



Design and Test Solutions for Medical Applications

Optimize safety, efficacy, and time to market with
your healthcare innovations

 KEYSIGHT

dataTec

Mess- und Prüftechnik. Die Experten.

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Precision in Design, Confidence in Testing

Patients and medical staff worldwide benefit from your life-changing and life-saving medical devices. Yet these devices are more complex than ever, as is their path to market. Rethink your workflows to confront these issues and ensure the safety and efficacy of your devices while avoiding costly rework and delays.

Keysight can help you every step of the way to deliver safe, compliant, high-quality medical devices on schedule. Start here to gain accurate insights and achieve precise measurements.

Hardware Circuit Design and Test Solutions

The development of cutting-edge medical devices relies heavily on the seamless integration of advanced electronics and hardware components. Keysight helps accelerate your design and test with our solutions for power consumption and battery life tests, signal and power integrity, and sensor measurements.

Improving safety, efficacy, and time to market

The performance degradation or failure of a medical device can devastate patients and your business. You need solutions that minimize risk to ensure efficacy and patient safety. Keysight solutions help you minimize risk to patients and medical professionals by ensuring that devices comply with regulations, have long battery life, run with high signal and power integrity, and perform reliably in the real world.

Create a design simulation

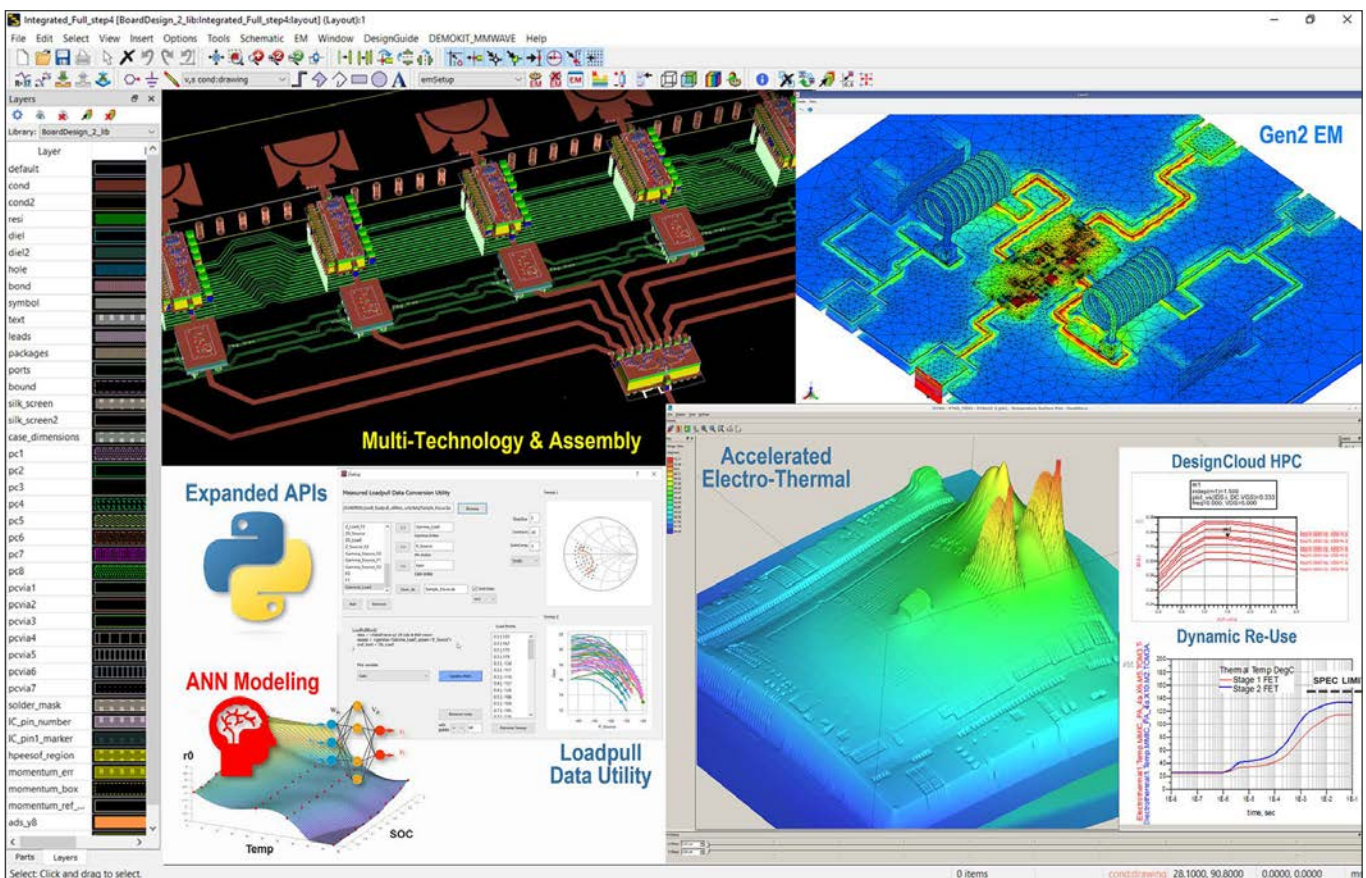
Actively mitigate risk in your medical system by simulating board operation before sending the design for fabrication. While simulations may not uncover every issue, identifying as many as possible enhances your board's performance and minimizes the need for hardware prototypes. Simulation saves valuable time and resources, ensuring a more efficient and cost-effective development process.

Optimize designs with certainty

The ability to rapidly prototype and simulate various design scenarios enables you to optimize the device's functionality, performance, and user experience.

Develop better designs faster and gain confidence in first-pass design success with **PathWave Advanced Design System (ADS)**.

Quickly accelerate your design with wizards, design guides, and templates. Automatic sync with layout enables you to visualize the physical layout while making schematic designs. The complete design flow includes schematic and layout tools, with circuit, electrothermal, and electromagnetic (EM) simulations.

