Keysight Technologies Exhibitor Guide

Dear customer,

As AI adoption accelerates, the balance of data center workloads is shifting rapidly: while training dominated in 2025, inference is expected to surpass it by 2027 as real-world applications drive continuous, usage-based demand. This surge will require globally distributed, low-latency infrastructure—pushing AI deployment toward regional data centers and edge systems that can serve users instantly and at massive scale.

AI data center scale in, scale up, scale out, and scale across no longer rely on a passive foundation — the fabric is becoming intelligent, adaptive, and deeply intertwined with the workloads it supports. The future belongs to those who can orchestrate infrastructure holistically—from silicon to photonics, from simulation to deployment—balancing power efficiency, latency, and scalability.

The supporting systems more than ever need to provide uncompromising resilience and higher data speed – the next step to 448 Gbps transmission supporting highest bandwidth connectivity and optimal resource utilization was demonstrated with Keysight test solutions.

Further trending technologies such as linear pluggable optics (LPO) and linear receive optics (LRO), co- and near-packaged optics (CPO/NPO), and photonic integrated circuits (PICs) are pivotal in preparing AI infrastructure for the next groundbreaking innovations.

With quantum photonics, an amazing new way of communicating and computing is developing.

At Keysight, we're committed to empowering this transformation with precision tools that help you design, validate, and lead in a world where infrastructure itself is becoming a strategic advantage.

We are pleased to present Keysight's latest test innovations in this brochure.

Find out about

In-depth, end-to-end test solutions that scale, from electrical to optical, optical to electrical and physical to protocol

- Realize **448 Gbps** for **3.2T**
- Address high power budgets for **photonic integrated circuits testing**
- Perform **high-frequency parametric testing up to 220 GHz**
- Assess **new parameters** for **linear drive optics (LDO)**
- Analyze **224 Gbps multimode and single-mode optical transceivers**
- Validate **200 Gbps electrical interfaces**
- Research for **quantum communications and computing**
- Get insight into **1600ZR coherent pluggables**
- Validate **1.6T transceivers** from design over electrical as well as optical physical layer to FEC and protocol
- Emulate **AI workloads** for 1.6T scale out

Our application experts are available to discuss with you challenges in R&D, design verification, validation, and fully automated production processes.

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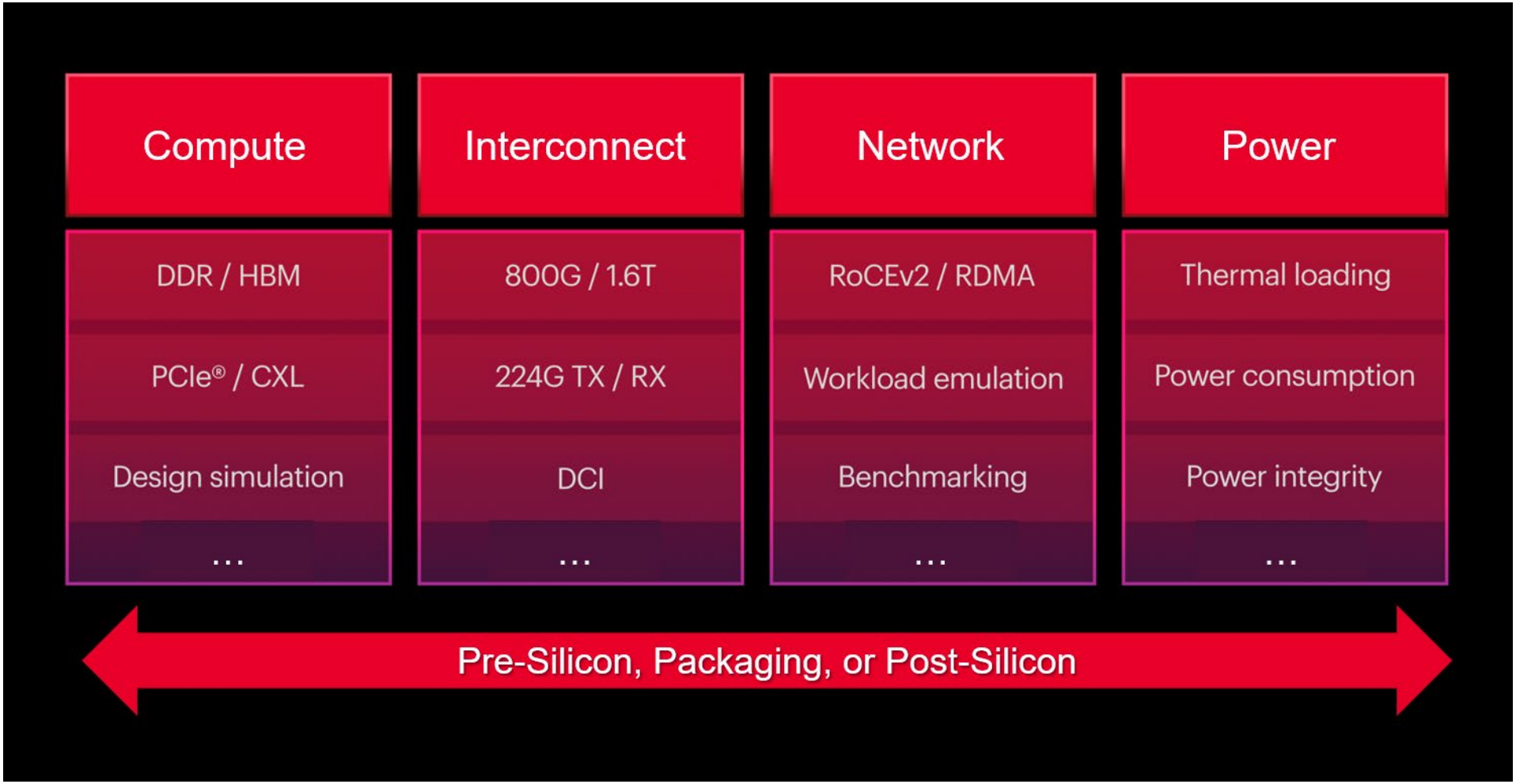
Addressing Your Key AI Infrastructure Challenges



Scale In - Design and Simulation

Predict and optimize device behavior before prototyping

The accelerated deployment of AI data centers significantly increases the pressure on design engineers to shorten time to market while minimizing the risk of redesign. Managing rising design complexity and controlling high prototyping costs demands efficient, high-performance simulation tools.

Advanced Design System (ADS)

ADS is one of the most sophisticated and widely adopted design platforms for simulating and validating high-speed digital circuits. It supports a digital standards-driven workflow, aligned with specific industry standards such as Ethernet, PCIe, USB, chiplet, and memory. In this workflow, every stage from schematic capture, design and simulation through compliance testing, is guided by the chosen standard's requirements. By leveraging this approach, design engineers can prevent critical specification violations, enhance productivity, optimize performance, and reduce the risk of delays to market.

Digital Standards-driven workflow solutions:

- System Design for Ethernet
- System Designer for PCIe®
- System Designer for USB
- Chiplet PHY Designer
- Memory Designer

ADS is engineered for high-accuracy/fidelity simulation of high-speed digtial circuits ensuring results that closely match to real-world measurements through:

- Transient convolution time-domain solver
- Bit-by-bit and statistical simulators
- Electro-magnetic physics-based solver
- Channel characterization with transient convolution engine

Key features:

- System-level end-to-end E-O-E workflow with VPIphotonics VPItransmissionMaker™ for modeling of optical channel
- COM (Channel Operating Margin) calculation for normative channel compliance
- Smart and modern digital standards-driven workflow
- Measured waveform-based transmitter (TX) models
- End-to-end system link margin analysis
- Multi-level PAM signals analysis – PAM4, PAM8, PAM16, PAM-n
- Eye diagram, mask margin, BER etc, computation for any PAM-n signals
- IBIS-AMI (Algorithmic modeling Interface) model generation with CTLE, FFE, DFE, CDR, etc
- FlexDCA (sampling scope) software integrated workflow for advanced PAM4 and TDECQ measurements for simulated waveforms
- Python automation

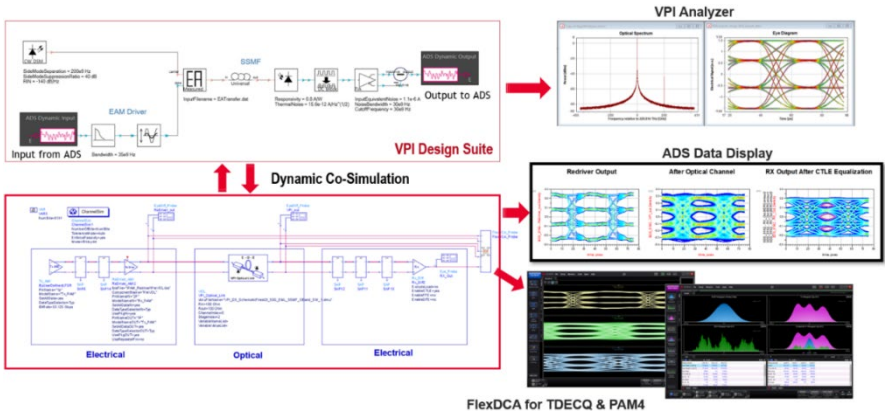


Figure 1. Advanced Design System (ADS) workflow

Photonic Designer

Keysight Photonic Designer is a powerful solution for photonic integrated circuit (PIC) design, fully integrated within the renowned **Advanced Design System (ADS)** platform. It enables design teams to bring next-generation photonic technologies to life with unmatched accuracy, efficiency, and confidence.

We are actively working with **all major silicon photonics foundries** to make their process design kits (PDKs) available through ADS. As these collaborations progress, more foundry-verified PDKs will be released, enabling designers to move seamlessly from schematic creation to layout and simulation with trusted, high-accuracy models.

As the only company offering both state-of-the-art design software and advanced test and measurement hardware, Keysight delivers a truly comprehensive solution for photonic innovation — from design through validation.

Key features:

- Advanced Modeling and Simulation: Achieve precise, physics-based results with sophisticated simulation tools.
- Seamless Workflow Integration: Move smoothly from schematic to final validation within ADS
- Expanding Foundry PDK Access: Leverage an increasing portfolio of foundry-certified process design kits as they become available.
- Innovation and confidence: Push the boundaries of photonic design with the confidence that comes from using the best tools available.

With Photonic Designer, you can confidently explore new frontiers in photonic technology and bring your innovative ideas to life. Join us in revolutionizing the future of photonic integrated circuit design.

System Designer for Ethernet

Keysight EDA System Designer for Ethernet is a digital standards-driven workflow solution for Ethernet standards.

Key features:

- Smart and modern digital standards-driven workflow
- Support latest Ethernet standards: IEEE803.3, OIF, UALink, UEC
- Ethernet AMI model generation with CTLE,FFE,DFE, CDR, RLM, SNDR,etc
- Support COM 4.7
- Support pathfinding mode for 1.6Tb/s

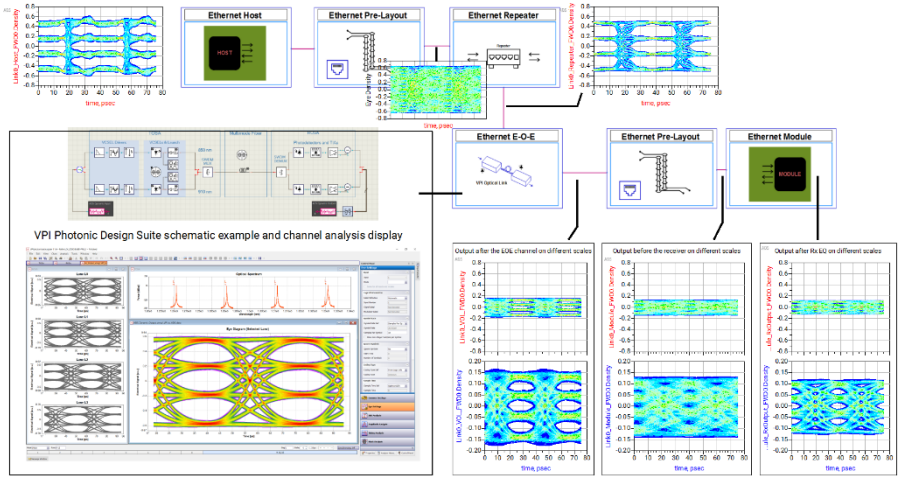


Figure 2. System Designer for Ethernet E-O-E example

Keysight EDA ADS empowers engineers to confidently deliver optimized, compliant designs for next-generation data center, AI, and high-performance computing applications.

Faster chip validation in emulation

Increased use of end-user streaming applications, cloud computing, and complex deployments driven by service providers, AI or industrial segments that require low-latency, high-throughput, and secure traffic are pushing the boundaries of network capacity.

