

Keysight Technologies 5G Solutions Brochure



HARDWARE + SOFTWARE + PEOPLE = 5G INSIGHTS

5G Evolution. Revolution. Reality.

Being first and best in 5G depends on tools that let you explore new signals, scenarios and topologies. Keysight's 5G solutions are ready to enable deeper insights as you, and we, evolve with the standard.

In design and test, our solutions support innovation across new and existing technologies as you transform ideas into reality. The race is on and Keysight will help you take the lead—from evolution to revolution to reality.

Enabling Transformative Research

As the leading provider of test and measurement solutions for wideband RF, microwave and millimeter-wave technologies, we have two primary goals in 5G. One is to assist commercial researchers as they accelerate the development and verification of new-generation designs (see pages 3-4). The other is to help researchers in academia explore groundbreaking concepts with greater precision and deeper confidence (see pages 5).

We're supporting these efforts with an unmatched range of 5G solutions based on Keysight hardware and software products. All will assist engineers and scientists as they drive the evolution of existing technologies, create revolution through new innovations, and transform the vision of 5G into reality (see pages 6-13).



Helping Create the Standard and Fostering Research Partnerships

The race is on to demonstrate successful implementations of 5G. Keysight has been there from the beginning, collaborating with the earliest players in 5G and supporting advanced research and experimentation.

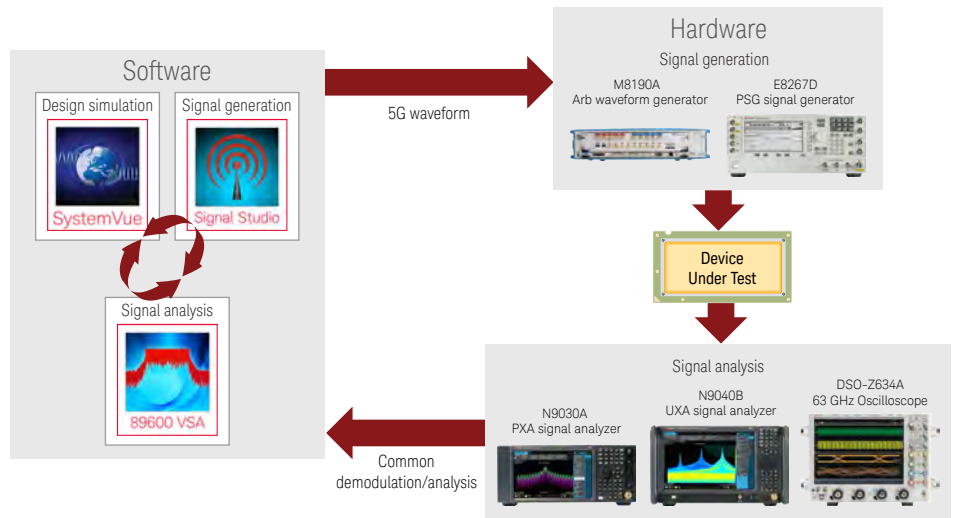
One conduit is Keysight Laboratories, which is our central resource for applied research. Laboratories staff has been, and continues to be, engaged with numerous commercial customers as well as the relevant consortia and standards bodies. Another important link is Keysight University Relations, which sponsors and mentors university research.

This level of direct involvement provides a firsthand view of the latest technological and marketplace developments. From that vantage point, we're offering measurement insight as the industry defines next-generation standards and the necessary test procedures. We're also applying that knowledge to the creation of new-generation instrumentation and software that provides headroom to meet current and evolving challenges.



Accelerate Development and Verification of New-Generation Designs for 5G

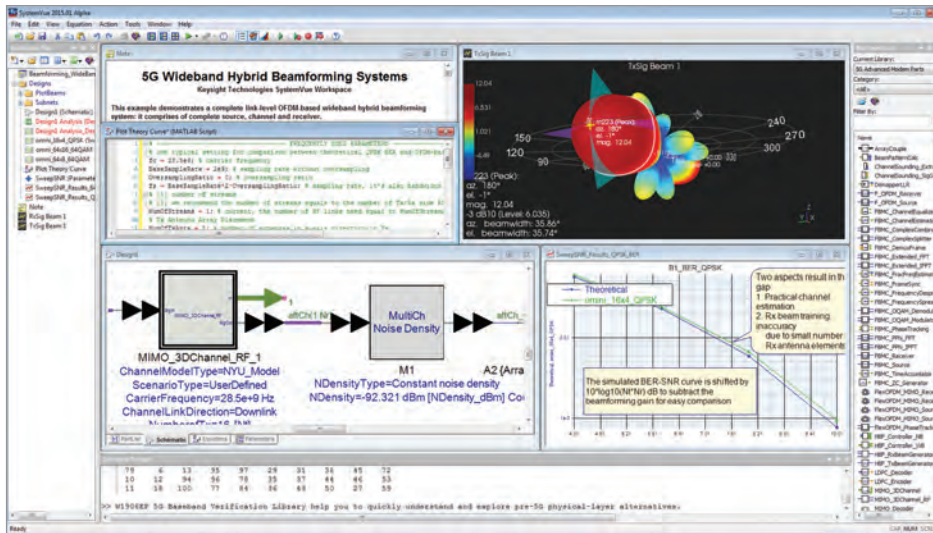
Gain the benefits of our early and ongoing collaboration with 5G research. The results are embodied in Keysight hardware and software products tuned for 5G.