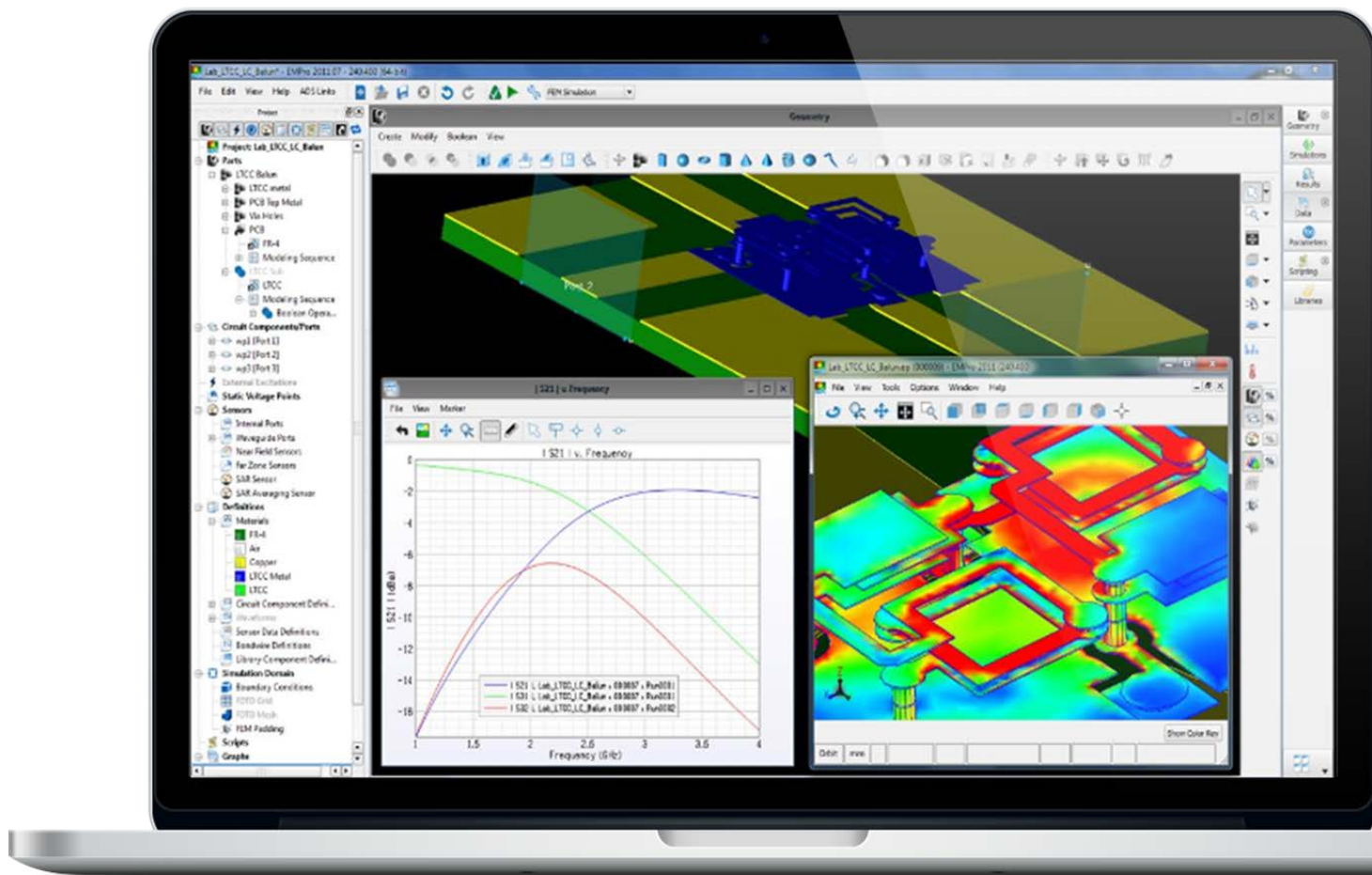


Gain insight before you prototype

EM simulation brings you insight before physical prototyping. You can analyze critical aspects like signal integrity, power management, and electromagnetic compatibility, ensuring the design aligns with regulatory standards and medical device requirements.

PathWave EM Design (EMPro) delivers EM simulation software for analyzing the 3D effects of components.

Customize EM simulations for speed and accuracy. Integrate EM analysis with your circuit simulations, increase your confidence with trusted algorithms, and gain insight into issues faster than with physical prototypes.



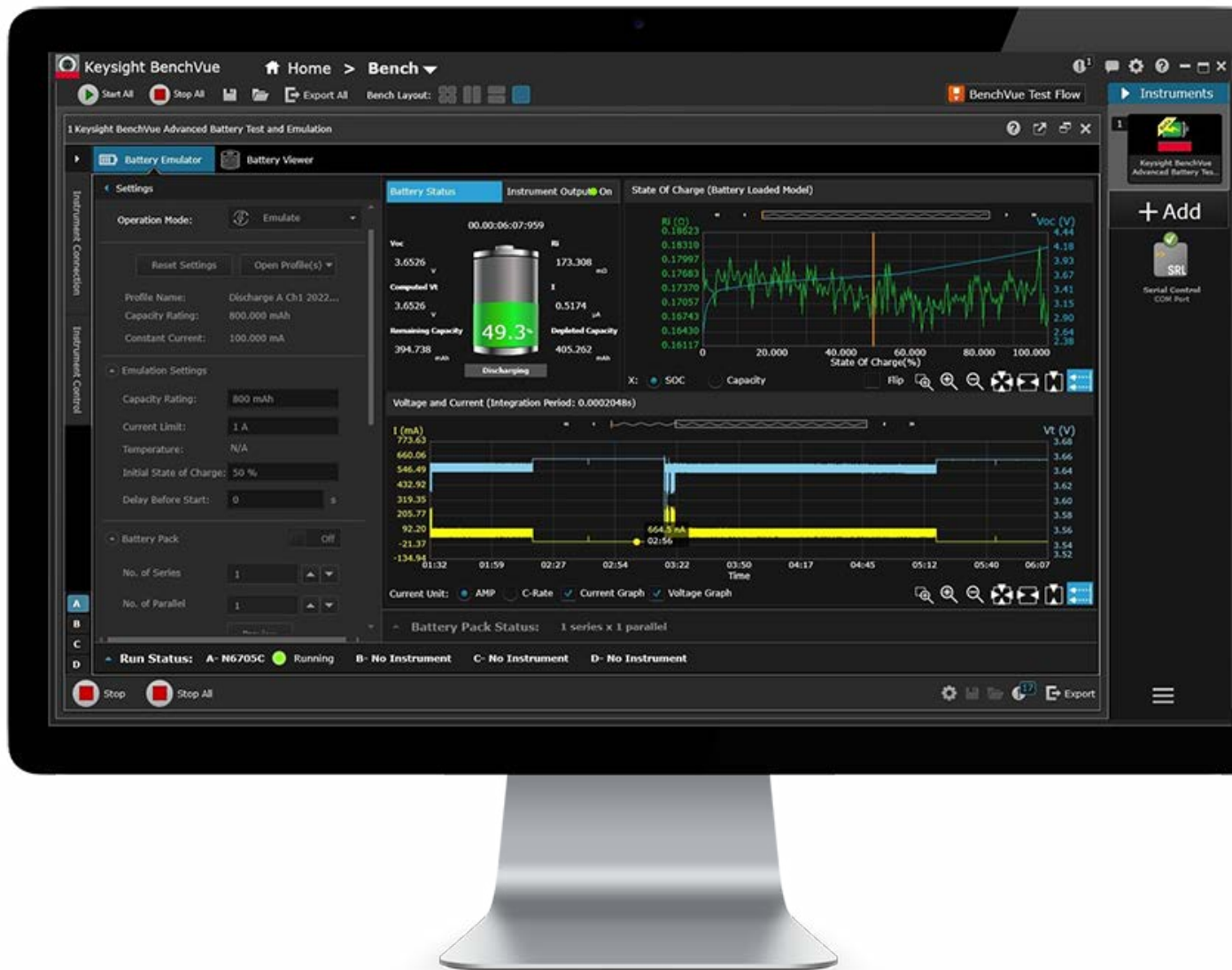
Delivering precise power to your device under test

Before you start testing, you must consider the power management of your connected medical device. From evaluating leakage currents during standby mode to measuring power consumption in various real-world scenarios, meticulous assessment enables you to tailor your device's power profile for efficiency and reliability. This process ensures that your device remains operational when it matters most.