This demand drives the market for time-accurate and ultra-high-speed devices powered by state-of-the-art application-specific integrated circuit (ASIC) and system-on-a-chip (SoC) solutions. Delivering chipsets capable of managing terabits of traffic on hundreds of ports and advanced features is an expensive and lengthy process. Not having the right tools, knowledge, or methodology to robustly test the chip designs may cause costly, image-damaging re-spins that further delay time to market.

IxVerify

IxVerify is the industry's first test solution specifically architected for pre-silicon verification of complex chips in emulation. With IxVerify, Keysight and its partners are leading the way in transforming the EDA market by offering virtualized design verification solutions that work in conjunction with next-generation verification flows – leveraging virtualization to reduce dedicated and specialized hardware costs while offering increased flexibility.

IxVerify derisks chip re-spins and ensures faster time to market.

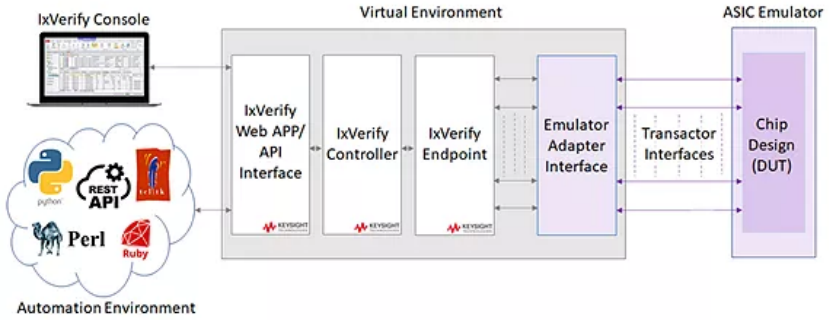


Figure 3. IxVerify concept

Key features

- Test switch and SmartNIC designs in emulation
- Integrated with main emulators on the market
- Deep key-performance-indicators (KPI) analysis of the device under test (DUT) via hundreds of statistics in emulation time
- Re-use same tests or regressions between pre- and post-silicon environments
- End to end test automation with multiple languages including REST API
- Scale to hundreds of virtual test ports in the 10Mb/s - 1.6Tb/s speed range
- Automated tests support via RFC methodologies
- Supports 450+ protocol templates and line-rate MACsec encryption/ decryption
- Validate time-sensitive-networking (TSN) capable designs with precision-time-protocol (PTP) and full TSN-feature test support using accurate time synchronization with the emulator

Scale In - Photonic Test

Design verification at the wafer level

Silicon photonics has rapidly evolved from a specialized research technology into a cornerstone of next-generation computing, cloud infrastructure, and AI-driven data centers. Hyperscale customers are now aggressively adopting photonic interconnects to overcome the physical limits of copper-based electrical signaling - reducing power consumption, increasing bandwidth density, and enabling longer-reach connections inside and between servers. Industry analysts forecast strong multi-year growth driven by optical I/O, co-packaged optics (CPO), chiplet architectures, and emerging applications in quantum, sensing, and 3D-integrated devices.

As systems scale from 800G and 1.6T to multi-terabit switching fabrics, Photonic Integrated Circuits (PICs) must meet stringent electrical-optical performance standards. This transition is accelerating demand for precise, automated, and scalable test solutions that validate devices at the wafer, die, package, and module levels. Keysight is uniquely positioned to support this shift, offering a comprehensive portfolio of electro-optic measurement technologies tailored for the full lifecycle of silicon photonics.

Characterizing up to 220 GHz electro-optic RF performance

Keysight delivers the measurement performance required to fully unlock the potential of innovative design and materials fabricated on Photonic IC. This includes DC parametric behavior, optical loss and wavelength response, small-signal RF S-parameters, and large-signal time-domain modulation quality. By providing the accuracy, stability, and automation frameworks needed for modern PICs, Keysight ensures device performance can be validated consistently across wafers, designs, and foundry processes.

Key solution components

- Small-signal test up to 220 GHz with new N4378A lightwave component analyzer
- Large-signal test beyond 224GBaud/lane with M8199B AWGs and N1093B DCA
- Optical loss and wavelength response with the new, N7774C ultra high power tunable laser source and N7700100C PAS
- Automated Wafer-Level Electro-Optic Probing with KS8400A PathWave and its Plug-ins
- Keysight official probe station partners with FormFactor Inc. and MPI Corporation

Figure 4. PIC on-wafer and die design verification test solution

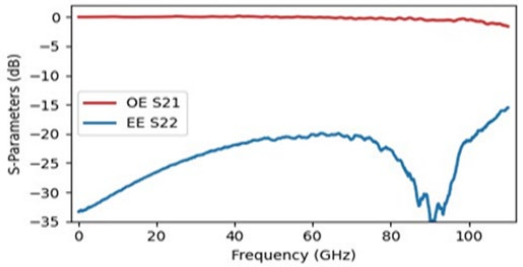


Figure 5. On-wafer PIC OE/EE frequency response

Wavelength and polarization dependence of optical components

For the characterization of PICs and other optical devices, the stability and repeatability of optical parameter measurements are not easily achieved.

Keysight integrated automated solution

Keysight offers integrated solutions for measuring wavelength and polarization dependence of optical components. The Photonic Application Suite software enables 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.

Newest generation of fiberoptic test instruments: N77-C family

Figure 6. Compact standard platform for N77-C instruments

For optical component development and manufacturing, these test instruments provide the required functionality and accuracy with faster data transfer and easy connectivity. Measurement and start-up times are greatly reduced. New tunable lasers with further increased output power, optical power meters and polarization instruments are optimized to work together making fast wavelength and polarization dependent measurements.

The N77-C instruments simplify integrating test solutions. Their compatibility protects investments made earlier in hardware and in software development.

All instruments have a browser-based GUI, simply and remotely accessible over the LAN and USB interfaces without installing additional software.

- The N777-C tunable laser family provides models to cover the full 1240-1650 nm range with performance classes for 2-way swept measurements up to 200 nm/s, picometer wavelength accuracy, and economical static and stepped-wavelength apps. The latest revision of the N7778C value line laser improves repeatability to ±1 pm, and absolute accuracy to ±4 pm. All N777-C lasers now offer enhanced 0.1 pm wavelength tuning without overshoot.
- The newest, **N7774C ultra-high-power tunable laser** is a perfect match for PIC testing where optical probing and signal sharing demand a large power budget. It also offers a power setting range spanning several orders of magnitude and safety features for laser class 3B such as remote interlock. Two wavelength options address the 1.3 µm and the 1.55 µm band.
- The N773-C optical switches are available in 1x4, 2x2 or 1x16 layout to ease the automation of common test configurations. They combine outstanding durability and repeatability with fast switching times.
- 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, synchronized with tunable lasers, supported by the new triggering on input signal events, good for time-dependent optical measurements. Analog voltage output is available for alignment and feedback use, with both linear and logarithmic proportionality to the optical signal. The N7753C return loss meter adds reflectivity measurements to swept- and fixed-wavelength test cases.
- The N7752C and N776-C optical attenuators enable highly efficient optical transceiver and network integration testing. N7752C is a two-channel model with two additional, independent optical power meters. The N7764C and N7768C are 4-channel models for single-mode and multimode fiber. The N7765C is a new, single and dual-channel, high-dynamic range attenuator.
- The N778-C polarization test instrument family includes 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 differential group delay (DGD) / polarization mode dispersion (PMD).

Figure 7. N7749C interface for 8162-C remote power head

Application software for wavelength and polarization dependence

- The Photonic Application Suite, PAS Version 3, supports 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. The latest version 3.5 adds support for the N7753C return loss instrument as well as the N7731C optical switch to make measurements over 2 or 3 tunable laser wavelength ranges.

Software packages

- New LS (lambda scan) engine: enhanced and extended functionality for lambda scans with or without polarization functionality, for insertion loss (IL), polarization dependent loss (PDL), PMD, and 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 (fast spectral insertion loss) 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.

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 IL and PDL, using the N7788C with 1 or more tunable lasers.

Swept-wavelength measurement solution for integrated photonics

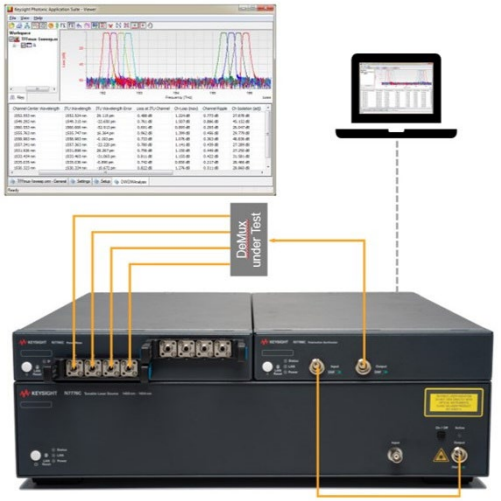


Figure 8. Basic configuration for single-sweep IL and PDL multiport measurements

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 transverse electric (TE) and transverse magnetic (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

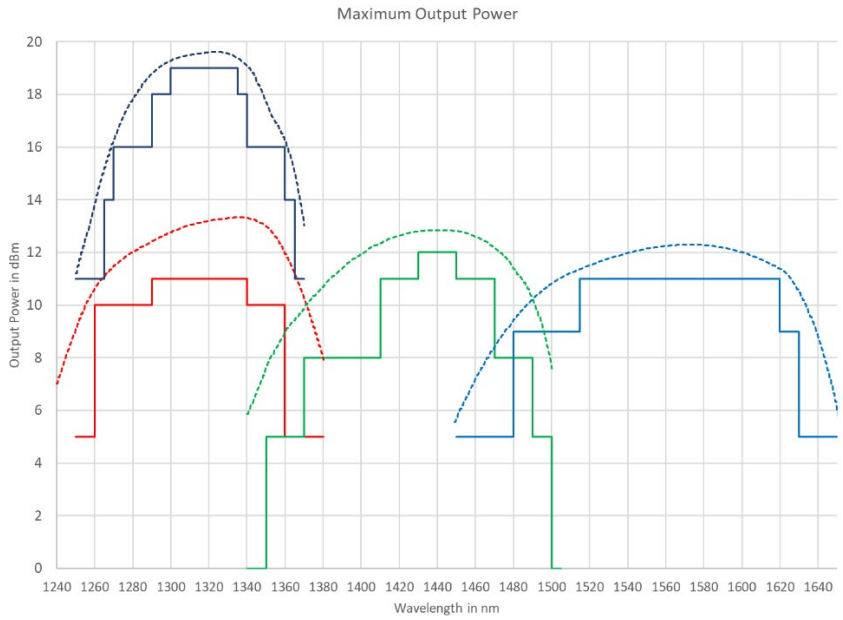


Figure 9. Output power profiles available for N7776C/78C/79C tunable lasers

The N777-C tunable laser family has options for complete coverage of the single-mode fiber wavelength 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. Option 013 provides up to +19.4 dBm in the O-band, while the newest model N7774C-A13 offers even higher output power in the O-band, ideal to compensate for the loss of optical probing or to support power splitting. The PAS LS software makes it particularly easy to make measurements combining multiple lasers with automated switching of the laser ports.Multi-wavelength meters.

Figure 10. 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 devices for 1.6T and beyond

Photonic integrated circuits (PICs) are key to enable higher data rates at better energy efficiency for intra-datacenter and inter-datacenter connections. To verify PIC designs, opto-electronic S-parameter testing is indispensable.

N437-series lightwave component analyzers up to 220 GHz

Figure 11. N4372E 110 GHz lightwave component analyzer

The new **N4378A lightwave component analyzer (LCA)** pushes the limits of high-frequency parametric testing of optical transmitters and receivers to 220 GHz! Based on the new NA5307A 250 GHz millimeter-wave frequency extenders and the new Keysight 0.5 mm connector eco-system, the N4378A is the only electro-optic vector network analyzer system realizing S-parameter measurements at 1310 nm and 1550 nm for both, E-to-O and O-to-E devices, from 100 MHz to 220 GHz in a single sweep. With external laser sources, other wavelengths in the O-band and C/L-band can be covered.

Combined with NA5305A 170 GHz millimeter-wave frequency extenders, N4378A measures from 100 MHz to 170 GHz.

The N4378A comes with mechanical fixtures for the optical receiver and transmitter, which ease the alignment of extender head and optical converter, as well as the mating of extender heads for the user calibration. Quick release plates and an alignment gauge allow for convenient and repeatable mounting and positioning relative to the 0.5 mm connectors.

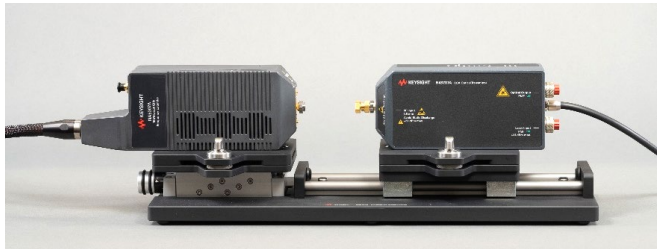


Figure 12. NA5307A frequency extender and N4378TA optical transmitter

The N4372E 110 GHz lightwave component analyzer (LCA) allows parametric testing of optical transmitters and receivers from 10 MHz to 110 GHz, based on the N5290A / N5291A 900 Hz to 110 / 120 GHz PNA mm-wave system and its 1 mm connector design. With optional 1310 nm and 1550 nm laser built-in or using external lasers for 1260 nm to 1620 nm, it enables measurements of E-to-O and O-to-E devices up to 110 GHz across all CWDM transmission windows.