Explore New Signals, Scenarios and Topologies

Our versatile bundle of SystemVue simulation reference libraries for 5G equips you to explore current challenges and continue forward as the standard takes shape. Modifiable source code allows you to quickly understand and explore pre-5G physical-layer alternatives. The ability to validate RF and baseband integration early in the development process reduces project risk.

The SystemVue environment also lets you simulate missing hardware and account for different multi-antenna architectures early in the design phase to model throughput performance. Integrated signal generators and signal analyzers simplify the validation of prototypes as the standard evolves.

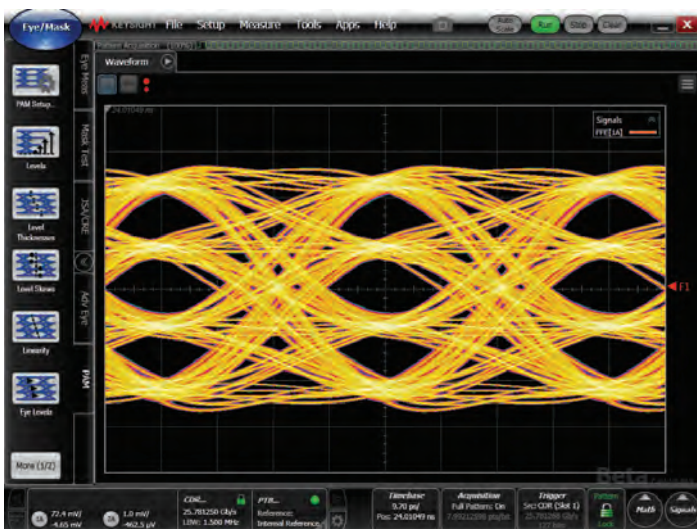
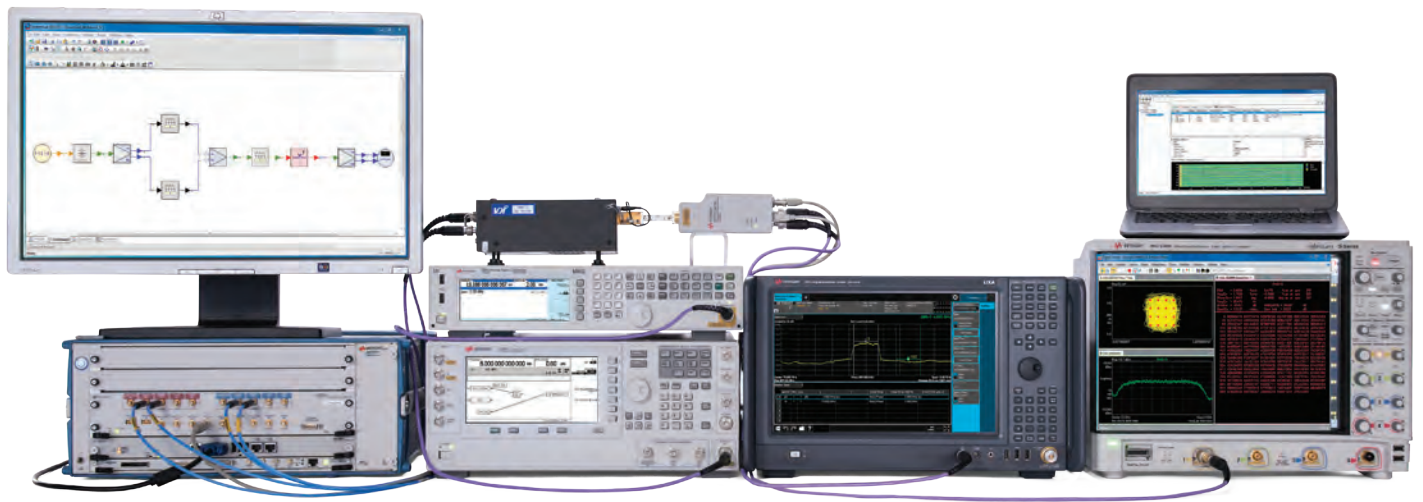


Create the Test Environment You Need—Faster—With Reference Solutions

Keysight continues to release a growing number of reference solutions that combine off-the-shelf hardware with application-specific software that encapsulates our measurement expertise. The result is a flexible foundation you can easily adapt to meet specific needs now and as 5G evolves.

Accelerate the development of new millimeter-wave (mmWave) channel models using the 5G channel sounding reference solution. It provides accurate broadband measurements that provide greater confidence as you characterize potential new 5G air interfaces.

Our testbed for 5G waveform generation and analysis solution provides the flexibility to perform broad “what if?” analyses. You can create waveforms at RF, microwave and mmWave frequencies with modulation bandwidths of up to 2 GHz. This reference solution also makes it easier to evaluate early concepts that use a variety of modulation schemes at different frequencies and bandwidths.



