Discover Your Next Research Breakthrough in Device Characterization, RF to THz

SOME BREAKTHROUGHS CANNOT WAIT. ACCELERATE YOUR PATH TO INNOVATION WITH CONFIDENCE.

KEYSIGHT TECHNOLOGIES

Keysight Solutions for Academic Researchers

Your research is crucial for the discovery of new sciences, new solutions for real-world problems, and innovation that accelerates technological breakthroughs. As you perform iterative characterization, simulation, and measurement to confirm your hypotheses, confidence in every measurement is paramount.

Keysight Technologies advances research by professors around the globe through close university-industry collaboration and industry-leading hardware instrumentation **for highly accurate and reliable measurements**. Researchers of radio frequency (RF) / microwave and high-speed digital circuit designs can also speed development and reduce costly prototyping errors through simulation with Keysight's leading electronic design automation (EDA) software.

No matter what breakthrough you are working on next, you can count on Keysight's wide range of robust test solutions and technical support expertise.

This brochure covers Keysight solutions for research in RF, microwave, mmWave, and Terahertz device characterization. Keysight also offers solutions for:

- Advanced materials science and engineering
- Key industry verticals such as 5G, biomedical sciences, energy, optical and photonics, and quantum engineering

For more information on how Keysight can help researchers go to:
www.keysight.com/find/education

RF, Microwave, mmWave, and Terahertz Device Characterization

Scenario

Wireless communications standards continue to evolve, as do new applications that enter the millimeter-wave (mmWave) and terahertz realm. Insight into your device's performance is critical to ensure that it behaves as expected. Do you see noise from the device, or is that noise from your equipment? How sure are you that the bandwidth and sampling rate of your equipment can effectively capture the elusive glitch in your device under test?

Keysight offers a broad range of hardware and software solutions that address the various challenges faced by researchers working on their next breakthrough in medical, automotive, radar, and wireless communications applications. From 3D simulation and modeling software to high-performance signal generators and analyzers in various forms, our solutions help you perform accurate device design, measurement, and validation.

In addition to our high-performing solutions, Keysight continues to be at the forefront of developing wireless communications standards such as 5G. Keysight actively participates in the development of test processes and measurement methods in many other wireless connectivity standards. Your Keysight test equipment is always updated to the latest requirements, so you can focus on your research.

Hardware solutions

Keysight offers a wide range of test and measurement instruments for RF and microwave to mmWave and terahertz applications. From handheld spectrum analyzers to highly dense PXIe signal generators, we have a solution to fit your application specifications, budget, and form factor need.

Vector network analyzer (VNA)

Solution for terahertz measurements: Keysight PNA-X network analyzer + frequency extenders

Frequency extenders directly connect to a dual-source, two- or four-port PNA-X network analyzer front panel. There is no need for a test set controller. This configuration enables banded S-parameter measurements up to 1.5 THz.

Further Reading: Banded Millimeter Wave Network Analysis

DID YOU KNOW?

You can transform select PNA-X network analyzers into nonlinear vector network analyzers with minimum accessories and nonlinear firmware options.

Further Reading: Nonlinear Vector Network Analyzer

The **N5290A / N5291A PNA-based broadband mmWave solution** is a single-sweep solution based on Keysight PNA or PNA-X network analyzers. The N5290A mmWave solution operates from 900 Hz to 110 GHz. The N5291A operates up to 120 GHz (125 GHz with over-range capability). The solution includes:

- a select PNA / PNA-X network analyzer
- N5292A mmWave test set controller
- N5293AX / N5293AX frequency extender module
- cables to make either two- or four-port measurements over the entire frequency range

The N5290A / N5291A mmWave solution is a key component in the wafer-level measurement solution that Keysight and solution partner Cascade Microtech created.

