Introduction by Dr. Joachim Peerlings

Keysight Technologies welcomes you to the Optical Fiber Communications Conference and Exhibition (OFC) 2020 in San Diego.

We are more than excited to showcase Keysight’s latest products and solutions that will contribute in accelerating innovations in connecting and securing the world.

Our Highlights

• 800G optical and electrical transmission is underway with new projects to develop the electrical links and optical components.
• 400G is in deployment. Verifying compliance for 400G and 800G requires careful attention to test setup and execution as design margins continue to decrease.
• Optical co-packaging is gaining momentum to co-exist with pluggable optics.
• 400G coherent is becoming increasingly attractive and complements direct detection for data center interconnects (DCI).
• Development to reach terabit speeds is way beyond 100 Gbaud rates for metro/DCI and long-distance networks are on top of many engineers’ mind.

Keysight's showcase will cover in-depth, end-to-end test solution and product demo workstations, spanning from electrical to optical physical layer and protocol test:

• Parametric Photonic Test
  • High-Volume PIC Test
  • 110 GHz O/E & E/O Test
• Data Center Transceiver Design & Test
  • Layer 1 Test with FEC
  • 400G/800G Manufacturing Test
  • Analyze FEC Performance Early

• PathWave Design 2020
  • PAM4 Simulation & Analysis
• Coherent Optical
  • Test Beyond 100 GBd

We are exceptionally thrilled to show Keysight’s latest unique innovations for integrated photonic testing, which combines Wafer Probing and Measurement Solutions for Parametric Testing with:

• Automated wafer and die test workflow based on KS8400A Keysight PathWave Test Automation (TAP) with integrated instrument and probe station control
• Edge coupling on wafer and die-level and fully automated fiber-to-facet alignment

Keysight technical experts and application engineers will be available to discuss challenges in silicon photonics testing for R&D and design verification and for scalable and fully automated production processes.

Visit Keysight at stand #2909 and connect with our experts.

Enjoy the show, Dr. Joachim Peerlings
Vice President and General Manager
Network & Data Center Solutions

Find us at www.keysight.com
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PAM4 System Analysis

Keysight will demo 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 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 PCB 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 workflow, to help you overcome signal integrity and power integrity issues for SerDes and memory designs, while ensuring the design for compliance.
PathWave advanced design system (ADS)

With PathWave ADS and other tools from Keysight you can:

- Analyze complete chip-to-chip links by modeling at the channel-, circuit and physical-level of abstraction.
- Import frequency-domain S-parameter models accurately into time-domain circuit and channel simulations, using patented causality and passivity algorithms.
- Analyze Eye Diagram, Eye Mask, etc. for PAM4 signals.
- Determine ultra-low BER contours in seconds not days using the statistical Channel Simulator and bit-by-bit modes for fast channel analysis.
- 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.

- Visualize CTLE transfer functions with poles and zeros (preset CTLE values provided for 802.3bs, PCIe Gen3, and Gen4, etc).
- Develop IBIS AMI models in days not months.
- IBIS-AMI Back Channel Interface – enables automatic negotiation of EQ settings between Tx and Rx models.

Find out more about Keysight’s PAM4 System Analysis
www.keysight.com/find/PathWave
800G Test Solutions for R&D for optical and electrical characterization of Tx/Rx

Keysight’s total solution approach

Keysight will demonstrate a new addition to its 400G/800G R&D characterization portfolio with a high bandwidth low noise O/E converter operating in concert with the 110GHz UXR Realtime Oscilloscope. This will offer designers clock recovery, equalization and PAM4 error detection capabilities operating at emerging 112G data-rates.

This station will feature:

- N7005A O/E converter for UXR
- UXR1102A Infiniium series 110GHz Realtime Oscilloscope
- M8194A Arbitrary Waveform Generator

Additional test equipment and solutions for optical and electrical characterization of Tx/Rx consist of:

- N1000A DCA-X digital communication analyzer
- N1060A precision waveform analyzer
- N1046A 75/85/100 GHz 1/2/4 port remote sampling heads for the N1000A DCA-X
- N1030A optical plug-in module

The N1000A DCA-X performs precision measurements on high speed digital designs from 50 MBd to more than 80 GBd on up to 16 channels simultaneously.