Push 5G I/O Performance Goals Forward

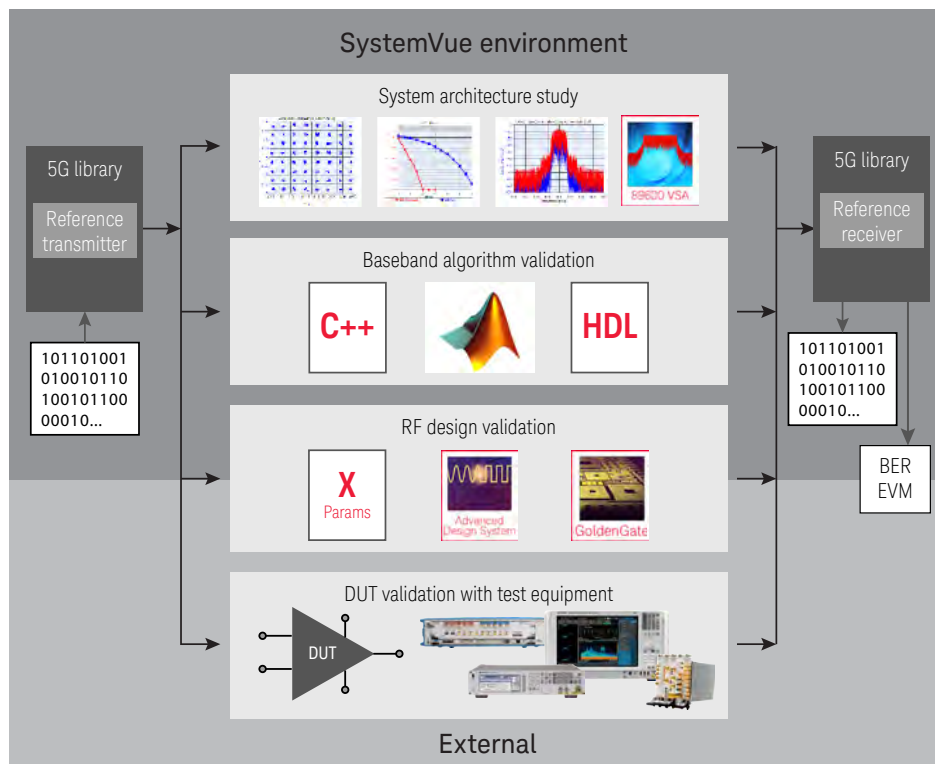
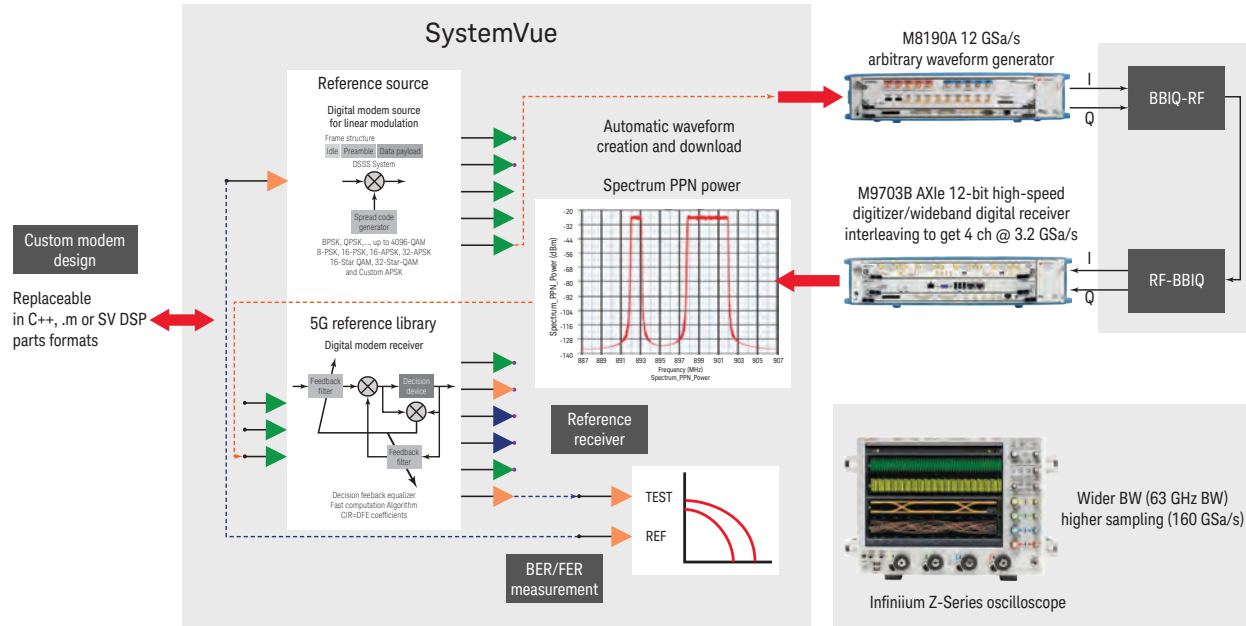
The design and test of high-speed digital systems goes faster with total solutions from Keysight. We help you handle the latest digital technology standards at all stages of design, from simulation to compliance testing. From device to data center, you can achieve faster implementation across the entire ecosystem.

Explore Groundbreaking Concepts with Greater Precision and Deeper Confidence

Whether your research horizon reaches out five years or longer, Keysight offers flexible, adaptable hardware and software designed to stay on the leading edge over the long term.

The integration of our test equipment and design software provides game-changing capability as you validate designs and simulations. For example, you can use sophisticated device and system-block models to prove out designs before investing in prototypes.

Moving from simulation to hardware in the loop



You can trust the results produced by our calibrated hardware and robust software: both represent exactly what's happening inside your devices and designs. Highly accurate measurements reveal what is and isn't working inside a system. Advanced signal-analysis software lets you see through the complexity of new signals and systems, enabling you to study new modulation techniques and fully understand how they affect system behavior.

Selecting Keysight means you're equipping your labs and research teams with the same state-of-the-art equipment and software being used in industry. This makes it easier to document and support research results with real data from industry-leading hardware and software.

Enable New Insights That Transform 5G Into Reality

The foundation is Keysight's unique mix of hardware, software and people. You can count on test equipment and design software that is built on more than 75 years of leadership in measurement science.