The **N5292A mmWave test set controller for PNA / PNA-X**

- provides a two- or four-port interface
- supports Keysight's N5293AXxx / N5293AXxx line of frequency extenders and OML / VDI head modules

Further Reading: Millimeter Wave Network Analyzers (N5290A / N5291A)

Drive down the cost of test with **Keysight ENA VNAs**:

- 5 Hz to 53 GHz
- high repeatability and reliability

Carry precision with you with **Keysight FieldFox handheld VNAs**:

- wide range up to 50 GHz
- rugged build
- portable VNA
- wide bandwidth up to 100 MHz, ideal for 5G field test

Find out more about Keysight FieldFox

Keysight USB VNAs offer compact forms with zero compromise in functionality

- wide range up to 53 GHz
- lightweight and portable form factor
- wide range of measurement applications available for greater insight
- the same intuitive GUI as a benchtop VNA

Drive down the size of test with **Keysight PXI VNAs**:

- 9 kHz to 90 GHz
- two-port or multiport configuration on one PXI VNA
- high throughput with minimal manual intervention and connections
- best performance for dynamic range, measurement speed, and trace noise
- multiple VNAs in a compact bench space (achieve up to 50 ports in a single M9019A PXI chassis)
- easily scalable to your needs

Further Reading: Network Analyzer Selection Guide

Spectrum / signal analyzer

X-Series signal analyzers are Keysight's most advanced benchtop signal analyzers. Choose from a wide range of models to suit your research requirements — from wide-open, real-time analysis to low-cost essential measurements.

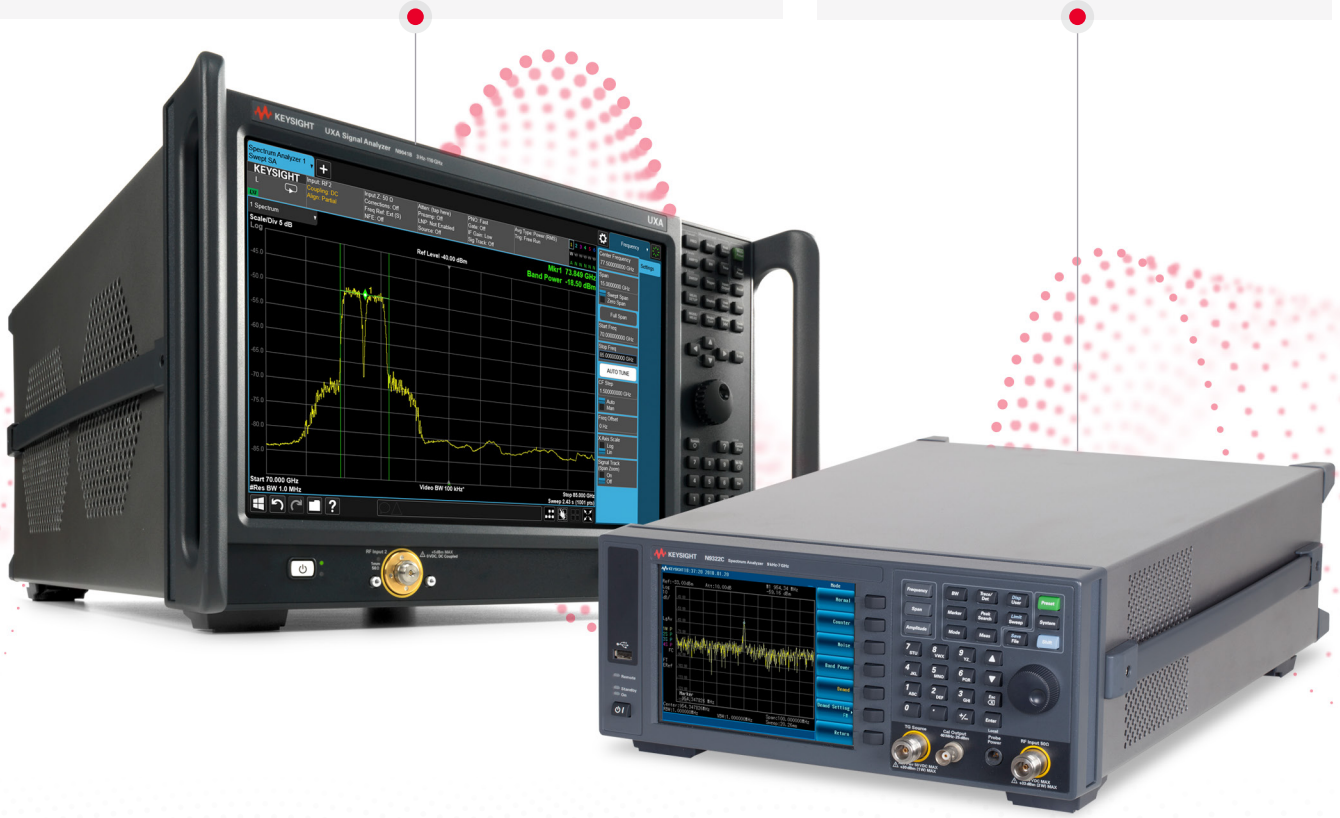
- 2 Hz to 110 GHz
- UXA, PXA, MXA, and EXA Series
- multi-touch user interface
- real-time spectrum analysis for capturing elusive signals — known or unknown
- VDI frequency extension modules for analysis of mmWave signals up to 1.1 THz