Applications include:

- Optical transceiver design and production test
- 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 complete Digital Communication Analyzer solutions that can be combined with or used alongside the DCA-X, including clock recovery, stand-alone Digital Communication Analyzers (DCA-M) and software.
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 GBd (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.)

N104X remote head modules

The N104X remote head modules (like the N1046A) provide “Highest Channel Count” solutions. Your grand test challenge is to characterize an IC (e.g. SerDes IC) with hundreds of differential pairs fast and with high-fidelity. You can quickly test up to 16 high-speed signals (8 differential pairs) in parallel, which is unmatched in the industry. The remote head concept enables you to get extremely close to the DUT with very high bandwidth, and to cover devices with high channel count.

Find out more about Keysight’s Tx/Rx R&D solutions
www.keysight.com/find/N1000A
400G/800G Optical Transceiver Test Solutions for Manufacturing

Keysight's demonstration of a total solution approach

Keysight will demo a total solution approach to 400G/800G optical transceiver test. Transmitter dispersion and eye closure quaternary (TDECQ) is the primary metric to assess PAM4 optical transmitter communication quality. This demo will feature the N1092A DCA-M Sampling Oscilloscope, with new N1030A/B mini-modules, N1060A Precision Waveform Analyzer and a N1078 Clock Recovery module. The N1092A is very popular in R&D, however, testing next-generation optical transceivers for data centers and manufacturing test of subsystems often require more bandwidth. The new N1030A/B mini-modules, combined with a N1060A or a N1078A, form a rich toolset to design and manufacture future 400G to 800G (and beyond) optical systems.

- Accurate TDECQ
- Integrated CDR to 58 Gb/s
- Bandwidth > 40 GHz

N1090A, 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 N10XXA plug-in modules. The N1090A supports 1 to 10 Gb/s measurements, while the N1092 and N1094 are for use from 20.6 to 28 Gb/s. (NRZ and PAM4) and 53 Gb/s (TDECQ on PAM4) (Data rate ranges of the N1092 can be extended using Options PLK and IRC.)

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**

Unlike the N1000A, which uses modules to create a waveform analysis system, the N109X are completely integrated instruments built in a small form factor. Low-noise, high-sensitivity calibrated reference receivers — compliant to industry standard tolerances — are available for both multimode and single-mode signals at wavelengths from 750 to 1630 nm. N1090A noise is as low as 1 μW, while N1092 noise is as low as 4 μW, creating a measurement system with very high dynamic range. The sensitivity of the N1092 is significantly better than the comparable N1000A system making it an excellent solution for PAM-4 waveform analysis. Electrical channels are available with 20 GHz (N1090A), 30 GHz, and 50 GHz bandwidths (N1092/4).

**Based on the modern FlexDCA user interface**

The N109X user interface and operating system is identical to the modern FlexDCA interface of the N1000A. A user-provided PC running N1010A FlexDCA software controls the N109X over a simple USB 2.0 or 3.0 connection.

**N1078A optical/electrical clock recovery**

The N1078A **Optical/Electrical Clock Recovery** provides instrument-grade clock recovery with adjustable loop bandwidth and peaking on both electrical and optical signals up to 64 GBd. The N1078A clock recovery instrument is controlled via a USB connection to an N1000A DCA-X mainframe, or to a standalone PC, running N1010A FlexDCA software.

**Key features & functions**

- 125 MBd to 64 GBd data rate range (continuous) on electrical and optical 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 86100DU-400 PLL Analysis software

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Find out more about Keysight’s N1090A
www.keysight.com/find/N1090A
400GE - Layer 1 BERT and KP4 FEC Multiport Test System

Keysight will demonstrate a cost-effective and scalable solution for functional and interoperability testing of 400GE optical transceiver modules and direct attached copper cables. R&D labs can deploy the A400GE-QDD as a companion to Keysight's BERT solutions, as well as in manufacturing environments.