Equip your teams with tools that ensure optimized designs, greater productivity and, ultimately, faster time-to-market. When you choose Keysight, you also gain the peace of mind that comes with our custom assurance plans and expanded calibration services that ensure ongoing measurement accuracy.

Our instruments are also designed to be future-proof, making it easier for you to evolve with changing technologies and stay on the leading edge. You can carry your investment forward with consistent measurement science that spans research and development today and extends to manufacturing and deployment in the future.

We can also advise, assist and augment your teams: all around



the world, you can tap into the expertise of Keysight consultants and application engineers who are deeply familiar with the latest wireless technologies—RF, microwave and mmWave. They have created custom systems for 5G channel sounding and massive MIMO, and can provide test-optimization consulting that simplifies systems and streamlines processes. Our expertise is also readily available through white papers, application notes and webcasts posted on www.keysight.com/find/5G-Insight.

Innovate Across New and

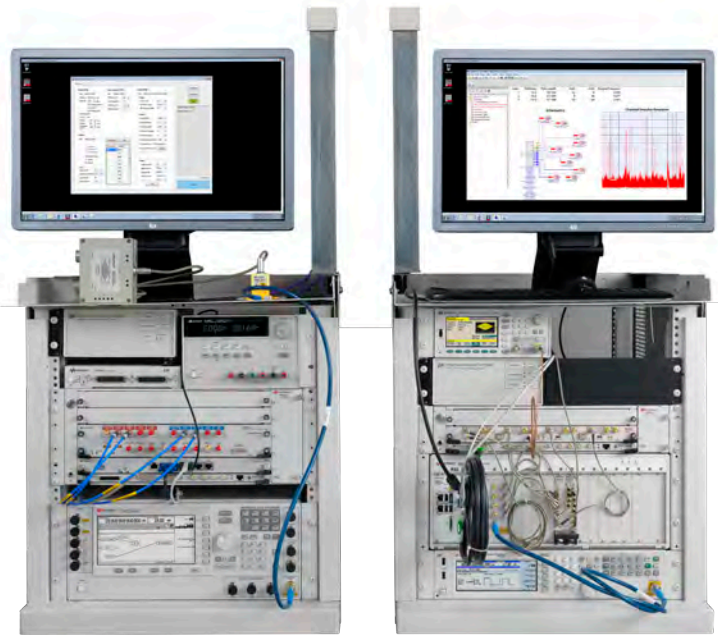
Existing Technologies with Reference Solutions

As you seek solutions to evolving test challenges, Keysight Reference Solutions provide a combination of hardware, software, measurement expertise and programming examples optimized for specific applications. Our 5G reference solutions show you how to get the most out of your test equipment and help you achieve half the time to insight.

Create the solution you need for 5G channel sounding

Accelerate development of new mmWave channel models using the 5G channel sounding reference solution. It enables you to characterize mmWave behavior at ultra-wide bandwidths in a variety of scenarios—SISO and MIMO. With fast data capture and real-time correlation and processing of MIMO channels, you can see more in less time compared to other approaches. You can also trust your measurement results: the reference solution includes system-wide calibration as well as precise timing and synchronization.

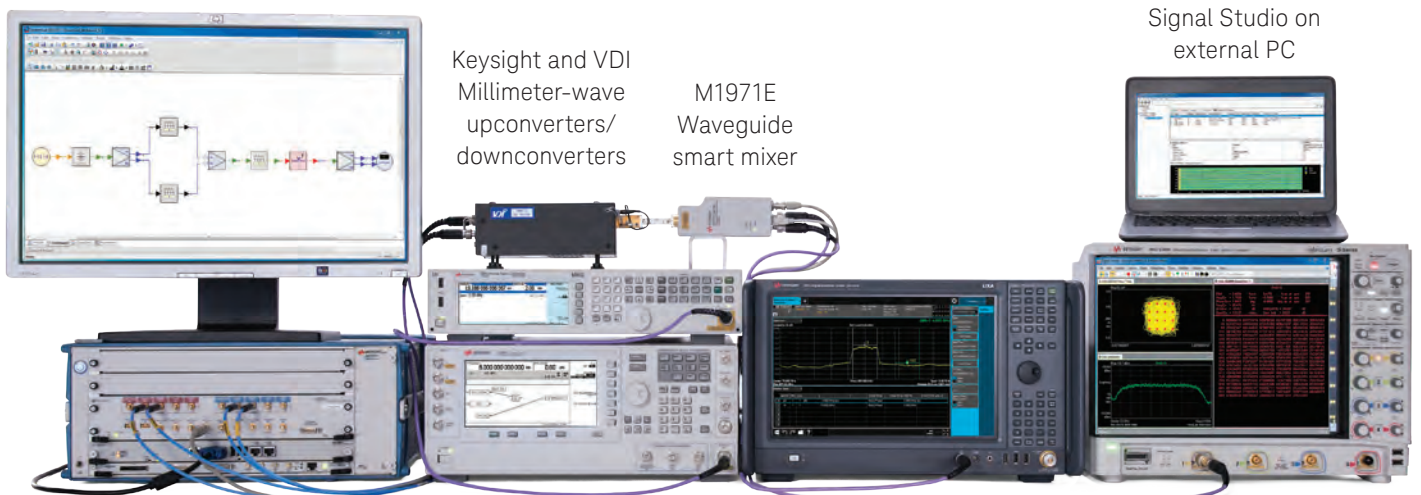
www.keysight.com/find/solution-5GSounding