Emulate real-world scenarios

The numerous functions in connected medical devices use multiple voltage and current levels. How do you optimize battery performance for your device under test (DUT) before you have the battery?

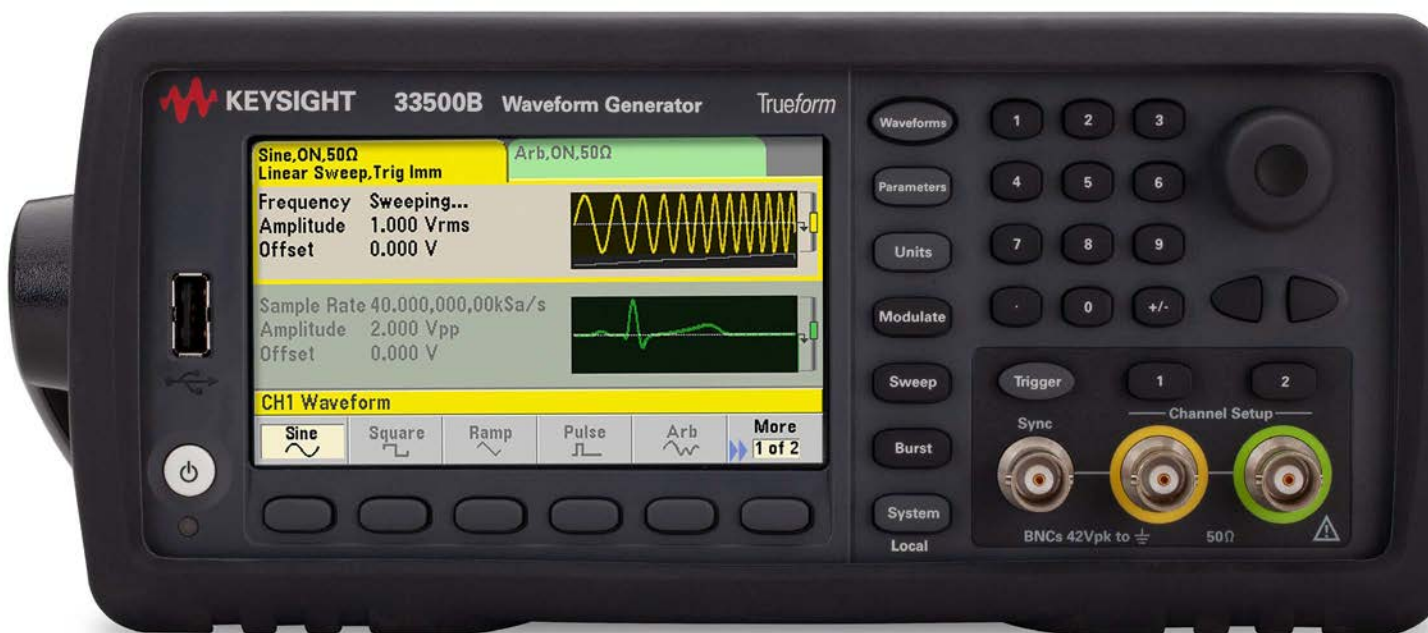
Advanced battery test and emulation software simulates the behavior of the battery that powers the medical device based on your battery model. Emulation lets you evaluate how your device consumes power and determine its runtime capacity without physical batteries.



Provide your DUT with an accurate, repeatable signal

When testing a device, you need a source that produces a clean, low-distortion, stable, and reliable signal. The exclusive Trueform technology from Keysight gives you the confidence to produce the exact waveforms you need with superior signal fidelity.

With **Trueform Series waveform and function generators**, you can define any waveform shape and length using point-by-point arbitrary waveform capability. Anti-aliasing technology ensures that your waveforms are exceptionally accurate. In addition, you can play signals as defined, at the exact sample rate, without missing fast transients critical for testing device reliability.



Testing power consumption and battery life

Battery life is of utmost importance in connected medical devices. Premature failure can have severe consequences, including financial losses, injuries, and fatalities. Powering lengthy modes of activity and RF bursts poses significant challenges for batteries.

Making accurate current measurements during critical RF events and identifying power-hungry components helps optimize the design of battery-operated medical devices for performance and safety. With more accurate data regarding the charge consumption of various functions, you can make informed decisions on software and hardware changes to improve efficacy.

Accurately measure load current

Compact form factors, complex circuitry, and multiple modes consuming different levels of power make obtaining accurate load current measurements a true challenge. The Keysight N6705C DC power analyzer enables precise measurement of load currents, especially in low-power modes like sleep or standby. It provides comprehensive measurements of voltage, current, and power consumption, helping clarify the DUT's energy characteristics across various modes and scenarios.

This capability expedites the development cycle, enabling you to optimize the design for energy efficiency and extended battery life.



Design for better battery life

Analyzing the current drain and conducting run-down battery tests of your designs pose several difficulties. The manual process of charging and discharging a battery is time-consuming. Testing the battery at different charge levels is crucial as characteristics vary. Furthermore, battery parameters and charge levels must be identical when comparing test results. Achieving this is challenging with physical batteries. Additionally, it is difficult to determine how long a device will last on a single charge, and battery life claims often do not match reality.

Keysight designed the [E36731A battery emulator and profiler](#) and [BV9211B PathWave BenchVue advanced battery test and emulation software](#) to solve these challenges.



Harness your power's potential

Access and accurately analyze complex power data faster than ever before with **PathWave BenchVue advanced power control and analysis software**. The software provides real-time graphical representation and analysis of power measurements, enabling you to quickly identify power consumption patterns, peaks, and fluctuations.

Create complex waveforms to stimulate or load down a DUT and set up automated test sequences to streamline the testing process, reduce human errors, and improve test repeatability.



Optimize battery life

To get the most out of your device's battery, you need to understand what events consume the most battery charge. This information enables you to make the hardware configuration and firmware programming decisions to optimize your battery's runtime.

The Keysight **X8712A IoT battery life optimization solution** correlates battery consumption to RF and DC events to identify which events or subsystems consume the most current.

With its wide dynamic range current measurement from nA to A and fast 20 μ s sampling rate, the X8712A accurately captures the dynamic current consumption of your device as it transitions between low-current sleep / idle modes and high-current RF transmissions.



Measure dynamic current and voltage with confidence

Because many medical devices have several power rails, characterizing current and voltage is critical to revealing how the device operates to improve the performance and optimize the circuit. The Keysight CX3300 Series device current waveform analyzer is an all-in-one measurement and analysis solution to solve your power rail, power delivery network, and power integrity challenges while measuring electrical waveforms with high precision and accuracy. The CX3300 Series integrates an oscilloscope's bandwidth and sampling rate, a digital multimeter's sensitivity, and a data logger's extended measurement recording to reveal accurate current and voltage waveforms that enable you to optimize your device.