**Challenge:** finding problems faster and earlier in the 400GE development cycle

400 Gigabit Ethernet (GE) technologies based on the 56Gb electrical lane signaling rates have exponentially increased the level of complexity for the development of stable port electronics in all networking devices. Now, the challenge has become characterizing and quantifying the actual bit error rate (BER) and forward error correction (FEC) performance of silicon devices, application-specific integrated circuits (ASICs), fiber and copper interconnects, optical transceivers, and the port electronics of switches and routers. Identifying 400GE BER and FEC problems quickly is critical as answers are complex and time-consuming to solve.

**Solution:** A simplified, affordable 400G functional and FEC test system

The A400GE-QDD makes the challenge of qualifying BER on 400GE electronics easier and affordable. Whether validating chips, optical transceivers, or port electronics, the A400GE-QDD is a dedicated BERT and FEC test system with 56Gb 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 performance of all the lanes, all at once, in real time.

**A quick ROI and upgrades to grow with your needs**

With A400GE-QDD you have the critical return on investment (ROI) for today's and tomorrow's test needs. N4891A upgrades quickly and easily extend the reuse of the base chassis system with the ability to field-upgrade any A400GE-QDD 2-port model to a full 4-port model. You can also field-upgrade any 2- or 4-port model to add the RS-544 FEC (KP4) test capability. Mix and match whatever upgrades you require, whenever you need them.

*Find out more about Keysight’s 400GE*

www.keysight.com/find/a400ge-qdd
N4891A 400GBASE FEC-aware Receiver Test Solution

High-performance BERT analyzer synchronization

Based on the same platform as the A400GE-QDD, Keysight’s N4891A 400GE Layer 1 BERT QSFP-DD test system is used to characterize and quantify the actual BER and FEC performance. It also tests interconnect interoperability for all types of networking devices and equipment. This provides your development teams the test capabilities to quickly pinpoint problems and to validate and qualify excellent BER performance.

Used in combination with the Keysight M8040A, the N4891A offers a unique 400GBASE FEC-aware Receiver Test Solution allowing measurement of frame loss ratio in 400G Ethernet links using FEC by supplying one stressed lane, while maintaining the proper FEC striped test pattern data. The test method is prescribed in the IEEE 802.3 standard clauses 121,122, 124 and 136, 137 and 138 (802.3bs and 802.3cd respectively). This solution provides unique insights to understand how component and system design tradeoffs are affected by Forward Error Correction (FEC) requirements and to predict the system margin under real conditions. This solution also supports both electrical and optical receiver stress testing (ORST).

Key features

- Excellent test platform for 400GE communications devices and hardware ports that use the 8x56Gb/s electrical interface with PAM4 encoding that is IEEE 802.3bs and IEEE 802.3cd compliant
- The Layer 1 classical BERT capability is extended with the ability to send PRBS patterns and it generates per-lane BER measurements and statistics
- PRBS pattern generation includes PRBS-31, PRBS31Q, PRBS-23, PRBS-20, PRBS-15, PRBS-13, PRBS-13Q, PRBS-11, PRBS-9, PRBS-7 and SSPQR
- Field upgradable to support interconnection and synchronization with Keysight’s M8040A High Performance BERT analyzer
- A highly intuitive web browser-driven UI supported by Google Chrome makes BER and FEC testing truly fast and simple
400GbE is Revolutionary Not Evolutionary

The steadily increasing demand for more computing power and bandwidth fueled by cloud applications has accelerated the deployment of higher speed interfaces in datacenters. The move from NRZ-based 100G interfaces to PAM4-based 400G interfaces is revolutionary, rather than evolutionary: New technologies such as linear broadband amplifiers and drivers as well as adaptive digital equalizers have become a mandatory part of the design but are not sufficient to ensure error-free operation. 400G links typically operate at rather high intrinsic bit error rates (BER) and forward error correction (FEC) is therefore required.