Achieve greater flexibility in 5G waveform generation and analysis

Our 5G waveform generation and analysis testbed reference solution supports broad “what if?” analysis as you evaluate proposed waveforms with prototype algorithms and hardware. For example, you can easily create waveforms at RF, microwave and mmWave frequencies with modulation bandwidths of up to 2 GHz. This reference solution also lets you evaluate early concepts that use a variety of modulation schemes at different frequencies and bandwidths.

www.keysight.com/find/solution-5Gtestbed



M8190A AWG with SystemVue W1906 5G Baseband Exploration Library and N7608B Signal Studio for custom modulation software installed on embedded controller or external PC

Keysight and VDI Millimeter-wave upconverters/downconverters

M1971E Waveguide smart mixer

N5183B MXG microwave analog signal generator for upconverter LO

44 GHz E8267D PSG vector signal generator with wideband IQ inputs

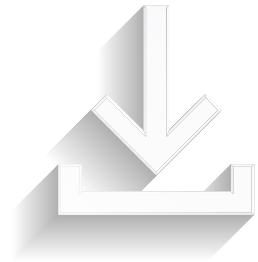
N9040B UXA signal analyzer

Signal Studio on external PC

Infiniium S-Series oscilloscope with 89600 VSA software

Download Your Next Insight with Keysight Software

Moving from a myriad of alternatives to one clear decision goes faster with fingertip access to the deepest know-how. We've captured it for you in Keysight software: it's our version of downloadable expertise. From first simulation through first customer shipment, we deliver the tools your team needs to accelerate from data to information to actionable insight.



Innovate in the physical layer with SystemVue

5th Generation Communications Systems Modeling using SystemVue

BF_Adaptive.wsv
Adaptive Receiver Beamforming for 5G Fiber Wireless Networks Proposal

Scenario:

- * CRAN (cloud radio access networks)
- * eNodeB receiver beamforming technique
- * Uplink intercell interference mitigation
- * Two interfering UEs

Cross boundaries and innovate the PHY layer with SystemVue electronic system-level (ESL) design software. Its simple and easy model-based design workflow enables you to define new architectures and algorithms for 5G. Through superior integration with Keysight test equipment, SystemVue helps you accelerate real-world maturity and streamline development.

www.keysight.com/find/SystemVue

Simplify signal creation with Signal Studio



Keysight Signal Studio software is a flexible suite of signal-creation tools that will reduce the time you spend on signal simulation. With Signal Studio for Custom Modulation

(N7608B), you can easily create various 5G candidate waveforms as well as custom OFDM and I/Q waveforms to produce highly realistic 5G signal scenarios with high resolution and wide bandwidth—simultaneously—using an M8190A arbitrary waveform generator. In addition, you can test your designs within and beyond their limits with the Keysight PSG, MXG and EXG vector signal generators.

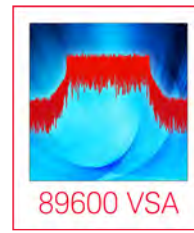
www.keysight.com/find/SignalStudio

The screenshot displays the 'F-OFDM Subband Filter Editor' window. It includes a table of subband parameters:

Subband Name	Subband Subtype	Subband Center	Subband Bandwidth	Subcarrier Spacing	FFT Size	Symbol Duration	Harmonic Spacing	Cyclic Prefix Length	Filter Length	Roll-off Factor	Filter Transition Bandwidth
Subband1	Subband1	19.700	5.760	12kHz	2048	66.66666666666667	12	100.00000000000000	1.0000000000000000	1.00	300.00000000000000
Subband2	Subband2	75.000	5.760	30kHz	1024	33.33333333333333	24	200.00000000000000	1.0000000000000000	1.00	300.00000000000000

Below the table, there is a 'Filter' section and a 'Time Frequency Plot' showing a signal spectrum with a peak at 19.700 MHz.

See through the complexity with 89600 VSA software



Explore virtually every facet of complex signals and optimize your most advanced 5G designs with the 89600 VSA software. It can be used with Keysight SystemVue

simulation software, signal analyzers, oscilloscopes, and on a standalone PC connected to more than 45 Keysight measurement platforms to demodulate and characterize the performance of potential 5G waveforms.