Maintaining signal and power integrity

The surging demand for advanced features in compact medical devices fuels the need for higher density, higher speeds, greater power efficiency, and smaller circuit designs. This trend brings about new challenges related to signal and power integrity. With traces positioned closer and supply voltage reduced, ensuring flawless signal transmission and efficient power delivery becomes increasingly crucial.

Ensuring signal and power integrity through rigorous testing is essential for a successful and dependable device. Characterizing and troubleshooting these issues early in the design cycle is vital to prevent performance degradation, avoid delays, and limit costly failures in later stages of development.

Balance reliability and speed

With the increasing complexity of medical devices comes the need for a comprehensive RF and microwave measurement solution to fully characterize them.

The Keysight **E5080B ENA vector network analyzer** enables complete device characterization for RF coil, passive components, amplifiers, mixers, and frequency converters. A flexible and integrated ENA vector network analyzer, it provides research and development performance up to 53 GHz and advanced test flexibility.

The E5080B fully captures device performance with a wide dynamic range of 140 dB and trace noise and temperature stability to ensure product efficacy. Additionally, as a single-box tester, it performs multiple accurate measurements on a single connection to save time and simplify processes, accelerating time to market.



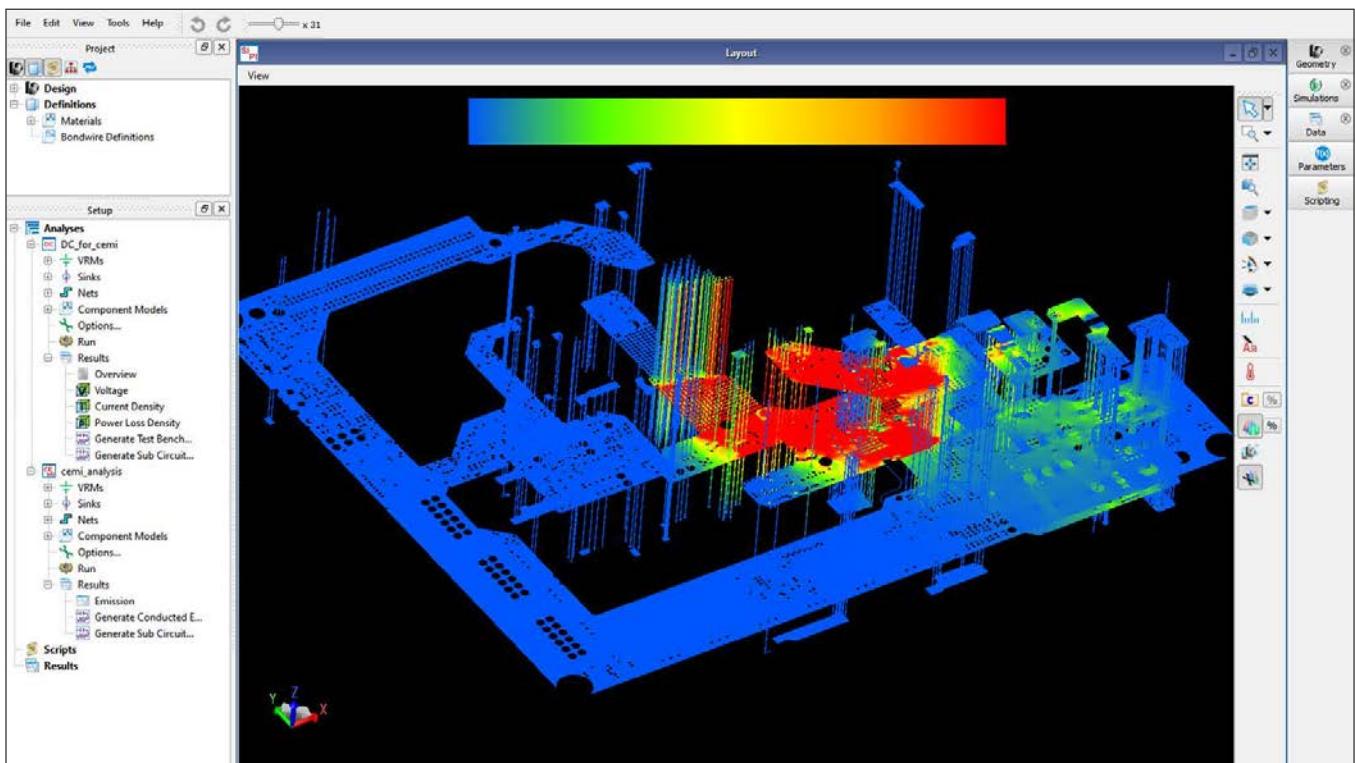
Overcome high-speed digital design challenges

Increasing signal frequencies and data rates in printed circuit boards (PCBs) makes signal and power integrity imperative. Losses associated with transmission-line effects can cause failures in electronic devices.

Modeling traces, vias, and interconnects is necessary to simulate the board accurately and make decisions that mitigate risk.

Keysight **PathWave Advanced Design System (ADS)** for signal integrity and power integrity can handle the challenges of today's high-data-rate, densely routed, complex PCB designs.

Advanced channel simulation enables you to replicate pulsed amplitude modulation signaling schemes. Complemented by fast and accurate signal integrity EM analysis, the software enables you to catch critical errors before releasing your board to fabrication.



Preserve complex signal integrity, simply

Medical imaging systems provide extraordinary value in helping doctors diagnose and treat patients. CT and MRI systems include increasing amounts of software to filter, de-noise, enhance, and segment images of greater grayscale or color depth and resolution.

To support these advanced features, the PCB assemblies must run with high signal integrity and minimal impedance mismatches, jitter, and voltage-level variability. Furthermore, this high signal integrity must run on a board with many layers, vias, fine pitch traces, and power rails at various voltages.

To make the measurements described above, you need an accurate and precise instrument with the necessary measurement bandwidth for your board. Achieve design insights you never thought possible with the Keysight **Infiniium UXR-Series oscilloscopes**. With the highest bandwidth, highest ENOB, and lowest noise floor, Keysight's breakthrough technology enables you to conquer even the most difficult measurement and design challenges.

You can get to market faster by addressing signal integrity issues during the design stage. The Keysight **D9120ASIA advanced signal integrity software** (crosstalk), for use with Infiniium UXR-, V-, Z-, and 90000-Series oscilloscopes, provides fast, accurate equalization with quick update rates and rapid analysis of real-time eye diagrams that are partially or fully closed.



Measure power parameters with ease

Keysight InfiniiVision 3000G X-Series oscilloscopes bring high-end technology to an entry-level scope. An intuitive touch-screen user interface, industry-leading waveform update rate, zone trigger, and eight new standard features enable you to capture and isolate elusive glitches and anomalies not possible on other oscilloscopes.

A waveform update rate of 1 million waveforms per second and 20 bandwidth models ranging from 100 MHz to 1 GHz enable you to analyze faster and make reliable measurements quickly to accelerate your time to market.



Perform measurements that require extra sensitivity

Advancements in medical devices have led to requirements for tighter tolerances on DC power rails compared to previous generations of products.