Key features of the LCA family

- Optical transmitter and -receiver test: responsivity, electrical return loss
- Configurations for photodiode and optical receiver testing, optical modulator and transmitter testing, and both (N4378A, N4372E)
- Single mode component test up to 220 GHz (N4378A), 110 GHz (N4372E), and 43.5 / 50 / 67 GHz (N4373E)
- Multimode component test up to 50 GHz, 820 – 980 nm range (N4373E-103)
- Absolute and relative electro-optic response (magnitude and phase)
- Expansion of measurement capabilities through combination with PNA measurement classes (e.g. for THD (total harmonic distortion) and gain compression measurements)
- NIST (National Institute of Standards and Technology) traceable
- Integrated optical power meter

N4377A calibrated lightwave detector

Figure 13. 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 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
- MW2: Extended 1310/1550 nm calibration for M40

NA5307A/ NA5305A 250 GHz/ 170 GHz frequency extenders

Keysight offers the N5290/91A broadband network analyzer solutions up to 110/120 GHz for millimeter-wave component characterization. Keysight's new NA5305A/7A frequency extenders with 0.5 mm coaxial test port connector pushes the limit of the frequency boundaries of the sub-THz component test. The new NA5305A/7A frequency extenders enable you to configure a 2 or 4-port millimeter-wave single-sweep broadband VNA up to 170 GHz/ 250 GHz using the N522x/ N524xB PNA/ PNA-X microwave network analyzer and the N5292A test set controller and measure S-parameters and power. The 4-port broadband VNA allows you to make differential measurements of on-wafer or packaged semiconductor device characterization/modeling up to 250 GHz for various applications: 6G research and data center network for 1.6T, 3.2T and beyond.
Sub-THz on-wafer or packaged components such as optical RF drivers, TIAs (Transimpedance Amplifiers), PCBs, cables, packages, and passive devices can also be characterized.

Figure 14. NA5307A frequency extenders form a 250 GHz PNA mm-wave system

Measuring sub-THz signals in on-wafer and packaged components demands specialized probes, adapters, and test cables that complement Keysight's new frequency extenders and calibration kit to form a comprehensive test setup. To deliver complete measurement capabilities, Keysight has collaborated with top-tier industry solution partners.

N5291A 900 Hz to 120 GHz PNA millimeter-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 a 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.

Key features and 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
- Various software applications for detailed analysis

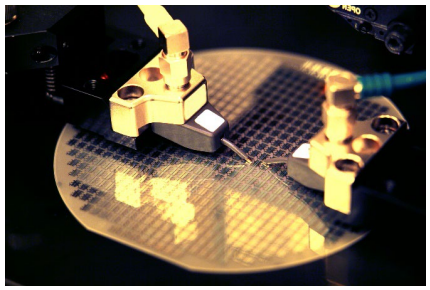


Figure 15. The combination of calibration, fixture de-embedding and fixture removal enhances the accuracy of on-wafer measurements.

Scale Up - Data Center Transceiver Test

Research on 448 Gbps transmissions

The growing demand for high-speed, low-power optical interconnects in artificial intelligence (AI), machine learning (ML) data centers, and high-performance computing (HPC) has accelerated the adoption of successive generations of interconnect interface speeds. In the past five years, more transmission speed standards have been introduced than in the preceding 35 years. The next-generation target is a data transmission rate of 448 Gbps.

In optical data center networks (DCNs), intensity modulation and direct detection (IM/DD) technology enables 224 Gbps per lane for 800 Gigabit Ethernet (800GbE) and 1.6 Terabit Ethernet (1.6TbE). While standardization around ~224 Gbps (PAM4) in IEEE 802.3 is still ongoing, discussions on next-generation optical interfaces enabling 3.2 TbE have already begun.

The Optical Internetworking Forum (OIF) CEI-448G Framework Project[1] focuses on defining the next electrical data rate beyond 224 Gbps. This initiative explores key challenges such as modulation schemes and test methodologies, aiming to enable 448 Gbps using multi-level pulse amplitude modulation (PAM).

The optimal modulation format for 448 Gbps remains an active area of research. Potential candidates include 150 Gbaud PAM8, 174 Gbaud PAM6, and 224 Gbaud PAM4. PAM4 remains a preferred option due to its backward compatibility, though its bandwidth demands pose challenges for copper-based transmission. In contrast, PAM6 and PAM8 reduce bandwidth requirements but demand higher signal-to-noise ratios (SNR).

Keysight offers tailored solutions optimized for these modulation formats, leveraging the powerful Keysight M8199B arbitrary waveform generator (AWG), which features a 75 GHz 3-dB bandwidth. To enhance the SNR for PAM6/8 signaling, multiple AWG channels are combined pairwise using broadband baluns[2]. Since the signals are generated by independent AWG channels, this approach improves SNR at the cost of reduced eye amplitude.

For PAM4, the generator's requirements shift from SNR to bandwidth. In this case, two AWG outputs are combined using the Keysight M8159A frequency-domain interleaver unit (FDIU) to increase the available bandwidth. The figure below shows a sample 224 Gbaud PAM4 eye diagram.

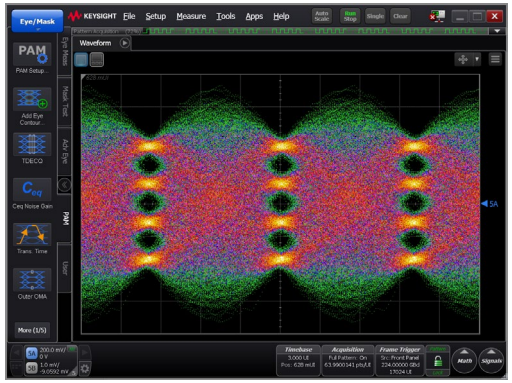


Figure 16. Electrical eye: 224 GBd PAM4. Equalization of the combined frequency response of AWG, cables, baluns, attenuator and FDIU is performed at the TX side only (IQtools). No equalization is applied in FlexDCA N1046A DCA-X.

[1] https://www.oiforum.com/oif-concludes-successful-q3-24-technical-and-mae-committees-meeting-with-launch-of-three-new-projects-to-advance-networking-technologies/

[2] https://www.keysight.com/us/en/assets/3125-1097/application-notes/Research-on-448-Gbps-with-PAM6-and-PAM8.pdf

The raw frequency response for the M8199B AWG connected to the M8159A FDIU is shown in the figure below. The M8159A FDIU extends the usable bandwidth of the M8199B AWG to beyond 120 GHz [3].

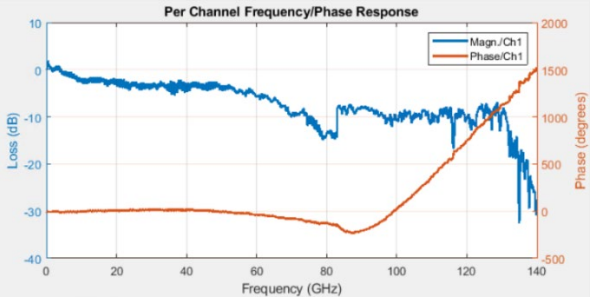


Figure 17. Frequency response for the setup optimized for 448 Gbps based on PAM4.

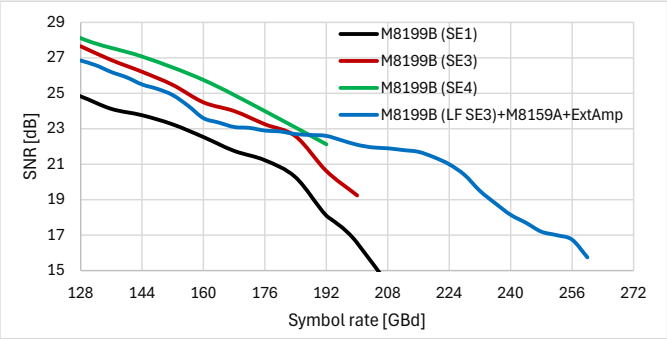


Figure 18. Performance evaluation for different configurations.

The SNR is measured on a non-return to zero (NRZ) signal as function of the symbol rate, setting the FlexDCA eye boundaries to 2% centered at the eye opening. Equalization of the combined frequency response of AWG, cables, baluns, attenuator and FDIU is performed at the transmitter side only (IQtools). No equalization is applied in FlexDCA (N1046A DCA-X).

When using the balun approach, a significant SNR gain is observed up to ~200 GBd, while the M8159A FDIU shows a significant SNR improvement at higher symbol rates. The crossing point between the two systems appears to be at ~180 GBd.

Using a 113 GHz Keysight UXR real-time oscilloscope, we measured bit error rates (BER) of 2×10-6 and 2×10-5 for 174 GBd PAM6 and 150 GBd PAM8, respectively. Ignoring the possible bursty behavior of errors, both solutions can theoretically achieve error-free performance (BER < 2×10-15) using KP4 forward error correction (FEC) with 6.5% overhead, resulting in a net bit rate exceeding 400 Gbps. BER measurements for the PAM4 are not reported yet.

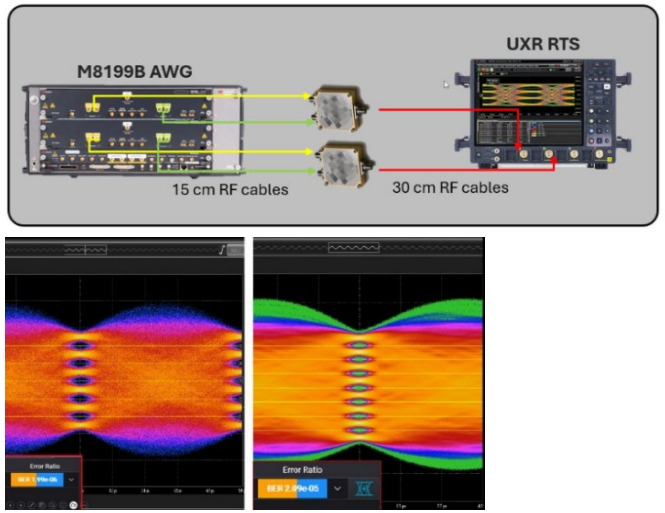


Figure 19. Test setup for BER measurements (above) and resulting signals for 176Gbd PAM6 (bottom left) and 150Gbd PAM8 (bottom right).

[3] https://view.keysight.com/viewer/558a6ce0f0bf5f82d858c66124fc8879

M8199B 256 GSa/s arbitrary waveform generator

Figure 20. Fastest on the market: M8199B 256 GSa/s arbitrary waveform generator

The M8199B is the fastest arbitrary waveform generator that provides R&D engineers the speed, bandwidth, precision, and flexibility to meet the challenges of next-generation applications, including > 400 Gb/s per lane in intensity-modulation / direct-detect (IM / DD) and > 1.6 Tb/s per carrier in coherent optical communications.

Key features and specifications

- Continuous sample rate from 200 to 256 GSa/s
- Analog bandwidth exceeding 80 GHz
- 5.0 V_{pp} amplitude at 400 MHz
  - Up to 2.6 V_{pp} differential output voltage at 128 Gbaud
  - Up to 2.3 V_{pp} differential output voltage at 144 Gbaud
  - Up to 2.2 V_{pp} differential output voltage at 160 Gbaud
- 1 MSa of waveform memory per channel
- Synchronization of up to 8 channels across 4 modules
- Built-in frequency and phase response calibration for clean output signals
- Integrated and ready to use out of the box
- Operates with well-known software, like Matlab / Python or Keysight IQTools and SCPI programming interface

Key benefits

- Applicable for electrical and dual-polarization coherent and IM / DD optical transmission systems at data rates up to 160 Gbaud and beyond
- Stimulus signal with flexible modulation schemes (NRZ, PAM3, PAM4, PAM6, and PAM8, QPSK, QAM-n); offline customized digital-signal processing before loading the signal into the AWG memory
- 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.
- Channel embedding / de-embedding

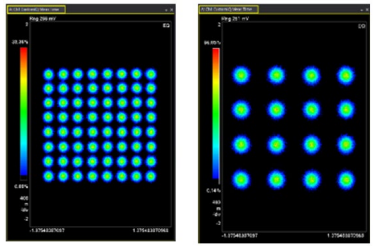


Figure 21. 64QAM at 160 Gbaud (1.92 Tb/s using a 4-channel system) and 16QAM at 180 Gbaud (1.44 Tb/s using a 4-channel system)

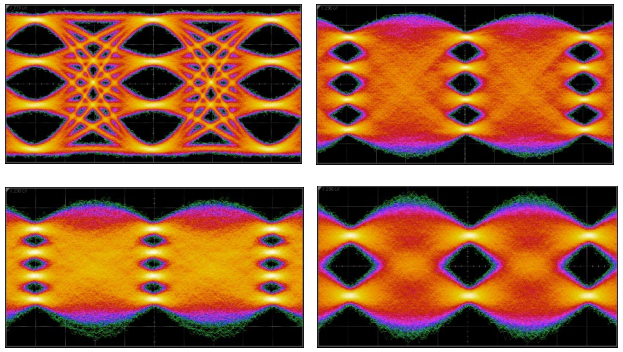


Figure 22. PAM4 at 112 GBd (224 Gb/s) top-left, at 160 GBd (320 Gb/s) top-right, PAM4 at 200 GBd (400 Gb/s) bottom-left, NRZ at 200 GBd (200 Gb/s) bottom-right

UXR1104B Infiniium UXR-series oscilloscope 110 GHz, 4 channels

The Infiniium UXR Series real-time oscilloscope 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, the 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 to accelerate the development of the next-generation technology.