The combination of adaptive equalization and FEC has drastically increased the level of complexity in the characterization and validation of silicon devices, application-specific integrated circuits (ASICs), fiber and copper interconnects, optical transceivers, and the port electronics of switches and routers. Identifying potential performance and interoperability issues at an early stage is critical as answers are complex and time-consuming to solve.

Testing FEC-enabled links

The IEEE 400GBASE standard requires the usage of the Reed-Solomon code RS(544,514), aka KP4, to ensure error-free operation. When bit errors are randomly distributed, the post-FEC BER and resulting Frame Loss Ratio (FLR) can be easily derived from the pre-FEC BER. However, jitter mechanisms, pattern-dependent effects (like inter-symbol interference, ISI) or adaptive equalizers such as Feed Forward Equalizer (FFE) and Decision Feedback Equalizer (DFE) can produce error bursts, which can overload FEC decoders, resulting in loss of the entire FEC code word – several thousands of bits of lost data. As such effects have a direct impact on interoperability, 400G Ethernet standards compliance tests for electrical and optical receivers require meeting both a conventional BER limit, as well as a Frame Loss Ratio (FLR) measurement.

The “FEC striping” mechanism which distributes the FEC-encoded frames over different electrical lanes effectively lowers the susceptibility to error bursts in operation limiting the validity of single lane PRBS-based measurements for FLR and FEC margin measurements.

Principle of FEC-aware layer 1 testing

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 400GE components and interfaces.

Find out more about Keysight's N4891A
www.keysight.com/find/N4891A
The Keysight M8040A is a highly integrated BERT for physical layer characterization and compliance testing. With support for PAM4 and NRZ signals and data rates up to 64 Gbaud (corresponds to 128 Gbit/s) it can be used for characterizing the receiver performance margins on the physical layer for popular high-speed digital interface standards, such as 400G Ethernet, OIF-CEI-56G, PCI Express 4 and 5, SAS and TBT 3.

The M8040A BERT offers true error analysis and provides repeatable and accurate results optimizing the performance margins of your devices.

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 GT/s PCI Express®
- Algorithmic PRBS, QPRBS and memory-based patterns such SSPRQ, pattern sequencer. For PAM4: Gray coding, FEC encoding and precoder an error distribution analysis
- All options and modules are upgradeable

Find out more about Keysight’s M8040A
www.keysight.com/find/M8040A
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 latest IEEE 802.3cd test procedure and user-specific test (design characterization)
- Up to 56GBd PAM4 in O- and C-band with 81492A-E01 reference transmitter
- 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-E01 reference transmitter.

Find out more about Keysight’s N4917BSCB
www.keysight.com/find/N4917BSCB
Silicon Photonics - Efficient Wafer Level Test

Integrated photonic devices

Integrated photonic devices require comprehensive testing for optical and electro-optical parameters at wafer as well as singulated on-die levels 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.

- Fully automated wafer and die test workflow based on KS8400A Keysight PathWave Test Automation (TAP) with integrated instrument and probe station control
  - N4370P01A LCA Plug-In for Test Automation
  - N7700210C Wafer Prober Plug-In for Test Automation
- Polarization resolved optical characterization over multiple wavelength bands (O-E-S-C-L) with
  - N7700100C photonic application software
  - New N7776C tunable laser source, N7786C polarization synthesizer, N7745C multiport power meter
- Scalable and modular PXI platform with
  - M9601A Precision Source/Measure Unit
  - M9808A 53GHz Vector Network Analyzer with N4377A Lightwave Detector
- Up to 110GHz RF tests with Keysight N4372/3E Lightwave Component Analyzer
  - Time domain and coherent test
- Partnering with FormFactor
  - Semi-automated Wafer probing 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 and Surface / grating coupling with single and multi-fiber connection with high degree of flexibility
  - RF probing up to 110GHz and multi-pin DC electrical probing