www.keysight.com/find/89600

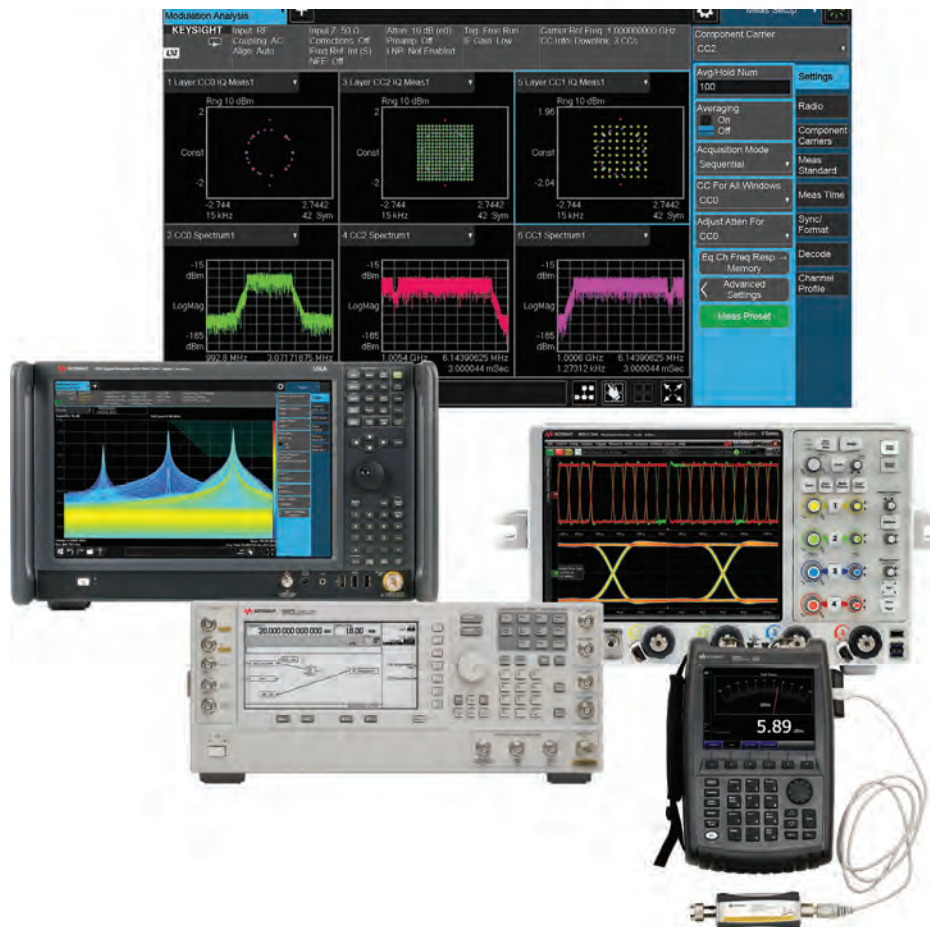
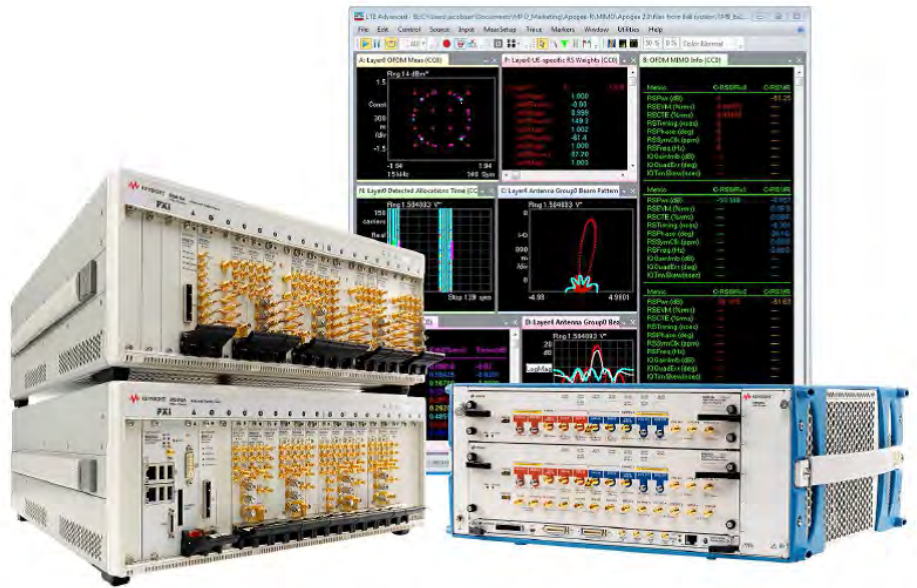
Unlock Your Next Insight with Leading-Edge Instrumentation

For more than 75 years, Keysight has been helping developers unlock measurement insights. Along the way, we've created industry-leading test equipment in the shapes and sizes you've asked for: full-size benchtop, small benchtop, handheld and modular. In every form factor, our goal is to deliver the performance your team needs to stay on the leading edge in 5G.

Achieve half the time to insight with modular solutions

Our growing range of modular products is an extension of our measurement expertise into PXIe and AXIe. Our modular platforms offer scalability for 5G applications with precise multi-channel synchronization to support more demanding 5G applications such as channel sounding and multi-antenna research such as massive MIMO and beamforming.

www.keysight.com/find/modular



Explore your designs in detail with benchtop instruments

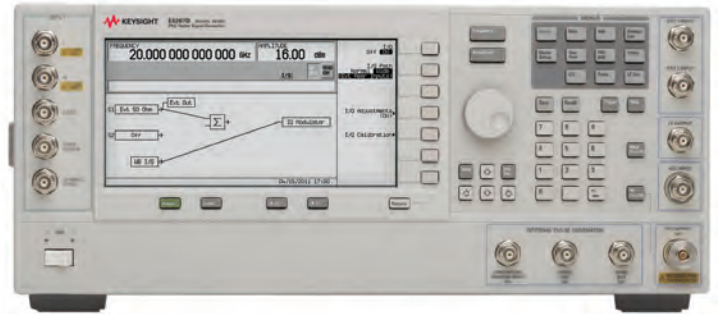
When you leverage our focus on measurements, you can address your toughest challenges with precision and confidence using our benchtop instruments that provide high performance with the convenience of a ready to use tool with a familiar front panel display. Many are the de facto standard for leading-edge capabilities in analog and vector signal generators, vector signal analyzers, vector network analyzers, and high-performance oscilloscopes. At RF, microwave and mmWave frequencies, we can help you deliver the breakthroughs that make a measurable difference.