The new UXR B also comes with more memory. With standard 500 Mpts memory, you can capture 2.5 times longer waveforms for your analysis.

Achieve next-generation technology breakthroughs:

- Enable higher-order modulation standards with 10-bit analog-to-digital Converter (ADC) and industry-highest ENOB (effective number of bits) performance
- See the true representation of your signal with ultra-low noise floor

Figure 23. UXR1104B Infiniium UXR-Series oscilloscope : 110 GHz, 4 channels

Key features

- Models from 5 to 110 GHz of industry-best real-time analog bandwidth up to 256 GSa/s sampling rate
- 1-, 2- and 4-channel models – unrestricted full bandwidth and sampling per channel
- Full bandwidth- and channel upgradability
- Industry's lowest noise floor
- 10-bit analog-to-digital converter (ADC)
- Industry-leading deep memory – up to 2 Gpts per channel
- Industry's lowest jitter with less than 25 fs (root mean square - rms) of intrinsic jitter and less than 10 fs (rms) of inter-channel jitter

1.6T and 3.2T electrical and optical developments

With the move to 1.6T and research for 3.2T in the data center networks, interfaces with 200 Gbps or higher are beneficial for increasing the bandwidth while significantly reducing power consumption and cost. Standards like OIF-CEI 224G, IEEE 802.3dj, and OSFP define the specifications for the various electrical and optical interconnects. The deployment of large language models (LLMs) drives pathfinding for 400 Gbps for even higher bandwidth and further power reduction.

Interface chips, DSP (digital signal processing chips), packaging, connectors etc. all will need performance improvements or new designs to work at the higher lane speeds.

Keysight's total solution approach

Keysight provides the industry's most comprehensive 224 Gbps and 448 Gbps pathfinding test solutions for both electrical and optical interfaces, enabling the validation of technologies like digital retimers, retimed transmitter linear receiver (RTLR), linear pluggable optics (LPO), and co-packaged optics (CPO), while supporting next-generation high-speed networking. Under unprecedented tight signaling conditions, Keysight frees up margin to ensure you get clear insights into the performance of your design.
With the M8050A high-performance BERT and its uncompromised signal integrity, support for NRZ, PAM4, PAM6, and PAM8 signals, and symbol rates up to 120 GBd, you are well prepared for 1.6T pathfinding.

The new N1096A/B DCA-M, N1093A/B DCA-M, the UXR-B Series and DCA-X Series oscilloscopes, the world's most advanced oscilloscopes with new optimized hardware and software, and higher standard memory are other important players here.

Test solutions for optical and electrical TX/RX characterization:

- UXR1104B Infiniium 110 GHz real-time oscilloscope
- M8050A 120 GBd BERT including M8053A 64 GHz interference source and M8067A ISI channel boards
- M8199B 256 GSa/s arbitrary waveform generator (AWG)
- N1096A/B 60 GHz multimode (MM) DCA-M sampling oscilloscope
- N1093A/B 60 GHz single-mode (SM) DCA-M sampling oscilloscope with integrated clock recovery (option CDR) and precision time base (option PTB)
- N1000A DCA-X Series wide-bandwidth oscilloscope mainframe
    - N1060A 50 / 85 GHz precision waveform analyzer
    - N1046A 75 / 85 / 100 GHz 1- / 2- / 4-port remote sampling heads module
    - N1032A/B 120 GHz optical plug-in modules

New 224 Gbps N1096A/B multimode and N1093A/B single-mode optical DCA-M sampling oscilloscopes

Keysight offers a comprehensive sampling oscilloscopes lineup to support 1.6T transceiver validation and manufacturing testing across both single-mode and multimode applications for AI data center deployments. The new N1096A/B and N1093A/B 224 Gbps DCA-M sampling oscilloscopes offer exceptional bandwidth, low noise, and high sensitivity, enabling precise characterization and high-speed analysis of next-generation optical transceivers, while ensuring reliable performance and accelerating time-to-market for AI-driven data center networks. With Keysight's high-accuracy, high-sensitivity 224 Gb/s optical measurement solutions, engineers can reliably validate complex 1.6T optical links and optimize production workflows for both SM and MM applications.

Figure 24. 224 Gbps N1096A/B MM optical DCA-M sampling oscilloscopes

N1096A/B Key features

The N1096 DCA-M is specifically engineered with the widest-bandwidth amplified optical channel to deliver up to 112 GBd PAM4 measurement capability for 1.6T multimode applications.

- N1096A/B single/dual optical channel
- 780 to 1100 nm, multimode
- Optical bandwidth 60 GHz with system impulse response correction (SIRC) enabled
- High sensitivity with ≤ 35 µW noise
- Accurate high data-rate analysis with <200 fs jitter

Figure 25. 224 Gbps N1093A/B SM optical DCA-M sampling oscilloscopes

N1093A/B Key features

The N1093A/B DCA-M is designed to deliver the highest optical measurement sensitivity, with integrated clock recovery up to 120 GBd for optical waveform and jitter measurements, enabling more reliable 1.6T single-mode AI networks.

- N1093A/B single/dual optical channel
- 1250 to 1350 nm, single mode
- Optical bandwidth 60 GHz with system impulse response correction (SIRC) enabled
- High sensitivity optical channel with < 15 µW noise
- Accurate high data-rate jitter analysis with 105 fs intrinsic jitter (option LOJ: 160 fs, option PTB: 105 fs)
- Integrated clock recovery up to 120 GBd (option CDR and CRX)
- N1093BB01A/02A/03A bundles offer quad-channel scalability at an affordable price, enabling higher throughput and drive down production costs.

N1095DJCA Optical IEEE 802.dj 200 Gbps per lane TX conformance test automation

The new N1095DJCA application offers standards-aligned IEEE 802.3dj optical transmitter conformance tests, developed to support standards aligned optical measurements as designs mature. The application delivers high fidelity, repeatable results on the DCA platform and supports the latest N1093A/B DCA M sampling oscilloscopes, enabling higher sensitivity and improved measurement margin for next generation optical interfaces.

Key features and benefits

- Standards aligned optical TX test workflows for IEEE 802.3dj
- Support the new N1093A/B DCA M sampling oscilloscopes
- High fidelity, repeatable optical measurements on the DCA platform
- Enables confident progression toward standards conformance and deployment

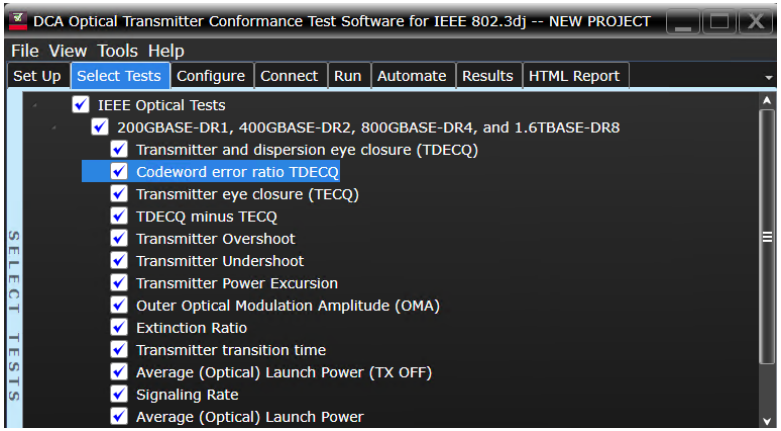


Figure 26. N1095DJCA IEEE 802.3dj optical TX conformance test application

N1060A precision waveform analyzer

Figure 27. N1060A precision waveform analyzer with N1000A DCA-X

Key features and benefits

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

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

Reduce validation time with analysis tools like jitter spectrum analysis and software clock recovery emulation

- 2-channel / clock recovery / precision time-base combo
- 50 or 85 GHz bandwidth
- 16, 32 or 64 Gbaud 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

Figure 28. N1046A 75GHz / 85GHz / 100GHz 1- / 2- / 4-port remote sampling heads for N1000A 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 designs such as 224 Gb/s

N1032A/B 90 / 120 GHz single- / dual- channel optical module

The N1032A/B optical module for DCA-X sampling oscilloscopes delivers the world's highest optical bandwidth, reaching up to 120 GHz. Designed for cutting-edge performance, its ultra-high bandwidth makes it ideal for 400 Gb/s (200 GBd PAM4) pathfinding applications or any use case requiring an ultra-wide optical receiver with > 65 GHz bandwidth (-3 dBo).

Figure 29. N1032A/B optical modules with N1000A DCA-X

Figure 30. Typical setup for signaling rates > 112 Gbaud

Key features and benefits

- Highest optical bandwidth: 120 GHz
  Benefit: Helps pathfinders and researchers to see the true performance of their designs
- Optical reference receiver for 33.3 GBd to 195 GBd with SIRC
  Benefit: The first optical reference receiver designed to support 400 Gb/s per lane pathfinding applications.
- Fully calibrated and easy-to-use ultra-wide optical reference receiver
  Benefit: Accurately characterize subsystems used in data communications that require > 65 GHz bandwidth
- Smooth frequency response enables accurate system impulse response correction (SIRC)
  - Adjustable BW (-3 dBo): 35 GHz – 90 GHz (option 09U) and 35 GHz – 130 GHz (option 13U)
  - Adjustable frequency response: Bessel, Gaussian, flat, sin(x)/(x)

M8050A high-performance BERT 120 Gbaud

Keysight's most advanced BERT, the M8050A, ensures success in next-generation chip deployments for up to 1.6 Tb/s, PCIe and USB 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. Alternatively, use the new M8043A 64 Gbaud error analyzer for your 800G receiver characterization and PCIe Gen7 pathfinding.

Figure 31. Generate patterns up to 120 Gbaud and analyze errors with the M8050A.

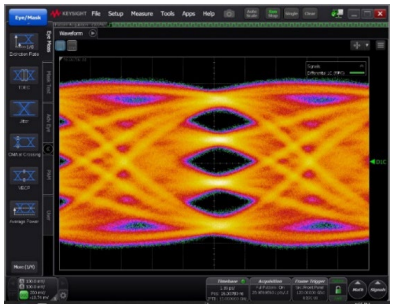


Figure 32. The M8050A provides pattern generation with clean open eyes up to 120 Gbaud

Key features

- Pattern generation up to 120 Gbaud NRZ, PAM3, PAM4, PAM6/8, FEC
- Fast transition times of 4 picoseconds
- Lowest intrinsic random jitter with less than 100 fs rms
- Output amplitude up to 5.0 Vpp 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 64 Gbaud with the M8043A error analyzer module driver and up to 120 Gbaud with the SD7150A receiver and transmitter test solution
- Emulate intersymbol interference (ISI) with ISI channel boards M8067A and the adjustable ISI software M8070ISIB
- Inject random and sinusoidal interference up to 64 GHz with the M8053A interference source for interference tolerance testing
- Software support from the M8070B system software, with additional receiver compliance test software packages.

FlexOTO optical test optimization solution

For 1.6T/800G validation and manufacturing

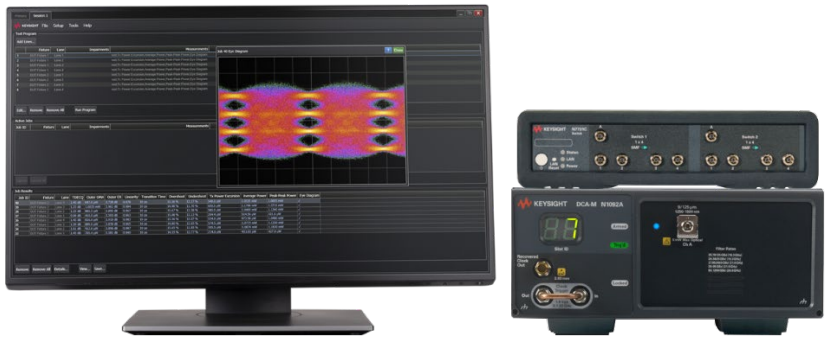


Figure 33. FlexOTO optimization software and controller for DCA-M sampling oscilloscopes

While 800 Gigabit Ethernet (800G) is being validated and rolled out in datacenter networks, there is already growing demand for 1.6T technology. This rapid advancement in technology introduces challenges for optical transmitter test to reduce cost, increase capacity, test more optical lanes, and ensure compliance with complex emerging industry standards.