The Keysight **N7020A power rail probe** helps ensure that today's products meet these tighter tolerances. It measures periodic and random disturbances, static and dynamic load response, programmable power rail response, and similar power integrity measurements. Use the N7020A for power integrity measurements needing millivolt sensitivity, capturing noise, ripple, and transients on DC power rails. Given the complexity of today's circuit boards, it is essential to have clean power rails, especially when using multiple voltage rails and sub-1 V components.



Measuring small sensor signals

Medical devices often rely on the smallest sensor signals to provide precise measurements and diagnostic data. Accurate signal measurements are essential to ensure the reliability and effectiveness of the device.

Prioritizing the measurement of small sensor signals during product design, development, and testing enables you to create innovative medical solutions that offer unparalleled precision, sensitivity, and reliability. This approach benefits patients and healthcare providers alike.

Make trusted measurements, from basic debugging to deep analysis

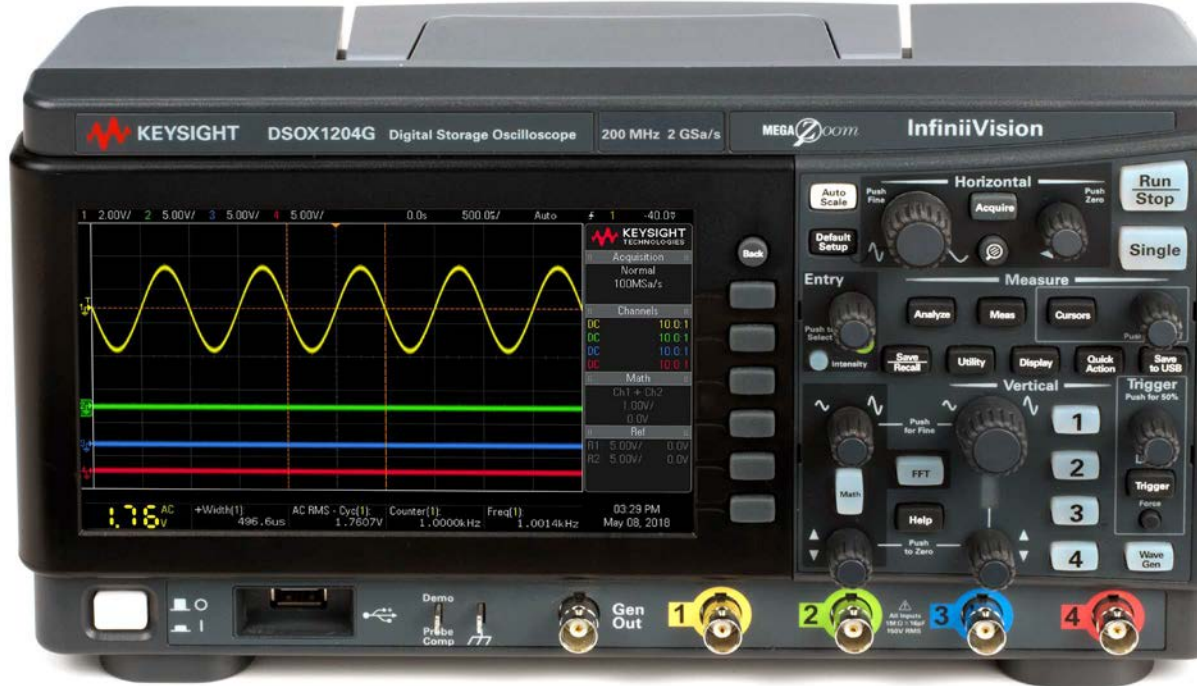
Some medical applications demand the detection of extremely weak signals, such as in early disease diagnosis or monitoring vital signs. By measuring small sensor signals with high sensitivity, we can detect subtle changes and respond promptly to critical patient conditions.

InfiniiVision digital oscilloscopes capture more, quicker, with fast waveform update rates, automated measurements, and up to seven-in-one instrument integration.

An intuitive user interface and high-end software applications place automated measurements and accessible expertise at your fingertips. See why others trust InfiniiVision and learn how you can measure with confidence.

InfiniiVision 1000 X-Series

Get quick insights and measure low-power devices. The 1000 X-Series features six-in-one instrument integration and maintains calibrated measurements with high levels of connected software for remote control and data logging.



Truevolt Series 6½- and 7½-digit multimeters

Get quick insights, measure low-power devices, and maintain calibrated measurements with high levels of accuracy, linearity, speed, and resolution.



Software Test Automation Solution

Software design and test automation are critical in the development of complex medical devices and systems to ensure safety, efficacy, quality and compliance. These tools and processes help detect issues early in the development cycle and accelerate time-to-market cycle.

Assess efficacy and streamline testing

Software-based prototyping and testing can expedite the feedback loop between engineering teams and stakeholders, fostering collaboration and facilitating informed decision-making. This accelerated development process shortens the time to market for medical devices, ensuring timely delivery of innovative and reliable solutions to benefit patients and healthcare providers alike.

Leverage test automation

Software testing that uses artificial intelligence (AI)-powered automation can help speed up releases, improve software quality, and optimize the digital experiences for electronic medical records, medical devices, and imaging systems.