N9041B mmWave signal analyzer

- built to capture and analyze challenging millimeter-wave signals: 5G, 802.11, satellite, radar
- continuous sweeps up to 110 GHz

Basic spectrum analyzers (BSA) provide enough capabilities for straightforward and efficient operations, including spectrum analysis, signal monitoring, and transmission / reflection measurements.

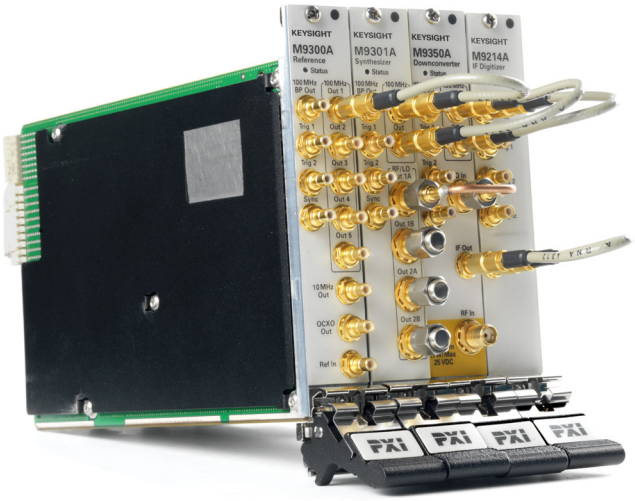
- 9 kHz to 3 GHz with N9320B
- 9 kHz to 7 GHz with N932C



Further Reading: Spectrum Analyzer and Signal Analyzer

FieldFox spectrum analyzers are ideal spectrum analysis solutions for the field:

- your choice of precision or value spectrum analysis at RF or microwave frequencies up to 50 GHz
- completely sealed, rugged, and weather-resistant (tested to MIL specs)
- clear screen and backlit keys for all lighting situations
- spaced-out keypad for easier operation with gloves on



Keysight's **PXI vector signal analyzers** are ideal for design validation applications that require fast, high-quality measurements where quality control, product conformance, and test optimization are essential:

- high throughput with the capability to pack more analyzers in a compact footprint
- scalable to your needs

M9391A PXIe vector signal analyzer

- 1 MHz to 3 or 6 GHz
- optimized for RF device design validation
- fast amplitude and frequency switching

M9393A PXIe performance vector signal analyzer

- 9 kHz to 27 GHz (extendable to 50 GHz)
- ideal for microwave measurements
- hardware speed and accuracy with stepped FFT-based spectrum analysis for harmonics and spur measurements to 27 GHz

Find out more about Keysight spectrum analyzers and signal analyzers

Oscilloscope

Keysight's Infiniium real-time oscilloscopes provide world-class signal integrity that researchers need to create next-generation technology. Infiniium oscilloscopes help you conquer your most difficult measurement challenges with superior hardware technology that offers the lowest noise floor, highest effective number of bits (ENOB), and highest bandwidth.

Keysight's **Infiniium UXR-Series oscilloscopes** provide unmatched bandwidth and signal integrity to help you achieve next-generation breakthroughs. The UXR-Series features ultra-low noise floor, ultra-low intrinsic jitter of less than 25 fs, and high-definition with a 10-bit analog-to-digital converter.