FlexOTO application software is designed for test system designers who are creating design validation and high-volume optical test systems. FlexOTO software drives down cost-of-test while maintaining the highest measurement integrity by automating control of Keysight DCA-M instruments, FlexDCA software, and optical switching hardware.

Key features and benefits

- Optimize test efficiency and maximize test hardware utilization
  Benefit: FlexOTO software drives down cost-of-test while maintaining the highest measurement integrity by automating control of your Keysight DCA-M instruments, including the new N1093A/B, FlexDCA software, and optical switch hardware
- Maximize return on investment for 1.6T / 800G and CPO / NPO testing of your DCA-M installed base
  Benefit: FlexOTO software supports a variety of switches to create high-volume test systems with your existing DCA-M assets and is easily integrated into manufacturing test flows
- Cost-effective solution bundles: Keysight N1002L31A/P31A and N1002L33A/P33A bundles provide complete software and hardware solutions
  Benefit: Save money and accelerate setup on a complete 400G/800G test system that includes FlexOTO and FlexDCA software licenses, N1092A / N1092B DCA-M with integrated CDR, and N7733C / N7731C optical switch

FEC-proofed designs

The application 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

100 Gb/s serial interfaces heavily rely on adaptive digital equalizers to compensate for the channel loss and reflections and on forward error correction (FEC) to run error free. However, 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 consists of the M8040A or M8050A BERT combined with the G800GE solution. It is designed to integrate FEC constraints into the physical design validation.

The G800GE generates and analyzes 100G, 200G, 400G 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 (53.25 Gbaud PAM4) or IEEE 802.3bs (26.5625 Gbaud PAM4). The traffic can be PRBS-based or FEC encoded – for this the G800GE and the BERT must be synchronized.

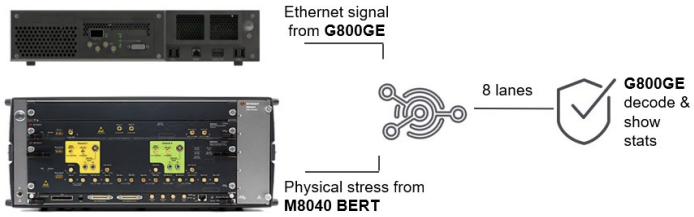


Figure 34. FEC-AWARE conformance test for 100G serial Interfaces with M8040A and G800GE

High-performance BERT analyzer synchronization

The G800GE 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-striped, FEC-aware physical layer BER tester for 53.25 and 106.5 Gbps electrical lanes. It is a solution for 400G & 800GE characterization-, stress-, and conformance tests, and for performing physical-layer channel stress and impairment of a channel. Additionally, advanced tests such as TDECQ and optical receiver stress tests (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/bs (electrical) and IEEE 802.3cd (optical)
- Real-time performance monitoring on G800GE e.g. BER, FLR, FEC margin, and bursts capture
- FEC-error trigger to capture an electrical or optical signal leading to a burst error with a real-time oscilloscope
- Connect a module compliance board to your device evaluation board by using the G800GE electrical coaxial cabling system

Standard conformance of electrical receivers

Receiver conformance validation requires accurately calibrating a victim lane following a complex procedure, which ends up being extremely time-consuming when performed manually.

Keysight automated test solutions

Figure 35. Electrical receiver test solution

Keysight's receiver conformance test applications are designed to assist and simplify the stress signal calibration used for testing the inputs of networking electrical interfaces using a Keysight M8000 Series of BERT, a digital communication analyzer (DCA) oscilloscope as well as a UXR Series real-time oscilloscope.

The test application helps to reduce user interaction to a minimum and performs all required calibration routines and conformance testing automatically by remote controlling all required instruments. A wide range of hardware configurations are supported, thus protecting your investment.

Key specifications

- Support of chip-to-module (C2M), chip-to-chip (C2C) copper cable twinax(CR) and backplane (KR) interfaces following IEEE 802.3bm/bs/cd/ck/dj test procedures
- Support of very short reach (VSR) medium and long reach (MR/LR) interfaces following OIF-CEI 3.1, 4.0 and 5.0 test procedures

Key features and benefits

- Guided setup, automated stress signal calibration and conformance measurements for electrical receivers according to IEEE 25 /50/100/200G and OIF-CEI 28/56/112G specifications
- Remote-controlled instruments for test automation and reduced user interaction
- HTML test report
- Flexible licensing

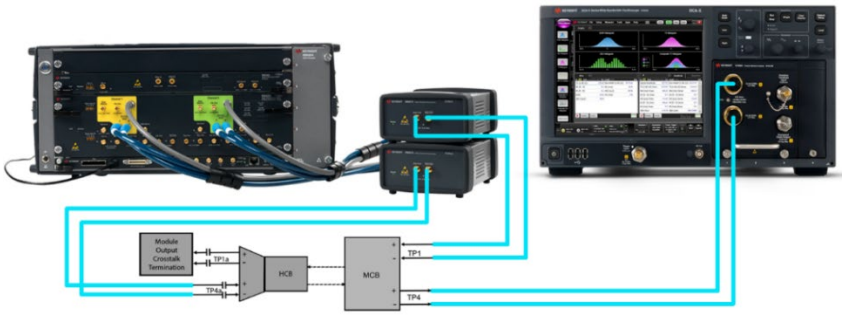


Figure 36. Setup configuration for C2M stressed eye calibration (host test)

Validation and standard conformance of electrical transmitters

Validating electrical transmitters in AI workloads faces critical challenges due to increasing speeds (800G/1.6T), such as managing tight signal integrity margins, and reducing, measuring, and correcting, jitter and noise. Manual validation of transceivers poses significant operational,costly, and sustainable challenges.

Validate 200 Gbps-per-lane electrical transmitters

Keysight offers a wide range of electrical transmitter test automation applications that help you to save test time while obtaining reliable and repeatable test results.

N1091DJPA IEEE 802.3dj TX electrical validation software

The new N1091DJPA DCA-based test application is designed to support IEEE 802.3dj electrical development from early validation through advanced testing. It enables engineers to move faster from bring-up and characterization to compliance readiness, reducing design risk and accelerating time-to-market for next-generation 200G-per-lane data center and AI interconnects.

The N1091DJPA validation application is based on a DCA half-rate architecture, purpose built for R&D and debug environments where rapid insight and measurement practicality are critical. It allows engineers to characterize transmitter behavior using half rate clocking setups, making it ideal for early silicon, ASIC, and system validation. The N1091DJPA test app is not a conformance application, but a powerful tool to uncover margin, isolate issues, and guide design decisions quickly.

Key features:

- Half-rate electrical validation workflow optimized for DCA platforms
- Designed for characterization, debug, and bring up
- Enables faster insight into signal quality and margin during early development
- Ideal for 802.3dj R&D and pre-compliance investigations

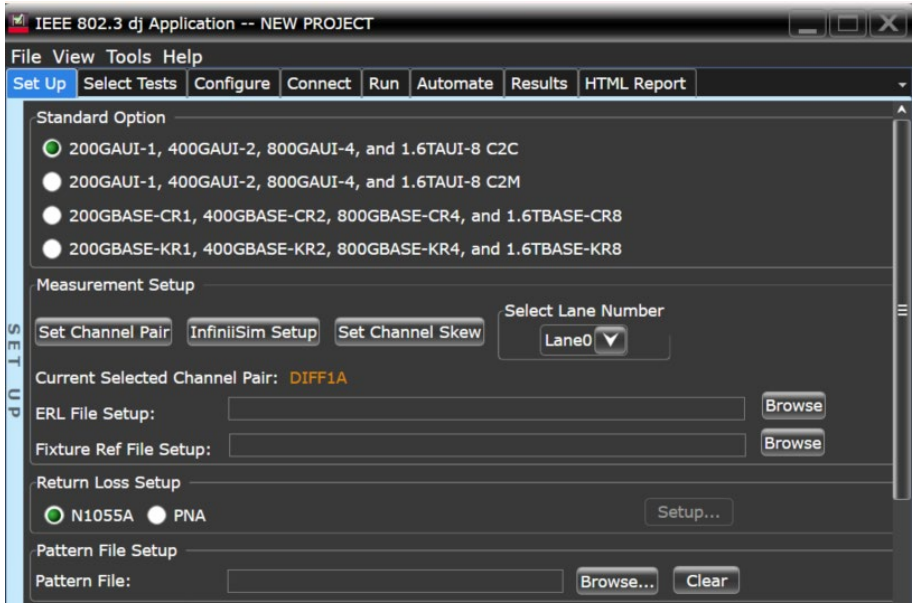


Figure 37. Standard selection and measurement setup with the N1091DJPA test app

Interoperability of optical transceivers

For seamless communication between devices of different manufacturers, compatibility across a wide range of parameters and conditions needs to be tested. Additional challenges arise as new optical transceiver technologies emerge.

Linear pluggable optics (LDO / LPO)

Linear drive optics (LDO) refers to a group of technologies that address the data center's need for high-speed data transmission with lower power consumption and lower cost than traditional pluggable optical transceivers.

For short to medium-reach data links (up to a few kilometers), these technologies include linear pluggable optics (LPO), linear receive optics (LRO) - also known as retimed transmit linear receive (RTLR), co-packaged optics (CPO), and near-packaged optics (NPO). Of these three technologies, LPO provides the lowest cost and power consumption while maintaining the flexibility and serviceability of traditional pluggable transceivers. The need for additional tuning of the host side to ensure interoperability with existing retimed optics is removed in LROs that include a re-timer on the transmit path (half-retimed).

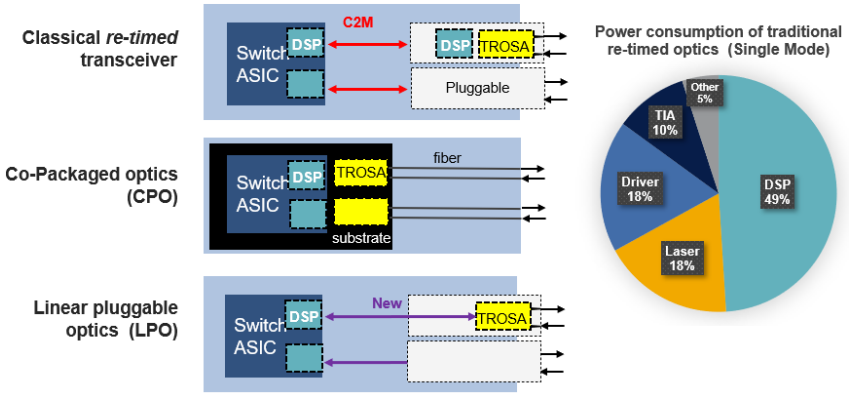


Figure 38. Reducing optical transceiver power consumption

Linear pluggable optical transceivers are like traditional pluggable transceivers except that the digital signal processing (DSP) functional block is removed thereby reducing the cost by around 20% - 40% and decreasing power consumption by about 50%. The LPO form factor is the same, using QSFP-DD or OSFP packaging. LPO links can be up to a few hundred meters and will typically be used for server top-of-rack (TOR) to leaf switch applications.

High-speed data links rely on equalization techniques at both the transmitter (TX) and the receiver (RX) to compensate for the effects of the channel between the TX and the RX. Removing the DSP from LPO transceivers eliminates the capability to re-time the signal and therefore puts more onus on the host ASIC for equalization and drive level control. Novel measurement techniques such as EECQ (electrical eye closure quaternary) and new reference receiver designs are required to describe this new scenario. Keysight has been an active contributor to the development of the 100G LPO standards under both the OIF-CEI-112G-Linear and LPO-MSA bodies, continuing its engagement in defining the 200G LPO measurement standards.

Keysight test solutions for conformance and validation testing of LPO include the M8050A high-performance bit error rate tester (BERT), the N1000A/N1060A DCA-X sampling oscilloscopes and modules, the N1092A/B optical DCA-M, the N109212CA electrical TX test software and the M809212CA RX test software both for OIF-CEI-112G.