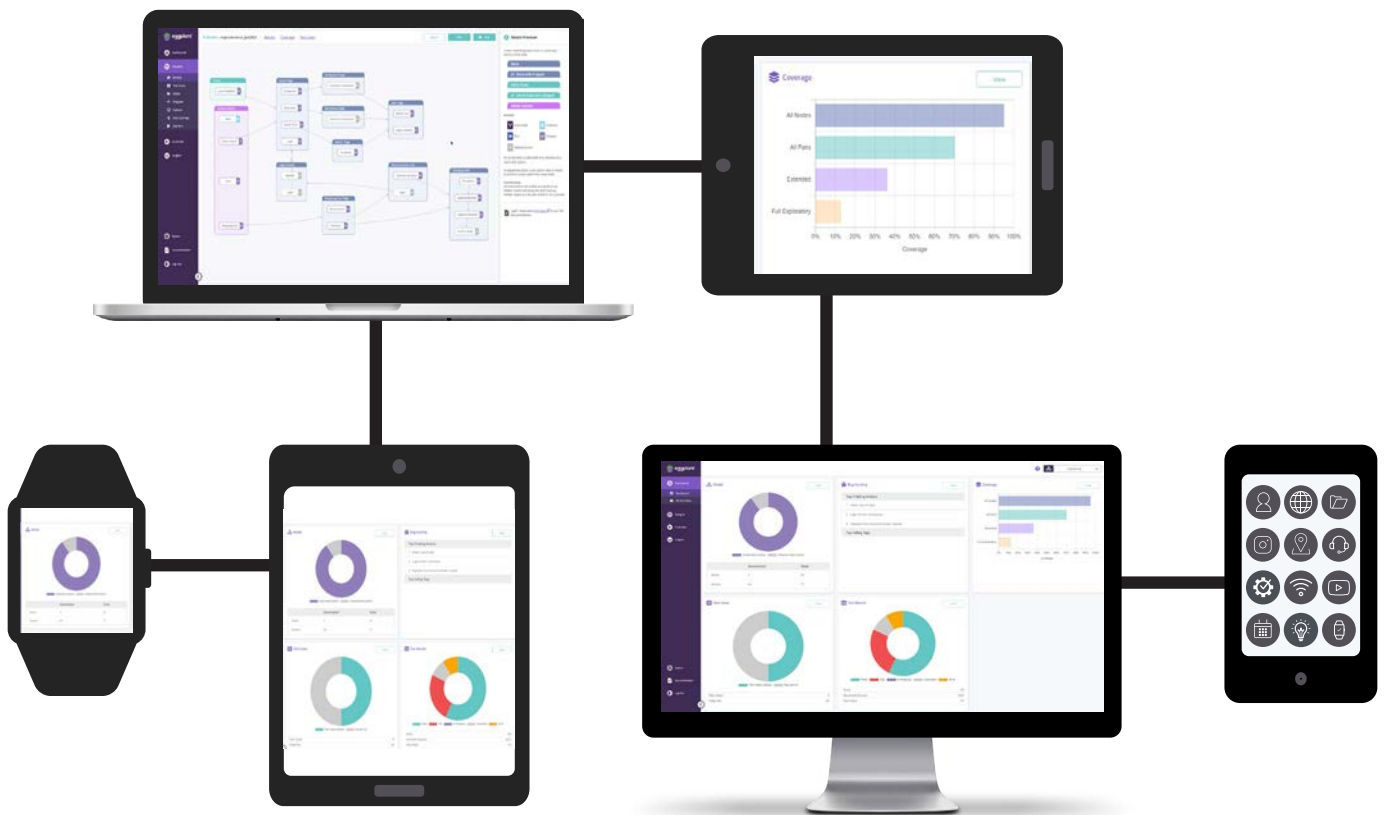


Reduce testing time with automation intelligence

In healthcare, digital transformation is top of mind. As software complexity increases, healthcare software testing teams face mounting challenges.

Balancing the need for faster releases with uncompromising quality is becoming increasingly complex using traditional manual approaches. A recent study by Keysight, in collaboration with HIMSS, reveals that 94% of software testing leaders report insufficient test coverage which increases risks to patients.

Keysight **Eggplant Test** can help. Using an AI-driven, model-based testing approach, Eggplant Test significantly increases test coverage, tests the system from the end user's perspective, and enables subject-matter experts such as clinicians and nurses to get more involved in testing. Discover a fast, noninvasive, and easy-to-use solution that tests any type of software on any platform or device.



Test load and performance from the user's point of view

When it comes to electronic health records, achieving user-centric performance at scale is essential. However, complex enterprise integrations and third-party services can make this task challenging. Additionally, the continuous evolution of endpoints and touchpoints, coupled with unpredictable spikes in demand, adds to the complexity.

That is where Keysight Eggplant Performance comes in. With this software, you can deliver fast and responsive user experiences as your health system grows and encounters increased demand.

Wireless Communication Design and Test Solutions

Medical device design engineers face an increasing challenge of ensuring that their devices communicate securely and effectively in hospitals and clinics. Meeting safety goals, efficacy, and time to market demands more than point solutions.

The comprehensive Keysight test and measurement portfolio offers end-to-end solutions to keep you on schedule with enhanced designs, faster prototyping, validation and manufacturing output, meeting time, volume, and quality targets.

Test coexistence and interference

Mission-critical medical devices connect through diverse wireless technologies, leading to rising and significant interference challenges in densely packed hospital settings. Robust coexistence testing minimizes risk and accelerates time to market. Ensure your medical Internet of Things (IoT) designs pass final compliance testing flawlessly, eliminating costly redesigns and retests at accredited facilities.



Produce the signals you need

Ensuring seamless communication and reliable operation in densely packed hospital settings with multiple wireless devices is daunting.

The Keysight **N5172B EXG X-Series RF vector signal generator** provides the signals you will need for basic parametric testing of components and functional verification of receivers, while the four-channel **N5186A MXG Vector Signal Generator** provides signal generation of up to 8.5 GHz with 960 MHz of modulation bandwidth per channel for testing with multiple interferers at one time.



Or take your designs to their limit with the Keysight **N5182B MXG X-Series RF vector signal generator**. MXG delivers high performance in five key categories: phase noise and spectral purity, bandwidth, error vector magnitude (EVM), adjacent power channel ratio, and output power.



Perform advanced receiver testing compatible with the latest standards using the MXG or EXG and Signal Studio software. Define signal parameters, transfer them to the instrument, and use closed-loop or interactive control during signal generation.

Analyze signals to address issues and speed time to market

Built for wireless device testing, the Keysight **N9020B MXA signal analyzer** helps you characterize signals from wireless devices quickly and confidently with up-to-date parametric or RF functional tests.

The intuitive multi-touch interface minimizes measurement complexity, even with innovative devices.

Shorten test times with hardware-accelerated power measurements, rapid display updates, rapid marker peak searches, and fast sweeps. Accurately analyze complex signals with EVM as low as 0.3% (-50 dB), and capture elusive or transient signals with full-band real-time spectrum analysis.