- bandwidth: 13 GHz to 110 GHz
- 2 or 4 analog channels
- max. sampling rate: 128 or 256 GSa/s
- max. memory depth: 2 Gpts

Further Reading: Oscilloscope Probes and Accessories

Signal generator / signal source

Keysight PSG signal generators are the most trusted microwave sources, providing metrology-grade frequency and level accuracy. PSG generators provide the highest-quality signals with excellent distortion and spurious characteristics.

- 100 kHz to 67 GHz
- optional PathWave Signal Generation software (formerly Signal Studio) for fast and easy signal creation
- optional E8257DSxx source modules / E8257DVxx frequency extension modules for high-power mmWave test signals on select PSG models

Keysight X-Series EXG and MXG signal generators produce pure and precise RF and microwave signals — from simple to complex, clean to impaired.

- 9 kHz to 40 GHz
- optional PathWave Signal Generation software (formerly Signal Studio) for fast and easy signal creation
- optional E8257DVxx frequency extension modules for high-power mmWave test signals on select MXG / EXG models

Further Reading: Signal Generator Selection Guide

Keysight VXG microwave signal generators provide unmatched power for 5G applications to help accelerate your 5G NR designs. The VXG signal generators also include automatic channel response correction and S-parameter de-embedding to improve measurement uncertainty and accuracy in wideband 5G carrier aggregation scenarios. Bench and modular models are available for frequency coverage of 1 MHz to 44 GHz.

Keysight PXI signal generators accelerate test throughput with fast, high-quality measurements optimized for automated RF or microwave design validation and test.

Find out more about Keysight signal generators and signal sources

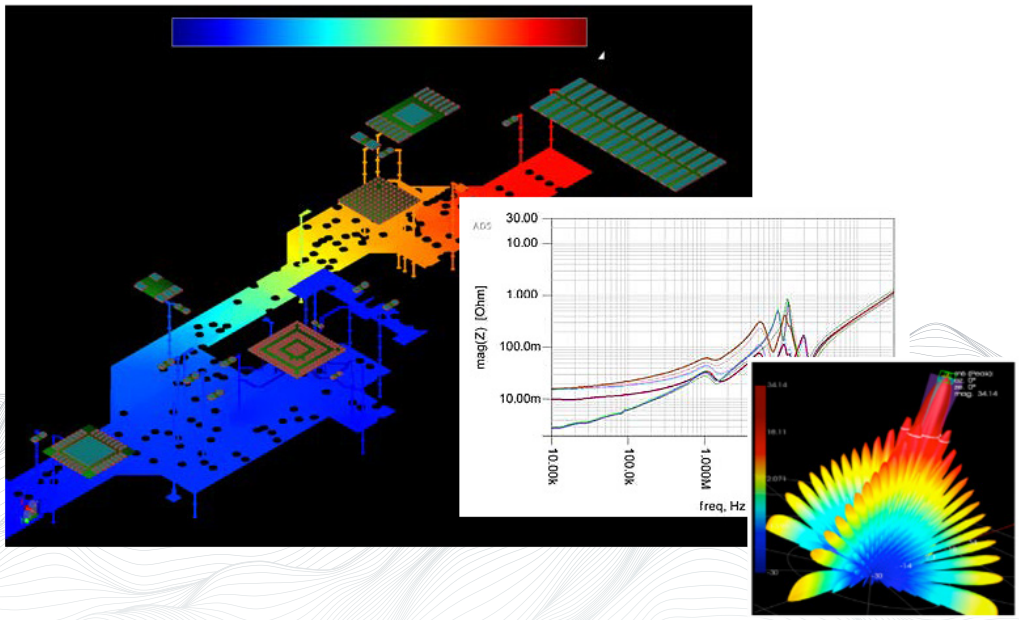
Software solutions

Electronic design automation (EDA) software

- **PathWave Advanced Design System (ADS)** is the industry's leading RF, microwave, and high-speed digital EDA software with integrated MoM-, FEM-, and FDTD-based EM simulation.
- **PathWave System Design (SystemVue)** enables system architects and algorithm developers to innovate the physical layer of next-generation communications systems.
- Keysight's device modeling tools provide end-to-end modeling solutions, including automated measurements, accurate device model extraction, comprehensive qualification, and final process design kit validation.

Faculty spotlight

See how PathWave ADS provides trustworthy simulations for Ericsson and the University of Freiburg in designing a high Q power-harvesting circuit.



