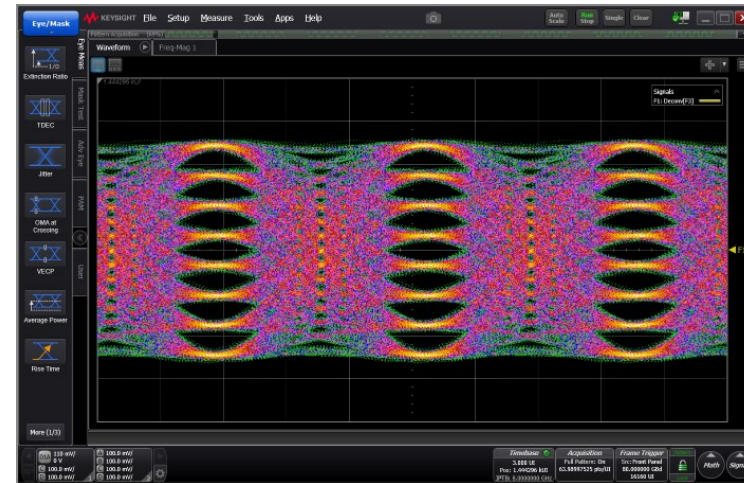
Multi-level / multi-channel digital signals

With increasing data rates in servers and computers, the trace loss increases, which reduces the signal to-noise ratio. Standard modulation formats, such as NRZ or PAM-4 may not be sufficient anymore. Here the M8199A is the right tool that provides the flexibility for advanced research on improved and more advanced modulation formats to boost transmission rates to the next level. For example, high speed research is already experimenting using PAM-3, PAM-6, PAM-8 or proprietary modulation formats at data rates up to 128 GBaud. Interleaving can boost the sample rate to 256 GSa/s, enabling symbol rates beyond 128 GBaud.



144 GBaud PAM-4 (= 288 Gbps)

The flexibility of the waveform generation with highest speeds, combined with excellent intrinsic jitter performance makes the M8199A a truly unique and versatile instrument. At data rates of multiple Gb/s, the effect of cables, board traces, and connectors etc. must be considered in order to generate the desired signal at the test point of the device under test. The M8199A incorporates digital correction techniques for frequency- and phase-response compensation of the AWG output and any external circuit to generate the desired signal at the device under test. Channels can be embedded/de-embedded if the S-parameters of the respective circuits are provided.



80 GBaud PAM-8 (= 240 Gbps)

M8199B 256 GSa/s Arbitrary Waveform Generator



Key features & specifications

- Up to 256 GSa/s for 2 channels in a 2-slot AXIe module
- 8-bit resolution
- Analog bandwidth >80 GHz (enabling 160 GBaud serial data generation)
- High-voltage output amplifier enables amplitudes > 3 Vpp, diff
- 1 MSa/channel memory
- Synchronize up to 8 channels (across 4 modules)

Helping you develop your innovation

Keysight knows you are pushing boundaries and understands that your innovation requires next generation test equipment. That's why we continually develop solutions that keep up with the latest technology waves and applications. The M8199B Arbitrary Waveform Generator (AWG) is the latest example of this commitment.

Fastest AWG on the market

The Keysight M8199A AWG uses an external passive coupler to interleave two 128 GSa/s channels to achieve signal generation up to 256 GSa/s. The M8199B AWG follows the same interleaving approach as the M8199A, but the passive combiner and RF amplifier are integrated into a single package, greatly improving the achieved bandwidth and signal-to-noise ratio (SNR).

The Keysight M8199B AWG offers you performance never seen before. It has a built-in frequency and phase response calibration, which ensures generating the most accurate signal possible. It is ready to use out-of-the-box, which means you spend less time setting up your test equipment and more time running your tests. Brand-new Keysight custom technology ensures highest signal quality and maximum flexibility.

Support for leading-edge applications

The M8199B AWG allows you to generate signals up to 256 GSa/s with sufficient signal integrity, perfect for applications like 1.6 Tb/s coherent transmissions or beyond 224 Gbit/s/lane intensity-modulation/direct-detect (IM/DD) transmissions.

The M8199B AWG is the unique solution in the market allowing R&D teams in the telecom and datacom industry, developing components, prototypes or products for coherent and IM/DD optical transmission systems operating at data rates up to 160 GBaud and beyond.

The M8199B AWG provides a stimulus signal with flexible modulation schemes (NRZ, PAM-n, QPSK, QAM-n). In addition, it allows you to apply offline customized digital-signal processing before loading the signal into the memory of the AWG.

KeysightCare – Support. Elevated.

Overview

When the pressure is on, costly delays come from waiting on tools, answers or help. That's why we created KeysightCare. It is ensured action, when you need it. KeysightCare transforms service and support to help your team deliver better results, consistently. It's a bold promise, and we back it up.

Flexibility

KeysightCare goes beyond basic warranty, offering three tiers of support to address your unique needs. Whether receiving accelerated response times, keeping your equipment operating like the day you purchased it, or getting access to experts, there is a KeysightCare offer that is right for you.



Assured - fast support

- 10-day instrument repair
- proactive firmware notifications
- 4-business-hour technical response
- support knowledge center
- self-service web portal

Enhanced - priority Support

- 7-day instrument repair
- proactive firmware notifications
- 2-business-hour technical response
- support knowledge center
- self-service web portal
- 5-day expedited calibration

Performance - enterprise support

- 5-day instrument repair
- proactive firmware notifications
- 2-hour technical response
- support knowledge center
- self-service web portal
- 3-day expedited calibration
- 24x7 emergency response

Software - subscription support

- software updates and enhancements
- proactive software notifications
- 4-business-hour technical response
- support knowledge center

References

PathWave Advanced Design System (ADS)

<https://www.keysight.com/find/ADS>

800G and 1.6T Test Solutions

<https://www.keysight.com/find/1.6T>

DCA-X Sampling Oscilloscopes

<https://www.keysight.com/find/dca-x-sampling-oscilloscopes>

DCA-M Sampling Oscilloscopes

<https://www.keysight.com/find/dca-m-sampling-oscilloscopes>

Electrical And Optical Clock Recovery Series

<https://www.keysight.com/find/infiniium-dca-equivalent-time-sampling-oscilloscopes/electrical-and-optical-clock-recovery-series-oscilloscopes>

G800GE OSFP/ QSFP-DD test system

<https://www.keysight.com/find/g800ge>

M8040A High-performance BERT 64 GBd

<https://www.keysight.com/find/M8040A>

M8050A High-performance BERT 120 GBd

<https://www.keysight.com/find/M8050A>

Optical Transceiver Test Solutions

<https://www.keysight.com/find/optical-transceiver-test-solutions>

Optical Receiver Stress Testers

<https://www.keysight.com/find/optical-receiver-stress-testers>

Integrated Photonics Test Products

<https://www.keysight.com/find/integrated-photonics-test-products>

Optical Component Test

<https://www.keysight.com/find/optical-component-test-products.html>

110 GHz Lightwave Component Analyzer

<https://www.keysight.com/find/N4372E>

N4377A Lightwave Detector

<https://www.keysight.com/find/N4377A>

Coherent Transmission Test Instruments

<https://www.keysight.com/find/coherent-transmission-test-instruments>

Infiniium Real-Time Oscilloscopes

<https://www.keysight.com/find/infiniium-real-time-oscilloscopes>

M8199A Arbitrary Waveform Generator

<https://www.keysight.com/find/M8199A>

N5291A PNA Millimeter-wave System, 900 Hz to 120 GHz

<https://www.keysight.com/find/N5291A>