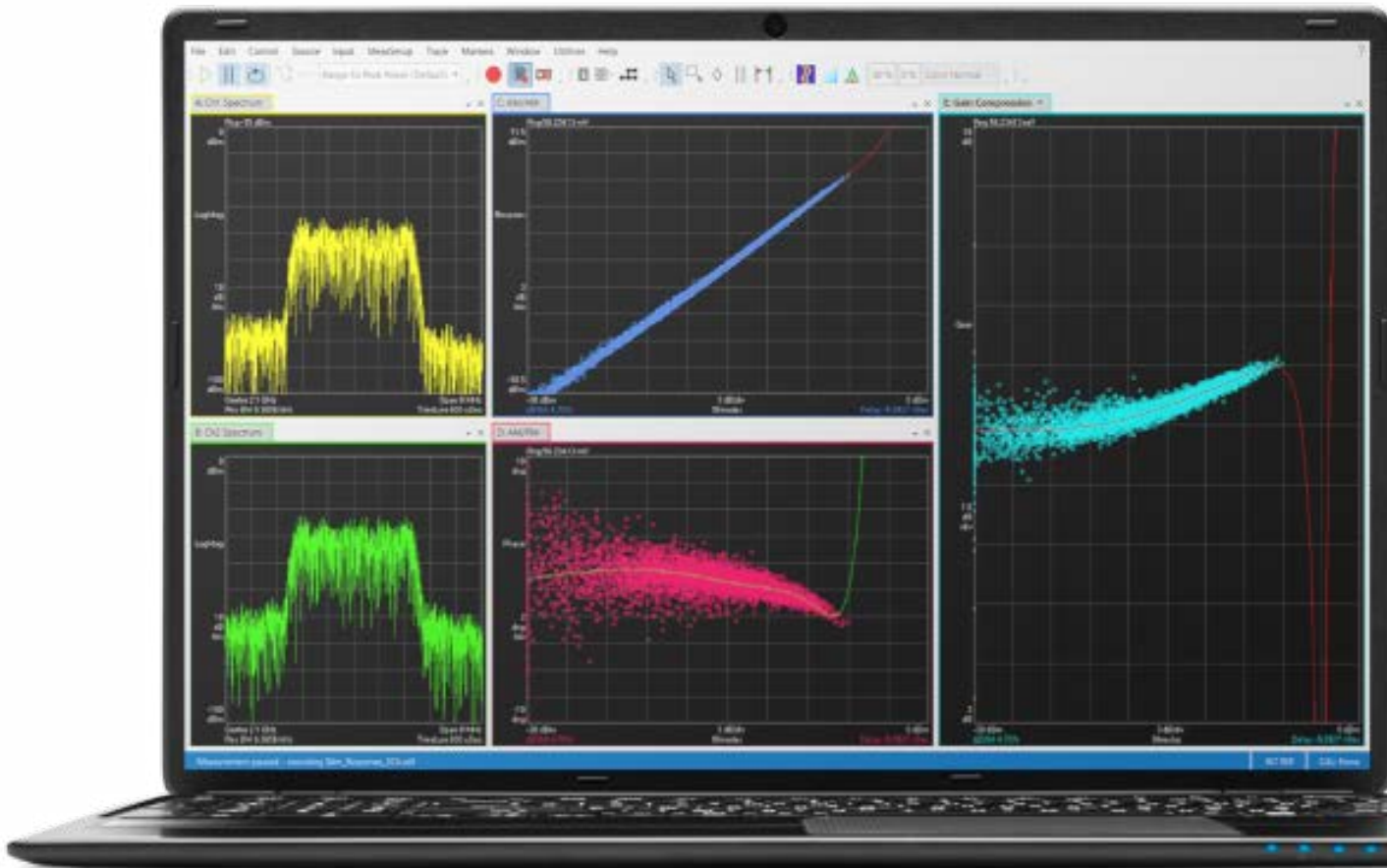


Optimize wireless performance

Vector signal analysis is crucial in medical device design. It enables engineers to comprehensively analyze and optimize the performance of complex wireless communication protocols, ensuring seamless connectivity and reliable data transmission in healthcare applications.

Perform basic or complex signal analysis with hardware connectivity using the [PathWave Vector Signal Analysis Base Platform](#).

PathWave VSA provides various demodulation and signal analysis configurations to better evaluate signal errors. It decodes the SIG field and preamble and automatically demodulates the signal from the source. It also provides error vector spectrum and time to help troubleshoot any problems in the transmitted signal.



Keep interference detection in the palm of your hand

EM and RF interference detection ensures a medical device's immunity to external EM disturbances, preventing potential malfunctions or inaccuracies in critical medical measurements and operations. Field testing communications networks puts new demands on your equipment and requires trade-offs between capabilities and portability.

With over 25 software-enabled measurement capabilities in one portable, battery-powered unit, Keysight **FieldFox** is a highly capable handheld analyzer.

FieldFox portable analyzers can handle your toughest working environments by performing site surveys to assess the types of signals your medical device may encounter in different areas of operation. By identifying and mitigating interference sources early in the design process, you can enhance the reliability and safety of medical devices, safeguarding patient well-being and optimizing healthcare outcomes.



Testing EMI / EMC

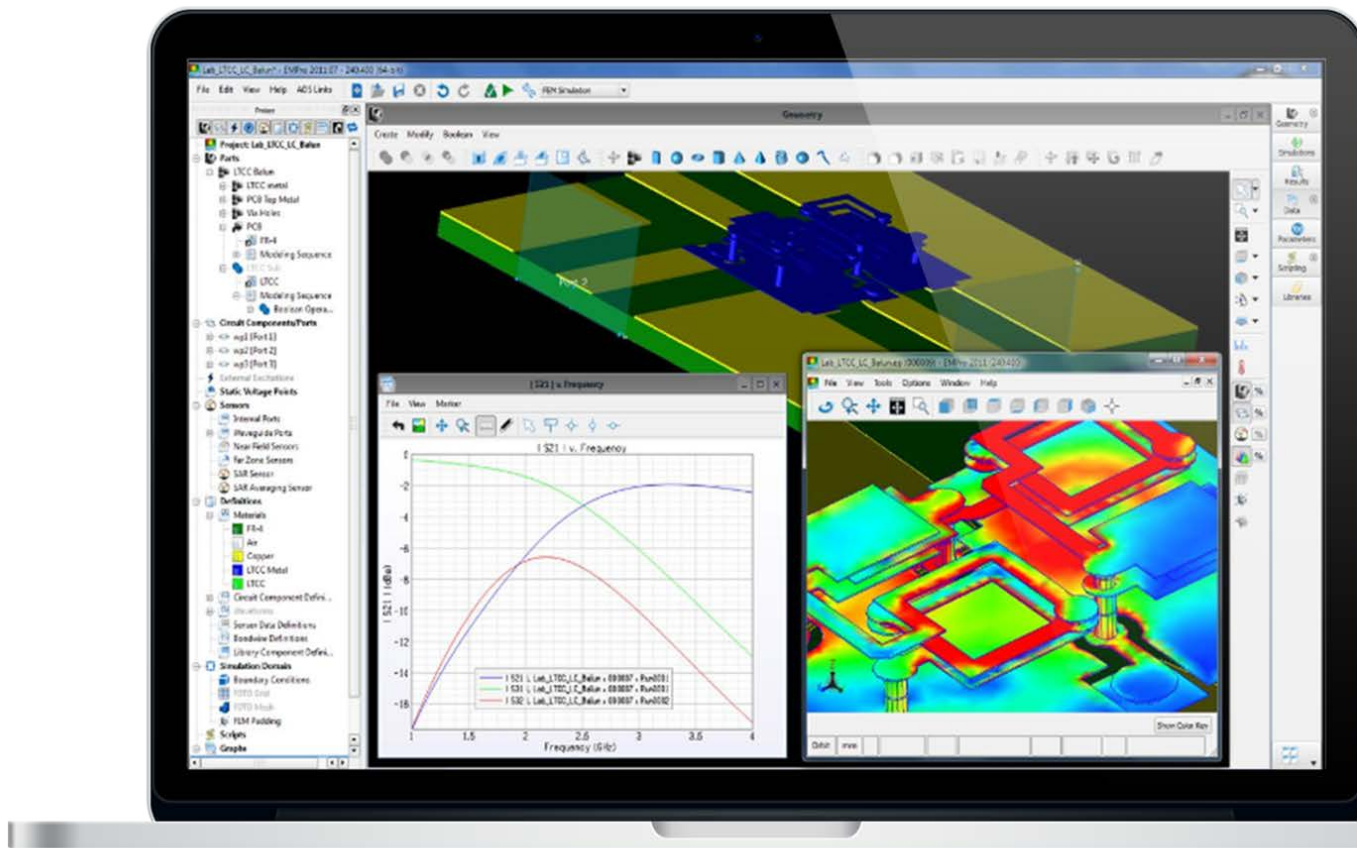
Electromagnetic interference (EMI) and radio-frequency interference (RFI) are among the most critical challenges for medical device developers. Such interference can cause electronically controlled medical devices, such as pacemakers or hearing aids, to operate incorrectly. Depending on the severity of the interference and the type of affected device, the consequences can range from inconvenient to life-threatening. It is vital to ensure that devices operate reliably and safely in the presence of electromagnetic interference, mitigating patient risks and adhering to regulatory standards.