www.keysight.com

Generate trusted performance in test signals



Keysight's modular arbitrary waveform generators (AWG) can produce the wideband waveforms needed to test 5G systems. The two-channel M8190A offers 5 GHz of analog bandwidth and up to up to 90 dBc of spurious-free-dynamic range (SFDR). The M8195A can provide 25 GHz of analog bandwidth on up to four channels—simultaneously—in a one-slot AXIe module. The AWG can be used to drive an E8267D PSG vector signal generator equipped with wideband differential external I/Q inputs to produce modulation bandwidth of up to 2 GHz at frequencies up to 44 GHz. For multi-channel applications such as massive MIMO and beamforming, M8195A AWG modules can be combined with M81097A synchronization module for up to 16 synchronous channels in a single five-slot AXIe chassis.
www.keysight.com/find/AXIe-AWG



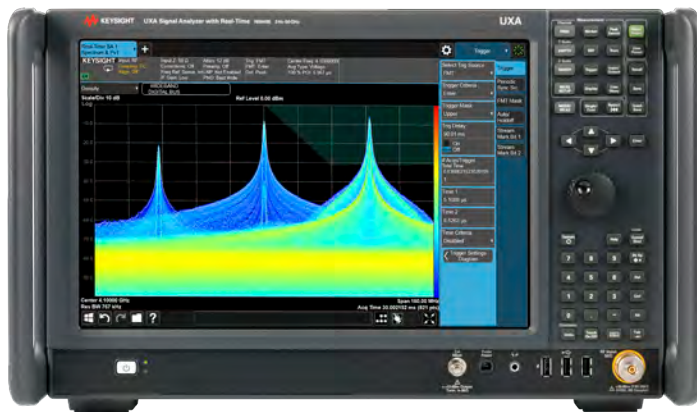
The PSG is the industry's most trusted microwave signal generator, with thousands of units deployed in hundreds of programs around the world. Its wideband I/Q inputs accept complex AWG inputs to enable generation of test signals with up to 2 GHz of modulation bandwidth at frequencies up to 44 GHz. For signal generation at millimeter-wave frequencies, an array of upconverters is available from Keysight and Virginia Diodes Inc.
www.keysight.com/find/PSG



For sub-6 GHz 5G, the MXG vector signal generator provides up to 160 MHz bandwidth at frequencies up to 6 GHz.

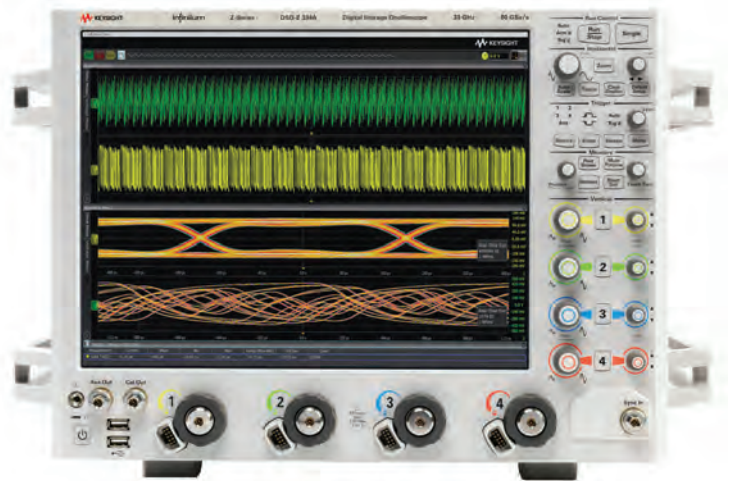
In addition, the pure and precise N5183B MXG microwave analog signal generator can be used to provide LO signals for millimeter-wave upconverters and downconverters.
www.keysight.com/find/MXG

Make inspired connections in signal analysis



X-Series signal analyzers are the benchmark for accessible performance that puts you closer to the answer by easily linking cause and effect. The UXA is our flagship, with up to 1 GHz analysis bandwidth, delivering wide-open performance and deeper views of elusive and wideband signals. It runs a wide range of X-Series applications, which are proven, ready-to-use measurements for signal analysis. To go even deeper, the 89600 VSA software is a comprehensive set of tools for demodulation and vector signal analysis that enable you to explore virtually every facet of complex signals. For higher frequencies, from 60 to 90 GHz, a waveguide wideband smart mixer can be combined with the X-Series signal analyzers.

www.keysight.com/find/X-Series



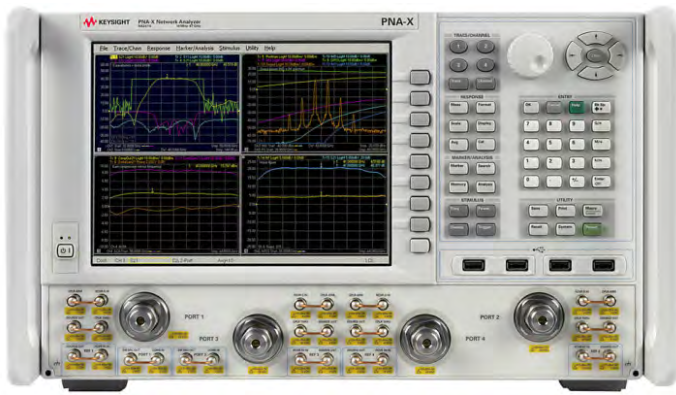
While signal analyzers are commonly used for RF testing, the need for wideband and multi-channel measurements has led RF engineers to use wide-bandwidth oscilloscopes. These enable direct measurement and analysis of wideband 5G transmitter outputs. With up to 8 GHz, 32 GHz and 63 GHz of analog bandwidth respectively, the S-Series, V-Series and Z-Series oscilloscopes deliver real-time measurement accuracy without external down-conversion hardware. These high-performance oscilloscopes can also be combined with 89600 VSA software for multi-gigahertz demodulation analysis.