Key features and benefits

- Automated TX and RX equalization
- Standard-defined reference receiver
- High-fidelity measurements for 112 Gbps linear LPO testing
- Hardware expandable to support 200 Gbps LPO pathfinding activities

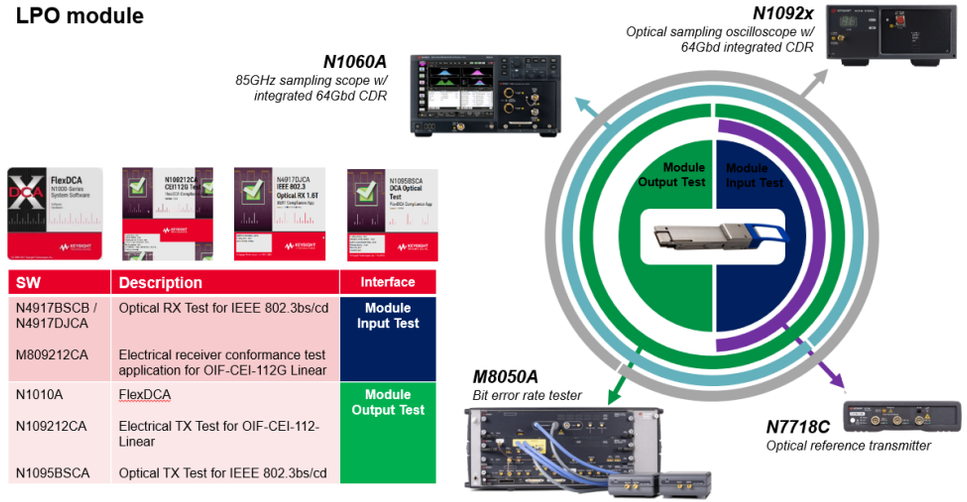


Figure 39. Keysight solution for validating LPO modules

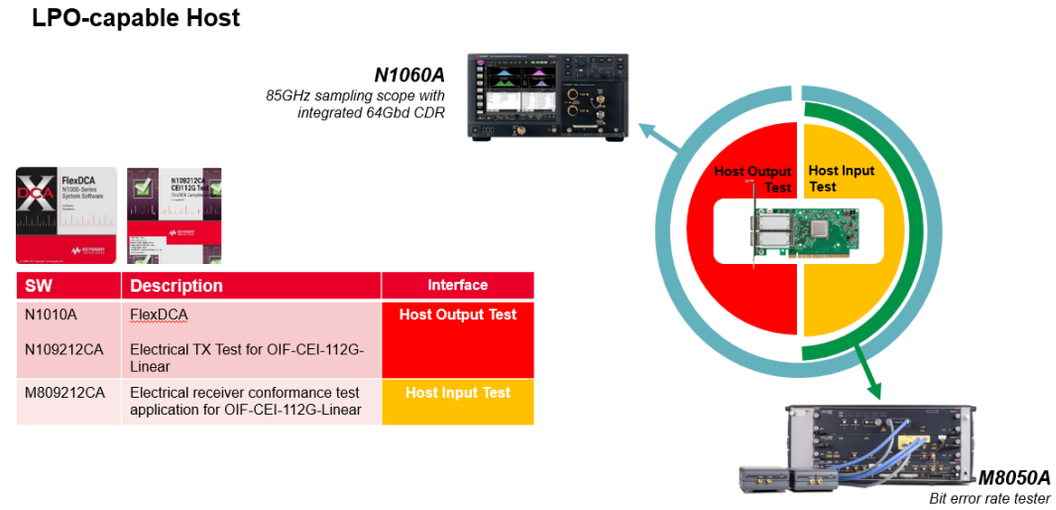


Figure 40. Keysight solution for validating LPO-capable hosts

Optical receiver stress test

Ensuring repeatable and reproducible results for 10G / 40G / 100G / 400G / 800G / 1.6T interfaces

Figure 41. 1.6T Optical receiver stress test solution

When transceiver modules interoperability issues arise, additional rounds of module characterization must be performed which can result in shipment delays or even product disqualification.

As a solution to this, Keysight provides fully automated solutions for optical transmitter characterization and optical receiver stress testing following IEEE 10G, 25G, 40G, 100G, 200G, 400G, 800G, 1.6T and MSAs standards.
The 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.

The Keysight N4917DJCA automation software combined with the 7718C optical reference transmitter, and the N1030A DCA-X oscilloscope is the industry-first turn-key solution for automated optical receiver stress, saving hours of calibration time

Key features and benefits

- Test compliance of optical 10G, 25G, 40G, 100G, 200G, 400G, 800G, 1.6T transceivers with IEEE standards and 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/cu/dj test procedures and user-specific tests (design characterization)
- 120 Gbaud and higher PAM4 with N7718C reference transmitter
- Controllable jitter-, noise- and ISI-induced penalty for NRZ and PAM4
- Automated stress signal calibration, receiver sensitivity and jitter tolerance measurements
- Repeatable and stable calibration of optical stressed NRZ and PAM4 signals

Figure 42. Optical 106.25 Gbaud PAM4 signal, generated using M8050A BERT and N7718C reference transmitter

N7718C optical reference transmitter

The newly released Keysight N7718C optical reference transmitter addresses the challenges of validating 200 Gbps per lane optical interfaces. Seamless integration with M8050A BERT platform enables the generation of optical PAM4 signals at up to 120 Gbaud with unmatched signal integrity.

Figure 43. N7718C optical reference transmitter

Combined with the Keysight N4917DJCA automation software and optical sampling oscilloscope, it builds up the industry's first turn-key solution for automated optical receiver stress test, providing repeatable calibration of the optical stressed eye and saving hours compared to calibrating manually according to the upcoming IEEE 802.3dj.

To push the boundaries even beyond 120 Gbaud, the N7718C optical reference transmitter can be used with the Keysight industry's fastest arbitrary waveform generator M8199B.

It is suitable for any intensity-modulated signal and operates in the optical O-band (1.3 µm window). Users can connect the optical input to either the built-in 1310 nm DFB laser or a tunable laser to cover LR4, ER4, CWDM4, or other wavelength grids.

Applications

- Validate 224 Gbps-per-lane optical interfaces
- Enable 448 Gbps-per-lane research

Key specifications

- Optical input power range +8 dBm to +20 dBm, (max. safe limit +20 dBm)
- Operating wavelength range 1260 nm to 1360 nm
- Output power at quadrature bias point typ. ≥ +5.5 dBm (using internal laser, set to +18.5 dBm)
- Frequency roll-off (characteristic) >102 GHz (10 dB), >77 GHz (6 dB)
- RF input amplitude range 200 mV to 2 V, (max. safe limit 4 V peak-peak)
- Vπ at 1310 nm (characteristic) < 1.45 V at 10 kHz
- NRZ, PAM4, PAM6, and PAM8 waveforms
- Max. baud rate (PAM4) ≥ 120 GBd
- TDECQ (PAM4)
  - Typical < 3.5 dB (Outer ER > 8 dB, without M8050A PG deemphasis)
  - Typical < 1.2 dB (Outer ER > 3 dB, with M8050A PG deemphasis)
- TDEC (NRZ) < 1.7 dB at 1310 nm
- Jitter (NRZ)
  - Typical total jitter < 5.3 ps peak-peak
  - Typical random jitter < 180 fs rms
- Rise and fall time (NRZ) (20% to 80%) < 5 ps
- Extinction ratio (NRZ) Typical ≥ 3.1 dB
- Outer ER (PAM4)
  - Typical > 8 dB at 1310 nm (without M8050A PG de-emphasis)
  - Typical > 3 dB at 1310 nm (with M8050A PG de-emphasis)
- Outer OMA (PAM4)
  - Typical > 6.5 dBm at 1310 nm (without M8050A PG de-emphasis)
  - Typical > 3.5 dBm at 1310 nm (with M8050A PG de-emphasis) 3

Scale Out – AI Interconnect and Network Test

Optimizing AI data center fabrics requires consistent and repeatable testing methodologies. It is key to be able to emulate realistic AI workloads, benchmark network equipment and infrastructure and monitor key performance indicators like job completion time.

Interconnect error performance and validation for design and manufacturing

Optical coherent parameter tests such as EVM, based on the N4391, the link quality needs to be tested considering the BER and preFEC measurements. New AI interconnect is being introduced in the data center, both optical and electrical, with a variety of configurations and speeds.

Functional Interconnect Test System (FITS)

Key features and specifications:

- Small footprint, affordable, multiple lanes, error validation system for in-process and near-line interconnect manufacturing process test applications and R&D lab use.
- May be used with MCB to measure the DUT using Tx, or Rx, or both functionalities with GPIO control port
- Front panel Clock IN and OUT SMA's with reference clock and clock division
- May be used as a 212G receiver with Keysight's high accuracy BERT system (M8050A)
- May be used with 1093A/B DCA-M for lane-by-lane tuning of active electrical cable DSP's, and for other active interconnects
- BER measurements on multiple lanes with pass fail reports and graphs
- Built-in SCPI API automation support
- Advanced Option software: FEC error correction stats on 212G lanes, and auto lane tuning for active interconnects

Functional Interconnect Test Solutions GUI for PG, BER, DCA interaction and reporting

Figure 44. BER & FEC error performance validation system, FITS-8CH, benchtop chassis

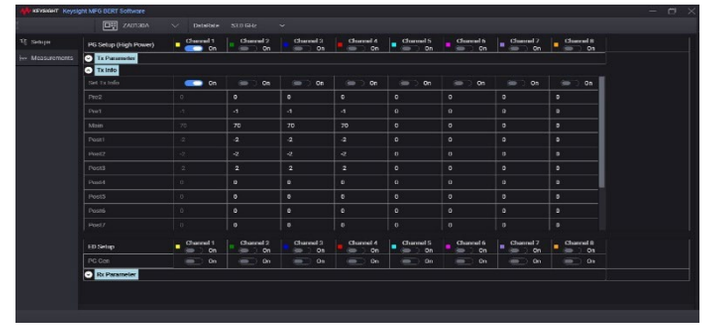


Figure 45. Functional Interconnect Test Solutions GUI dedicated for BER and FEC measurement and reporting with pass/fail

High Drive I/O channels, 2Vpp

- 8 channels to drive a higher voltage signal for auto-lane tuning of devices with Keysight DCA

Chip-to-Module I/O channels, 1Vpp

- 8 Tx and 8 Rx multiple channel BER per lane validation

Lanes speeds: 212G, 106G, and 53Gb/s

AI infrastructure performance validation

Emulation of AI workloads and precise benchmarking with KAI Data Center Builder

Validation of AI network infrastructure by reproducing the behavior of AI workloads, can be accomplished with the Keysight AI (KAI) Data Center Builder software. Designed for fast deployment and streamlined operations, it provides deep insights into performance characteristics of AI cluster networking to identify bottlenecks, increase throughput, and optimize the overall efficiency of your AI systems. The solution can complement, minimize or even replace GPU usage in AI cluster infrastructure performance testing, enabling AI operators to reduce the spending they would otherwise allocate entirely to GPU-based benchmarking systems.

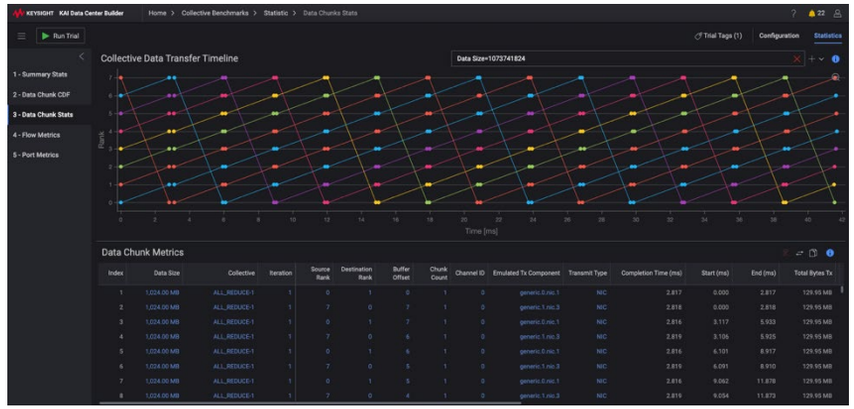


Figure 46. AI Data Center Builder software

To accelerate AI / ML network design, the KAI DC Builder:

- **Emulates realistic high-scale AI workloads** — Reduce dependency on large GPU clusters for infrastructure experimentation and validation.
- **Simplifies the benchmarking process** — Validate AI network fabric with pre-packaged benchmark applications and dataset analysis tools.
- **Offers a choice of Test Platforms** — Choose between RoCEv2 endpoint emulation on high-density AresONE traffic load appliances, software endpoints on servers equipped with RDMA NICs, or real AI accelerators.
- **Automates AI fabric testing** — assess network impact on job completion time, performance isolation, load balancing, and congestion control for optimized AI training performance.

AresONE AI Fabric RoCEv2 Test Solution

Figure 47. AresONE-M 800GE traffic-load appliance

- 2 / 4 / 8-port QSFP-DD800 and OSFP800 models
- Stress network fabric with stateful RoCEv2 traffic on 8000 Q-Pairs per port
- Reproduce Priority-based Flow Control (PFC), ECN/CNP congestion notification and DCQCN rate control per Q-Pair

Interconnect and network performance tester 1600G benchtop and rackmount

1.6 Tb/s is a new technological speed and is now introduced into the networking ecosystem, as the 1.6T switches become available. There is an ever-growing need to test the functionality and performance of all the different optical and copper interconnects at 1.6T/s for their individual performance. Interconnect links are connected to networking equipment for additional interoperability, link quality, performance, and reliability testing.