Find out more about Keysight’s Silicon Photonics

www.keysight.com/find/silicon-photonics
Integrated Photonics Test Solution

RF Electro-Optical Measurement

N4372E Lightwave Component Analyzer

Optical and DC Electro-Optical Measurement

N7745C Multiport Power Meter
N7786C Polarization Synthesizer
N7776C Tunable Laser Source
M9601A & B2900A Series Source/Measure Units
M9808A 53GHz YNA

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

Wafer & Die Probing and Alignment

KEYSIGHT TECHNOLOGIES

PATHWAVE
Parametric Photonic Test

Keysight will show an integrated solution 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

- 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/stepped-wavelength applications.
- The N774-C multiport power meters with 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.
- 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.

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.

For optical component development and manufacturing, these new test instruments provide the required functionality and accuracy with faster data transfer and easy connectivity. These new tunable laser, optical power meter 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.
Application software for wavelength & polarization dependence

The new PAS Version 3.0 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

- **FSIL Engine**: calibrate and adjust devices at highest repetition rates using N774x power meters
- **IL/PDL Engine**: measure IL and PDL vs. wavelength using the N7786B, also for integrated detector devices
- **New LS Engine**: enhanced and extended functionality for lambda scans without polarization control or with the new N7786C, also for integrated detector devices

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 FSIL or LS engine.

Swept-wavelength measurement solution for integrated photonics

Keysight’s single-sweep technique for polarization-resolved spectral measurement dramatically improves the 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, wavelength scans can be performed at these stabilized polarizations.
All-band coverage with new wavelength option for tunable laser family

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 (www.cwdm8.org), while the full CWDM spectrum is covered by the combination of three wavelength options: 113, 114 and 116 or 216. The LS and IL/PDL software makes it particularly easy to make measurements combining multiple lasers with automated switching of the laser ports.

Multi-wavelength meters

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 exchanges.

Find out more about Keysight’s Parametric Test
www.keysight.com/find/oct
High Frequency Parametric Testing for Silicon Photonics and Electro-optic Device Testing

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 both E-to-O and O-to-E S-Parameter measurements 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)
- NIST traceable
- Integrated optical power meter

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

Find out more about Keysight’s N4372E
www.keysight.com/find/N4372E
100 Gbaud R&D Test System
Test QAM signals 64/96/130 Gbaud

The next generation coherent transceiver generation will operate at symbol rates around 100 GBd and beyond. We will demonstrate a test solution that mimics the function of a coherent transceiver. It generates signals with flexible modulation formats for this speed class using our M8194A arbitrary waveform generator (AWG) and analyzes these signals with our groundbreaking N4391B optical modulation analyzer (OMA) based on our UXR real-time oscilloscope family. This solution enables full transceiver analysis at the new speed class to verify and improve their performance.

- Highest bandwidth
- Lowest noise floor
- Upgradable to 110 GHz

110 GHz optical modulation analyzer receiver

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. Optical modulation analyzers provide physical insights into 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 Tb/s – for your current and future needs.

Key features & specifications
- 110 | 100 | 80 GHz and 70 | 59 | 50 | 40 GHz system bandwidth options with one oscilloscope
- 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
- Average input power monitor accuracy ± 0.5 dB
- Integrated coherent receiver test application with on-site verification and re-calibration software
- Coherent optical device test application software

Find out more about Keysight’s N4391B
www.keysight.com/find/N4391B
400G Manufacturing Test for Coherent
Testing the 400ZR ecosystem

Interoperability and volume requirements necessitate a paradigm shift in coherent transceiver manufacturing. We offer 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 M8196A arbitrary waveform generator (AWG).

- Low cost T&M solution
- Smallest form factor
- Modular & customizable

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.

Automated test solution for coherent optical transmit and receive devices

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, integrating an M8292A optical modulation analyzer module, an M8296A 4-channel high-speed digitizer module and an M8196A high-speed arbitrary waveform generator module in one single mainframe.