www.keysight.com/find/scopes



The M9703B and M9709A are revolutionary AXIe high-speed digitizers, able to capture signals with excellent measurement accuracy. The M9703B offers eight channels up to 1.6 GSa/s or 4 channels up to 3.2 GSa/s, and the M9709A offers 32 channels up to 1 GSa/s. The M9703B offers an optional real-time digital downconverter (DDC) that enables tuning and zooming on signals of interest, improving dynamic range, extending capture time, and accelerating measurement speed. When combined with microwave and mmWave downconverters and 89600 VSA software, the M9703B is ideal for broadband, 5G, vector signal analysis measurements. It also offers multi-module processing synchronization, supporting phase-coherent solutions scalable from 8 to 104 channels, which is ideal for massive MIMO and beamforming applications.

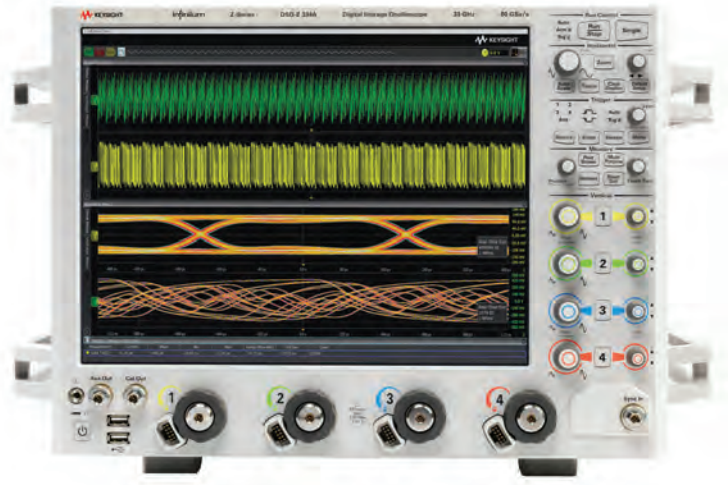
www.keysight.com/find/AXIe-digitizers



Reach for unrivaled excellence in network analysis

Every Keysight network analyzer is the ultimate expression of our expertise in linear and nonlinear device characterization. In research and development, the PNA family provides a level of measurement integrity that lets you transform deeper understanding into better designs. In 5G, you can drive antenna designs forward with exceptional measurements and precise models using the PNA-X measurement receiver.

www.keysight.com/find/PNA



Pinpoint, optimize and deliver in the digital domain

When digital signals reach gigabit speeds, the unpredictable becomes the norm. The process of getting your project back on track starts with the best tools for the job. Keysight's high-speed digital solution set is a range of essential tools—measurement and simulation—that support the latest digital standards. These tools provide views into the time and frequency domains, revealing the underlying problems and ensuring compliant designs.

www.keysight.com/find/HSD



N9029AV12-UDC Millimeter-wave upconverter/downconverter*

The N9029AV12 millimeter-wave signal analyzer frequency extension module is one of the mixer/amplifier/multiplier chain series (WRxx SAX series) from VDI Inc. Option UDC enables it to be used as a millimeter-wave upconverter to upconvert the E8267D PSG vector signal generator output up to 60 to 90 GHz. It can also be re-configured as a downconverter, designed to work directly with the X-Series signal analyzers.

www.keysight.com/find/SA_mmwave



M1971E Waveguide harmonic smart mixer

The M1971E wideband smart mixer is combined with an X-Series signal analyzer, such as an N9030A PXA signal analyzer, and DSOS804A S-series oscilloscope for wideband signal analysis from 60 to 90 GHz. The M1971E 55, 60 to 90 GHz waveguide harmonic mixer is an un-preselected mixer for wideband millimeter-wave signal analysis of more than 2 GHz with X-Series signal analyzers.

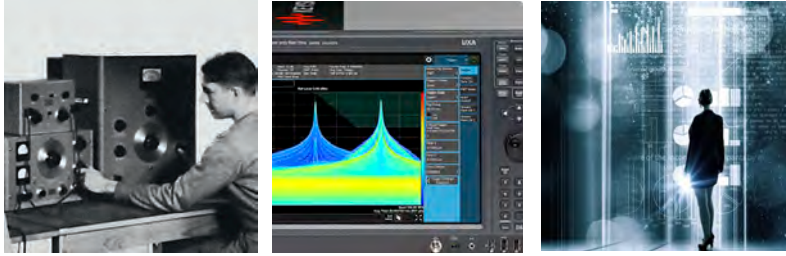
www.keysight.com/find/smartmixer

*Note: Other frequency bands may be available, depending on the application. VDI VDI12.0AMP amplifier and WR12BPF71-76 filter are not shown. Please contact Keysight for further information.

Evolving Since 1939

Our unique combination of hardware, software, services, and people can help you reach your next breakthrough. We are unlocking the future of technology.

From Hewlett-Packard to Agilent to Keysight.



For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at:

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Register your products to get up-to-date product information and find warranty information.

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Accelerate Technology Adoption.
Lower costs.

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Keysight Services can help from acquisition to renewal across your instrument's lifecycle. Our comprehensive service offerings—one-stop calibration, repair, asset management, technology refresh, consulting, training and more—helps you improve product quality and lower costs.



Keysight Assurance Plans

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Up to ten years of protection and no budgetary surprises to ensure your instruments are operating to specification, so you can rely on accurate measurements.

Keysight Channel Partners

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