Optical transceiver and cable interoperability

The new INPT-1600GE is versatile and can be supported as a benchtop unit or rack mount unit. It supports PAM4 signaling on 212Gb/s host electrical lanes, with configurations of 1x1600GE, and 2x800GE speeds. Updated versions will support 4x400GE and 8x200GE speeds.

1.6T measurement features include:

- L1 BERT, L1.5 FEC symbol error correction performance, FLR, Pre-FEC BER, BER/FEC/PCS error injection
- Active optical and active copper interconnect support
- Layer 2/3 Ethernet traffic Tx, Rx capture
- (Planned) RFC benchmark and network protocol emulation test
- (Planned) support for RoCEv2/RDMA, AI Data Center Builder SW

Key features and specifications:

- The 1600GE benchtop chassis operates at an audio level that is classified as office quiet operation, less than 60 dBA audio noise. It can be added onto the instrument bench without disturbing the existing noise level in your lab.
- IEEE P802.3dj draft standard compliant
- Optical and copper interconnect media support with CMIS 5.2
- Support for up to 40 W power consumption and cooling per port
- It has a small footprint, 17.0” (L) x 10.86” (W) x 8.06” (H), or 431.8 mm (L) x 275.7 mm (W) x 204.8 mm (H). And the unit can be used in a horizontal or vertical chassis orientation to maximize lab bench space. It is lightweight at 22 pounds (9.9 kg) and portable with a built-in handle.
- The benchtop has an Ethernet management port for connection to a laptop or into a management network.
- Low power consumption is important to reduce the carbon footprint in the lab. The benchtop chassis operates at a maximum 15 amperes using 100-127 VAC, 50/60 Hz. Only a single 15 or 20 ampere power source is required.
- The Interconnect Test System software application (ITS) runs on the benchtop and provides support for Layer 1 BERT, Layer 1.5 PCS and FEC, FLR testing, Layer 2 and Layer 3 data plane Ethernet traffic generation, reception, error injection, and analysis with extensive statistics and counts.

Figure 48. Interconnect and network performance tester (INPT) benchtop INPT-1600GE-BT and half-rack INPT-1600-RM

Interconnect and network performance tester 800G benchtop

A variety of AI interconnects are being introduced in the data center, and there is an ever-growing need to test the functionality and performance of all the different optical and copper interconnects for their individual performance. Interconnect links are connected to networking equipment for additional interoperability, link quality, performance, and reliability testing.

Optical transceiver and cable interoperability

The new 800GE benchtop chassis is designed to respond to this ever-growing and ever-changing set of network equipment and interconnect test requirements. It supports all the 800GE and 400GE-PAM4-related Ethernet speeds, Layer 1 BERT PRBSQ pattern generation, BER and FLR measurements, CMIS management, auto-negotiation and link training for all speeds, and all the required data center network protocol emulation and benchmark performance testing that is also required.

Figure 49. Interconnect and network performance tester (INPT) with 4 ports of OSFP800

Key features and specifications:

- Enables up to 4 users to work independently on the same 4-port platform at the same time: up to 2 users on a 2-port system.
- The 800GE benchtop chassis operates at an audio level that is classified as office quiet operation, less than 60 dBA audio noise. It can be added onto the instrument bench without disturbing the existing noise level in your lab.
- It has a small footprint, 17.0” (L) x 10.86” (W) x 8.06” (H), or 431.8 mm (L) x 275.7 mm (W) x 204.8 mm (H). And the unit can be used in horizontal or vertical chassis orientation to maximize lab bench space.
- It is lightweight at 22 pounds (9.9 kg) and portable with a built-in handle.
- Low power consumption is important to reduce the carbon footprint in the lab. The benchtop chassis operates at a maximum 15 amperes using 100-127 VAC, 50/60 Hz. Only a single 15 or 20 ampere power source is required.
- Support for up to 30 watts per port for high power consumption coherent optical transceivers. The benchtop solves an ongoing concern about test system support for these types of optical transceivers.
- The benchtop has an Ethernet management port for connection to a laptop or into a management network.
- Optical and copper interconnect media support with CMIS 5.2
- A wireless connection to the benchtop using a Wi-Fi USB plug is available.
- The Interconnect Test System software application (ITS) runs on the benchtop and provides support for Layer 1 BERT, Layer 1.5 PCS and FEC, FLR testing, Layer 2 and Layer 3 data plane Ethernet traffic generation, reception, error injection, and analysis with extensive statistics and counts.

Scale Across - Coherent Transceiver Tests

Coherent optical transmission at 220 GBd and beyond

To support data rates ranging from 400 Gb/s to 1.6 Tb/s, advanced modulation formats are essential. The next generation of coherent optical transceivers is designed to operate at symbol rates of 220 GBd and higher, enabling ultra-high-speed data transmission for future optical networks.

Keysight full coherent transceiver analysis

This test solution emulates the functionality of a coherent transceiver by generating signals with flexible modulation formats using Keysight's M8199 series arbitrary waveform generators (AWGs) and analyzing those signals with Keysight's advanced N4391 optical modulation analyzers (OMAs). These analyzers are built on Keysight's industry-leading UXR real-time oscilloscope platform.

The solution enables comprehensive transceiver analysis at next-generation speed classes, helping to validate and enhance both overall transceiver performance and the performance of individual components.

Optical modulation analyzers deliver detailed insights into the physical characteristics of complex modulated optical signals. They assess signal quality and evaluate components designed for IQ modulation and demodulation.

Keysight provides the broadest portfolio of optical modulation analysis and synthesis tools, supporting testing up to 1.6 Tb/s to meet both current and future requirements.

The N4391C offers configurations with 1.85 mm and 1.0 mm connectors, both of which are upgradable to higher bandwidths for electrical and optical applications.

The 1.85 mm connector configurations support bandwidths of 40, 50, 59, or 70 GHz, with upgrades available up to 70 GHz.

The 1.0 mm connector configurations support 40, 59, 70, 80, 100, or 110 GHz, and can be upgraded incrementally to a maximum of 110 GHz.

Figure 50. N4391C optical modulation analyzer

In combination with Keysight's AWG portfolio for coherent optical signal generation, the IQTools software enables the creation of clean, complex, dual polarization modulated signals. It also offers the ability to pre-distort the signal using S-Parameter measurements as well as individual skew and imbalance settings, which can be used to overcome impairments in the optical transmitter setup.

Key features and specifications

- Optical operating wavelength range 1528 nm to 1620 nm; O-band version available for 1270 nm to 1340 nm
- Maximum detectable symbol rates 80 / 100 / 118 / 140 GBd and 160 / 200 / 220 GBd depending on licensed bandwidth; demonstrated 260 GBd[4]
- 40 / 50 / 59 / 70 GHz and 80 / 100 / 110 GHz bandwidth options for electrical measurements with a single 4-channel oscilloscope
- The new N4391C allows you to choose the optical bandwidth independently from the oscilloscope's electrical bandwidth
- Two paths of bandwidth upgradability for electrical and optical use cases: upgrades can be accomplished in minutes through the installation of licenses
- Specified typical EVM noise floor < 1.1% at 2.5 GHz (typical < 1.5% at 2.5 GHz for option 011)
- Relative skew after correction < ± 0.5 ps typical
- Average input power monitor accuracy ± 0.5 dB typical
- Powered by the industry-leading UXR real-time oscilloscopes
    - 256 GSa/s sample rate
    - High-definition 10-bit analog-to-digital converter (ADC) for all bandwidth grades
    - The industry's lowest noise and jitter measurement floor
    - The industry's highest ENOB at all supported bandwidths

[4] First 260 GBd Single-Carrier Coherent Transmission over 100 km distance Based on Novel Arbitrary Waveform Generator and Thin Film Lithium Niobate I/Q Modulator; European Conference on Optical Communication (ECOC) 2022 Technical Digest Series (Optica Publishing Group, 2022), Paper Th3C.2

400G coherent transceiver validation

Meeting interoperability and high-volume production demands requires a new approach to qualifying, validating, and manufacturing 400G coherent transceivers.

Keysight's scalable and cost-effective solution

Keysight delivers a scalable test solution tailored for the 400G coherent ecosystem. Designed for efficiency in both cost and footprint, the solution includes:

- M8290A modular optical modulation analyzer (M-OMA) family
- Arbitrary waveform generators (AWG):
  - M8196A: 92 GSa/s sample rate, 32 GHz analog bandwidth
  - M8194A: 120 GSa/s sample rate, 50 GHz analog bandwidth

Figure 51. M8290A optical modulation analyzer

M8290A optical modulation analyzer and high-speed digitizer test solution

Optimized for the 400G speed class, the **M8292A optical modulation analyzer**—a compact, affordable, rack-mountable member of the M8290A family—connects directly to the optical output of coherent transmitters. It integrates seamlessly with both Keysight's vector signal analyzer, and optical modulation analysis software, delivering a consistent and intuitive user experience for analyzing complex modulated optical signals.

Key features and specifications

- Turnkey solution for testing coherent optical transmit and receive devices
- Compact and flexible AXIe modular form factor
- Common specifications for M8292A and M8296A
  - 74 GBd maximum symbol rate
  - 83 to 92 GSa/s sample rate
  - 512 k 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

System integration of coherent optical transmit and receive devices

Coherent optical components – such as dual-polarization IQ modulators and intradyne coherent receivers – must be tested throughout their development lifecycle. This includes both parametric evaluations and system-level testing to ensure optimal performance.

Automated test solution

Keysight's optical modulation analyzer (OMA) software includes dedicated application packages that offer turnkey solutions for the parametric characterization of coherent optical transmit and receive devices. These results can be seamlessly transferred for further system-level performance validation. The solution supports both the M8290A and N4391 hardware platforms.

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

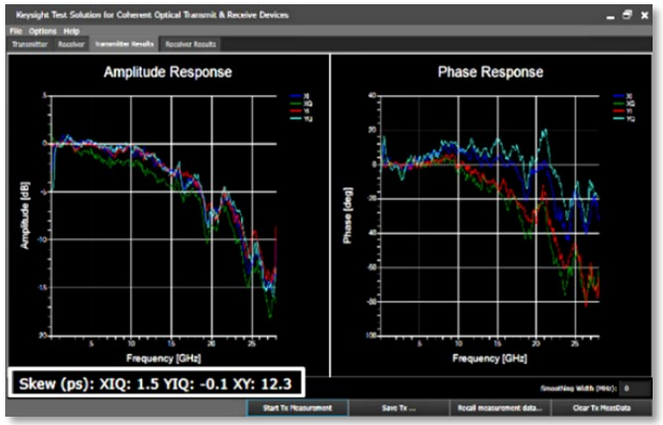


Figure 52. COD test result: TX amplitude and phase response with zoomed-in skew results

Key highlights:

- Simultaneous measurement of all four S21 magnitude and phase responses
- Sequential measurement of IQ skew and XY skew for both transmitter and receiver
- RX IQ angle analysis (requires heterodyne configuration)
- Single connection between fixture and instruments for improved repeatability and reduced setup time
- Cable and fixture de-embedding
- Scalable setup for extended measurement capabilities

Integrated coherent receiver (ICR) testing

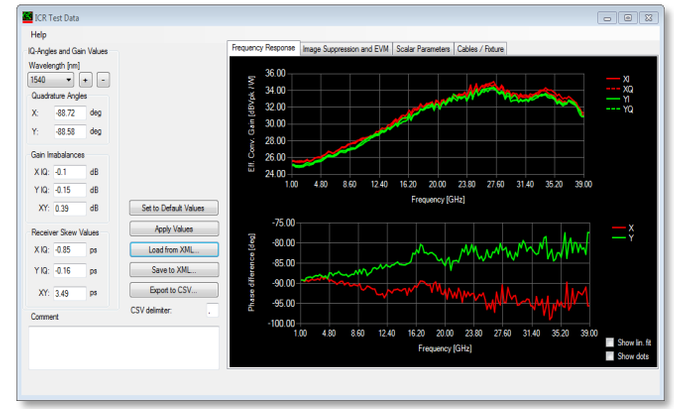


Figure 53. ICR test result screen with phase and frequency response

Key highlights:

- Simultaneous measurement of all four S21 magnitude responses
- Evaluation of IQ skew, XY skew, IQ angle, IQ gain imbalance, and XY gain imbalance
- EVM noise floor analysis
- Image suppression capability
- Cable and fixture de-embedding

Quantum Photonics

Quantum photonics leverages superposition and entanglement to enable breakthroughs in computing, communications, and sensing. Integrating AI with quantum systems accelerates algorithm development and enhances applications.

Quantum communications

Quantum Key Distribution (QKD) provides secure communication using quantum mechanics, allowing two parties to share a secret key for encryption. Global research focuses on characterizing QKD components to improve performance.

Keysight's Role: we offer automated solutions and instruments such as tunable lasers, optical power meters, attenuators, polarization controllers, reference modulators, AWGs, and oscilloscopes for QKD testing.

Single-Photon Detectors (SPD) Characterization: critical for long-distance quantum links. Key goals include reducing timing jitter and improving detection efficiency.