Target applications

- Coherent optical transmitter testing
- Integrated coherent receiver ICR testing
- Testing of coherent optical transmit and receive devices

Key features & specifications

- Compact and flexible AXIe modular form factor
- 74 GBd maximum symbol rate
- 83 to 92 GSa/s sample rate
- 512k samples maximum record length
- 8 bit ADC resolution
- Turn-key solution for testing coherent optical devices

Find out more about Keysight’s 400ZR Test
www.keysight.com/find/M8290A
Terabit Research – Precision Tests at Terabit Speeds

Keysight will demo the latest industry leading signal generation (M8194A AWG) and analysis (Infiniium UXR) technology. 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. The M8194A AWG provides the highest combination of speed (120 GSa/s), bandwidth (45 GHz typical to generate signals with frequency components up to 50 GHz, and channel density (1, 2, or 4 differential channels).

- 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 13 to 110 GHz of real-time bandwidth
- Enable higher modulation standards with 10-bit ADC and superior ENOB performance
- See the truest representation of your signal with ultra-low noise floor

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

- 13 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 13 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

Find out more about Keysight’s Terabit Research
www.keysight.com/find/UXR
M8194A 120 GSa/s Arbitrary Waveform Generator

Designed to meet requirements of 64GBd/64 QAM

Designed uniquely to meet the requirements of 64 GBd/64 QAM and 100 GBd PAM4, the Keysight M8194A especially addresses coherent optical and multi-level/multi-channel digital signal requirements. The M8194A is currently the fastest AWG from Keysight (120 GSa/s), delivering the highest bandwidth and best ENOB for cleanest signal generation. In addition to best-in-class instrument performance, the M8194A offers flexibility, without complexity, in single or multi-channel operation.

Key features & specifications

- AWG with the highest combination of speed, bandwidth and channel density
- 1, 2 or 4 differential channels on a 1-slot AXIe module enable optimized channel density
- 120 GSa/s sample rate
- Arbitrary signal generation with frequency content up to 50 GHz
- Synchronization across modules
- 8-bit vertical resolution
- 512 kSamples per channel (enables PRBS $2^{15}-1$)

Coherent optical applications

400G and 1 Terabit applications demand a new class of generators that provide high speed, precision and flexibility at the same time. The M8194A is the ideal solution to test different optical systems from discrete components like optical power amplifiers to more complex dual polarization systems like optical modulators or optical receivers. With up to 4 channels per 1-slot AXIe module, each running at up to 120 GSa/s with 45 GHz of analog bandwidth, it allows dual polarization testing in a small form factor and the generation of complex signals with multiple modulation schemes (PAM-4, PAM-8, QPSK, nQAM) up to 100 Gbaud. Compensation for distortions generated e.g. by cables and amplifiers can be realized 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. Combined with the 81195A optical modulation generator software, the M8194A makes it easy to generate optical impairments (e.g. PMD) for stressing the optical receiver over multiple test scenarios.

64-QAM at 64 Gbaud (electrical)
Multi-level / multi-channel digital signals

The M8194A Arbitrary Waveform Generator is also ideally suited to address multi-level/multi-channel interfaces using any standard or custom data format, for example high-speed backplane connections using PAM-4 or PAM-8 format, as well as technologies in the mobile application space. The flexibility of the waveform generation at its highest speeds, combined with excellent intrinsic jitter performance makes the M8194A a truly future-proof instrument.

At data rates of multiple Gb/s, the effect of cables, board traces, and connectors etc. must be taken into account in order to generate the desired signal at the test point of the device under test. The M8194A incorporates digital pre-distortion 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. In conjunction with the 81195A optical modulation generator software various kinds of distortions can be added to the signal.

With its high channel density, the M8194A is well suited to affordably and precisely stimulate multilane high-speed interfaces.
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. Our 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 Cascade Microtech now FormFactor.

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 application for detail analysis

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

Find out more about Keysight’s PNA MM Wave System
www.keysight.com/find/pna
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