PathWave X-Series Applications

- X-Series applications include a library of more than 27 measurement applications that are transportable between X-Series signal analyzers.
- N90x0A or N90x0B X-Series signal analyzers come with traditional or multi-touch GUI measurement applications.
- X-Series is a precursor to running the PathWave Vector Signal Analysis software or MATLAB for a more detailed analysis.

PathWave Vector Signal Analysis software

(formerly 89600 VSA software)

- Multiple simultaneous views in time, frequency, and modulation domains help verify signal performance quickly.
- Advanced troubleshooting tools get to the bottom of signal problems faster; tools include trace-to-trace coupling, triggering, and record and playback.
- Consistent measurements at any stage of design accelerate development — from baseband to RF and millimeter wave, and simulation to design validation.
- The software supports more than 75 signal standards and modulation types.

PathWave Signal Generation software

(formerly Signal Studio software)

- Comprehensive and easy PC-based signal creation works with a variety of applications, including cellular, wireless connectivity, aerospace / defense, broadcasting, and general purpose.

Signal Optimizer software

- Allows for simple calibration of complicated 5G wideband channels at RF, microwave, and mmWave frequencies.
- Enables easy creation and analysis of digital / custom IQ modulated waveforms and 5G candidate modulation on OFDM.

BRINGING YOUR IDEAS TO LIFE WITH INTEGRATED DESIGN AND TEST

PathWave Product Development Software

Engineering leaders know that every step in the path to new electronic product development is crucial — from design and simulation to verification and manufacturing. Unfortunately, measurement results from one step do not seamlessly transition to the next. Test engineers spend hours correlating measurements from their design teams. Software engineers write workarounds because their hardware and software do not natively talk to each other. Most organizations use standalone products for design, test, measurement, and monitoring. This siloed structure creates disconnected and inefficient workflows and is a major cause of frustration.

Connected, agile design and test is a groundbreaking way to approach the development of electronic systems. It combines new software, new workflows, and powerful automation tools in a way that transforms legacy processes and yields substantial productivity and equipment utilization improvements. Integrating design and automation software throughout a product development workflow increases efficiency by accelerating routine tasks. Keysight PathWave software is a systems engineering platform that connects design and test, providing common data models and open standards to accelerate product development life cycles.

PATHWAVE

To learn more, go to:
www.keysight.com/find/pathwave

Bring your design ideas to life

PathWave Design is a collection of electronic design automation software tools that connect circuit design, EM analysis, and system simulation. PathWave Design accelerates product development by reducing the time engineers spend in the design and simulation phase.

Automate, accelerate, and scale your tests

PathWave Test is a collection of test software that connects teams and test stations. Scalable from a single user to a global enterprise, PathWave Test accelerates your test workflow. It gives you the power to collaborate and manage test projects from your web browser.

Perform analytics for improved decision-making

PathWave offers powerful analytics to help you find, visualize, and understand big data to improve business knowledge. It includes visualization tools, real-time asset monitoring, and advanced algorithms that anticipate anomalies to drive process improvements and increase productivity.

YOUR PARTNER IN EDUCATION SOLUTIONS

Keysight Services

Calibration and repair services

Having the right measurement solution is only the beginning. Design engineers count on repeatable results across work groups to avoid discrepancies that can impact development cycle time, time to market, and budgets.

Manufacturing strives to meet production goals, but inaccurate measurements can affect yield and product quality. Keysight calibration and repair services keep instruments operating to warranted specifications over their lifetime, ensuring accurate, repeatable measurements across R&D and manufacturing.

Our partnership with you

Keysight offers a broad portfolio of services and support to address all your test equipment needs:

- Startup assistance and training help you quickly and effectively use your new equipment.
- Calibration and warranty assurance plans provide coverage for 5, 7, or 10 years.
- Flexible service delivery includes on-site mobile labs that reduce your calibration turnaround time from days to hours.
- Premium used equipment includes the same high performance and three-year standard warranty as new units.
- Trade-in programs (available on both Keysight and non-Keysight models) offer you significant credits to upgrade to the latest Keysight technology.

To learn more, go to:
www.keysight.com/find/services