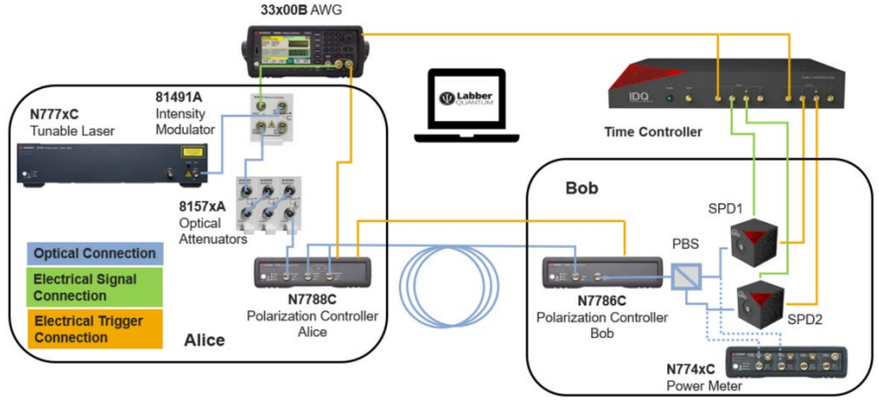
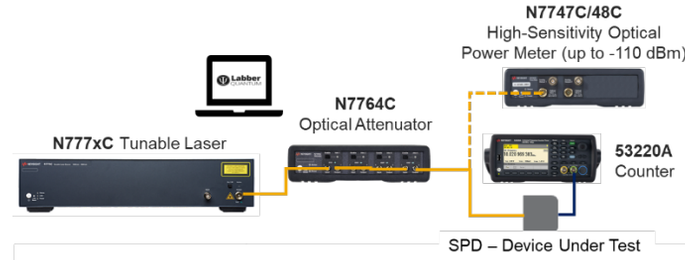


Figure 54. DV-QKD (discrete variable) testbed example



Step Wavelength	0 dB	0 dB	Measure Power – P0(λ)
Step Wavelength	X dB	0 dB	Measure Power – P1(λ)
Step Wavelength	0 dB	Y dB	Measure Power – P2(λ)
Step Wavelength	X dB	Y dB	Measure Photon Count – PC(λ)

Figure 55. SPD's detection efficiency measurement setup

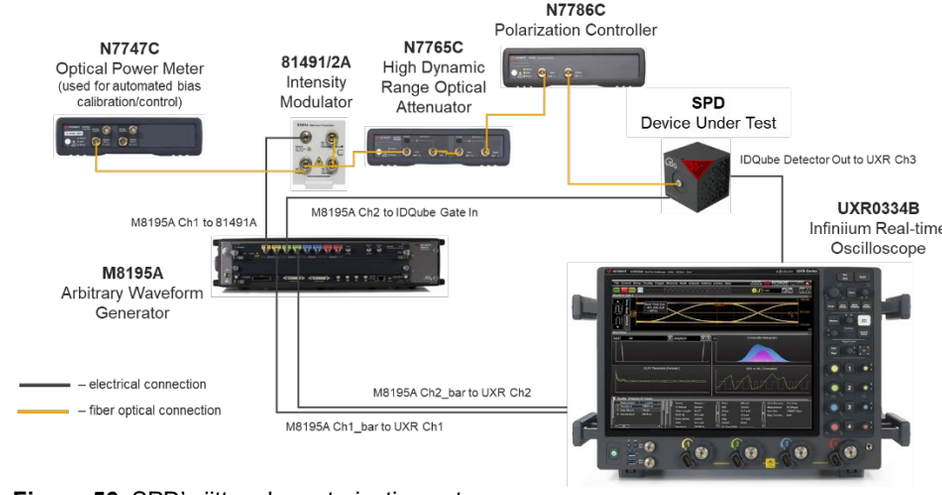


Figure 56. SPD's jitter characterization setup

Quantum computing

Quantum computing faces challenges from noise and calibration errors.

QuantumPro: an integrated design environment for superconducting qubits, combining circuit analysis, layout, EM simulation, and quantum extraction to accelerate chip development.

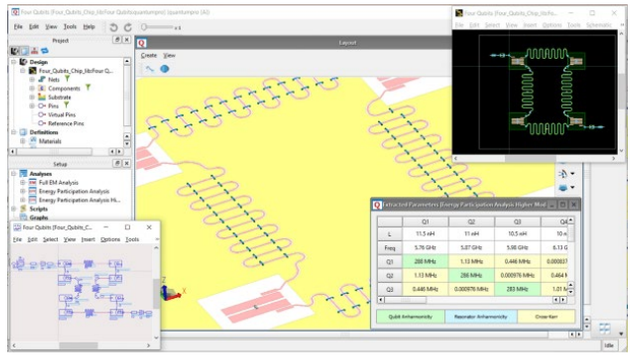


Figure 57. A four qubits circuit example in QuantumPro

Quantum Control System (QCS): Provides hardware and software for qubit control and readout, featuring:

- **Signal generation and acquisition** up to 16 GHz
- **Quantum-friendly** API/GUI for experiments and pulse sequences
- **Advanced timing** synchronization
- **Real-time** sequencing and FPGA programming

Figure 58. Q5401A Quantum Control System (QCS) in PXIe format

Quantum sensing

Quantum sensing uses entanglement, single photons, and squeezed states for ultra-precise measurements, often via interferometry.

Applications include:

- **Rydberg atom sensing** (Keysight MXG signal generators)
- **Diamond NV centers** (Infiniium MXR/UXR oscilloscopes, M819x AWGs)

N51xxA/B MXG signal generators use in Rydberg atom applications

Infiniium MXR/UXR- oscilloscop used in diamond nitrogen-vacai applications

High-speed AWG M819xA/B used i diamond nitrogen-vacancy applications

Figure 59. Keysight instrument examples used in quantum sensing.

Post-quantum cryptography validation

Keysight supports **testing and validating post-quantum cryptographic implementations** against side-channel and fault-injection attacks. We provide:

- **Security evaluation tools** for PQC algorithms.
- **Automated test environments** for robustness under real conditions.
- **Compliance support** for NIST PQC standards and future-proof cryptographic systems.

Figure 60. DS1050A Next-Generation Embedded Security Testbench

Power in the AI Data Center

AI datacenter deployments are driving a fundamental evolution in power architectures, with AI datacenter installations expanding from megawatt-scale to gigawatt-scale power consumption.

These trends place heightened demands on rack-level and server-level PSU (power supply unit), BBU (battery backup unit), supercapacitor, DC-DC and point-of-load (PoL) conversion, requiring highly efficient, scalable, and robust power supply solutions across the entire power delivery chain. Increasing power density further necessitates advanced thermal management solutions for direct liquid cooling and immersion cooling.

Power supplies and storage for racks and servers

- RP7900 serial regenerative power system, seamless source and sink, fast transient response, voltage and current slew rate. Advanced features like voltage and current digitizer, data logging and ARB waveform with PW9252A software. Key models include:
  - RP7933A/43A supports 20 V /800 A /10 kW, cell test and core test, sink current 800 A at 0.5 V.
  - RP7935A/45A supports 80 V /125 A /10 kW, 48 V DC test, voltage program time less than 300 µs.
  - RP798x supports 500 V ~ 2000 V, 30 kW, HVDC (high-voltage direct current) test, voltage program time less than 200 µs.
- BT2152B self-discharge measurement solution for supercapacitor
- B1506A power device analyzer, PD1500A / PD1550A double pulse tester, and E5080A ENA for parasitic & on-state CV.

Figure 61. B1506A power device analyzer / curve tracer for circuit design

Simulation for power electrical circuit design

- ADS supports nearly every stage of DC-DC converters chain.
  - VRMs/RPL: Designing control loops to handle load transients without crashing the voltage. Optimizing switching frequencies and inductor selection.
  - IBC: Simulating efficiency, thermal performance, and EMI generation.
  - Ideal for PSU simulating complex topologies, particularly resonant converters
- Handling high-speed switching events and complex frequency-domain behaviors.
- Balancing efficiency vs. switching frequency capabilities of GaN/SiC devices.
  - Designing the interface electronics of BBU and supercapacitors
- Designing the topology and control scheme for bidirectional power flow.

Simulation for power integrity design

The W3034E ADS PIPro element is used to analyze the physical PCB layout of GPU/accelerator (OAM/UBB) including analysis of DC IR drop, and AC impedance, simulation of power plane resonance, advanced packaging and interposers, AI processor package substrate, decoupling capacitor optimization.

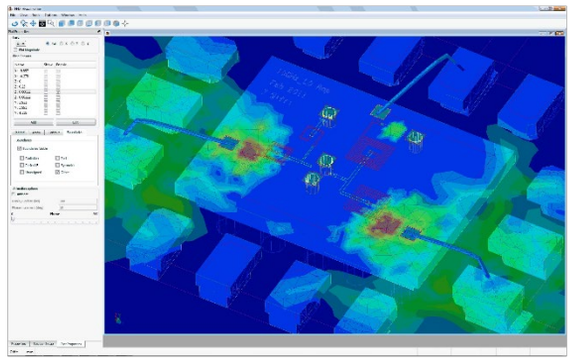


Figure 62. Power integrity analysis for your PDN including DC IR drop analysis, AC impedance analysis, and power plane resonance with W3034E PIpro software

Power integrity test and measurement

- Frequency domain measurement using E5061B 5Hz ~ 3GHz network analyzer
  - E5061B reveals the root cause of PI issues (impedance peaks, resonance, insufficient phase margin), not just the symptoms
  - **Measure PDN impedance (mΩ) vs frequency** at XPU socket or VRM output
  - **Compare against target impedance profile**
  - **Identify resonance peaks** caused by decoupling or plane effects
  - Measure DC-DC loop gain and phase margin
  - Correlate measurements with ADS PI-AC simulation
  - Iterate capacitor placement, VRM compensation, or plane design.
- Time domain measurement using power rail probe and power integrity software
  - Power integrity analysis with MXR oscilloscope, N7020A power rail probe, and automation software
  - Measuring DC rail ripples, broadband noise, and switching artifacts directly at GPU, HBM, FPGA, or ASIC power pins.
  - Validating whether the PDN meets GPU voltage tolerance during compute bursts,
  - Crosstalk analysis between power and data

Immersion cooling liquid electrical performance test

- Keysight 50GHz VNA, N1501A, N1500A option 004, N1500A option 003, fixtures.
- OCP compliance check: “Is Dk <=2.3, Df <=0.05?”
- Four typical methods are supported including coaxial probe, parallel plate, resonant cavity, and microchip extraction.
  - Coaxial open-ended probe method is endorsed by OCP
  - Resonant cavity / cavity perturbation method is recommended when Df is < 0.01

KeysightCare

Uptime. Precision. Expertise. At your Service.

From the highest accuracy repair and calibration, up-to-date software enhancements, and unlimited access to expertise, KeysightCare curated plans bundle essential services with prioritized response and turnaround times to get and keep your engineering teams innovating at speed.

Maximize uptime

With KeysightCare plans, you choose from various response and turnaround time options while ensuring your teams have unlimited repairs, scheduled calibrations, ongoing software updates, and expertise at no extra cost.

KeysightCare saves money, too. When you choose multi-year plans, your savings multiply.

KeysightCare Plans

Carefully curated KeysightCare plans deliver the service features you need most, when you need them. Find the KeysightCare plan that fits your organization's needs today and expands to cover what you need for tomorrow.

- Access to technical expertise
- Prioritized turnaround times
- Unlimited repairs
- Keysight-certified calibration
- Timely software updates
- Fastest response times

KeysightCare Assured

- KeysightCare Technical Support
- Technical support response with 4 business hours
- ≤ 10-day instrument repair turnaround time
- Complimentary calibration after repair service, based on country and model availability
- Firmware update notifications

KeysightCare Enhanced (recommended)

- KeysightCare Assured
- Technical support response within 2 business hours
- ≤ 7-day instrument repair turnaround time
- Complimentary calibration after repair service, based on country and model availability
- Keysight-certified calibration coverage
- ≤ 5-day instrument calibration turnaround time
- Firmware update notifications

KeysightCare Software Support

- KeysightCare Technical Support
- Technical support response within 4 business hours
- Application software updates and enhancements
- Proactive software notification

References

Advanced Design System (ADS)

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

IxVerify

https://www.keysight.com/find/ixverify

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

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FlexOTO Optical Test Optimization

https://www.keysight.com/find/flexoto

M8050A High-Performance BERT 120 GBd

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

Optical Transceiver Test Solutions

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Coherent Pluggable Modules Test

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N4377A Lightwave Detector

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Coherent Transmission Test Instruments

https://www.keysight.com/find/oma

Infiniium Real-Time Oscilloscopes

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

M8199B Arbitrary Waveform Generator

https://www.keysight.com/find/m8199B

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

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

Quantum Innovation

https://www.keysight.com/find/quantum

KeysightCare

https://www.keysight.com/find/keysightcare

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