Optimize compliance using simulation

Modeling helps you estimate emission levels and eliminate costly compliance failures by simulating before you develop the hardware.

Keysight PathWave EM Design (**EMPro**) is a simulation software design platform for analyzing the 3D EM effects of components such as high-speed and RF IC packages, bond wires, antennas, on-chip and off-chip embedded passives, and PCB interconnects.

Use it early in the development cycle to simulate the radiated emissions of electronic circuits and components. Calculated results help design engineers determine whether emissions are within levels specified by common EMC standards.



Maximize throughput in compliance testing

Increase productivity while achieving measurement integrity and keep your test queue flowing with the accuracy, repeatability, and reliability you need to test medical IoT devices with confidence.

The Keysight **N9038B MXE EMI receiver** is a powerful EMC compliance test solution. It provides fast time-domain scanning, enhanced built-in EMC measurements, advanced diagnostic capability, and real-time spectrum analysis for diagnosing high-speed transient signals.



Perform pre-compliance measurement

Reduce development expense and speed time to market by ensuring that your medical IoT designs will pass final compliance testing at an accredited facility the first time, without costly redesign and retesting.

The Keysight PathWave X-Series Measurement Applications offer EMI-specific software that runs on an X-Series signal analyzer.

Use this solution to perform pre-compliance radiated and conducted emission measurements to any international EMC standard and diagnostic evaluation of IoT designs early in the design cycle.



Cybersecurity Test Solution

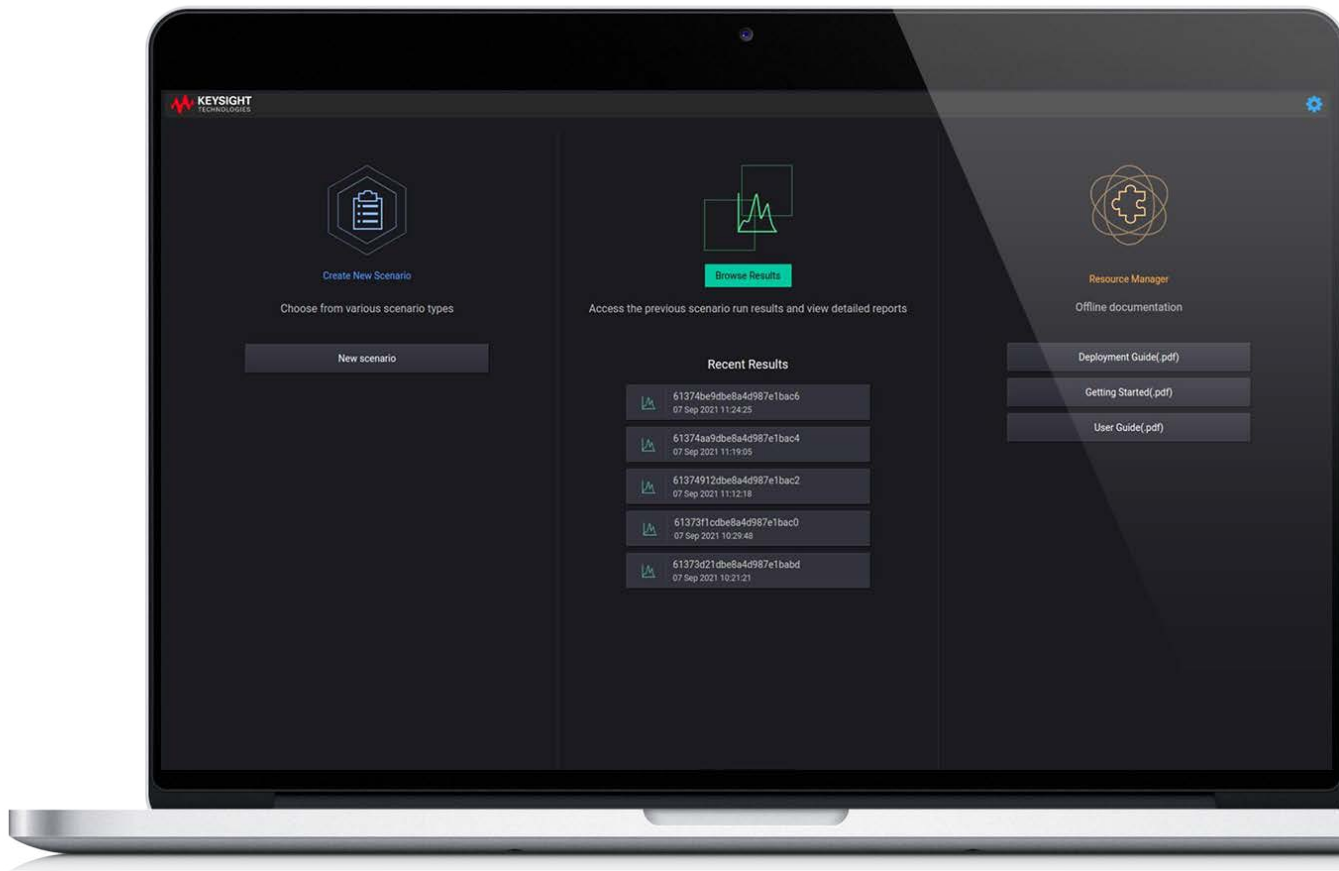
Demand for better, faster, and more reliable medical services is on the rise. Connected medical devices promise to meet that demand, and they are helping dramatically reshape medical treatment, services, and patient outcomes.

However, as IoT's role in healthcare grows, cybersecurity threats to patient privacy and safety increase. That is why manufacturers and healthcare providers trust Keysight to ensure their devices will perform reliably and are resilient to attack.

Comprehensive, automated security testing for IoT

IT security operations teams know how to secure traditional computing devices with patching and antivirus solutions, but they lack visibility and control for connected medical devices. Device manufacturers may introduce vulnerabilities, or flaws may lurk in third-party systems on a chip. Flaws from the supply chain are notoriously difficult for device manufacturers to find and even more difficult to fix.

Keysight's **IoT Security Assessment** helps you quickly find and fix critical vulnerabilities in connected healthcare devices. Unlike other tools, it combines traditional vulnerability assessment with a protocol-fuzzing engine under an integrated user interface or comprehensive REST application programming interface. It includes comprehensive reporting on discovered security flaws.



Conclusion

Test at each phase of the product development life cycle with higher confidence, efficacy, accuracy, and reliability to bring products to the market faster. Keysight's powerful simulation and testing capabilities enable you to reduce risks and increase your chances of success in many aspects of your medical product development efforts. With Keysight as your trusted partner, you always have the data and insights you need to deliver safe, compliant, high-quality medical systems or devices on schedule.

About Keysight

Keysight is your innovation partner, delivering market-leading design, emulation, and test environments that help you develop and deploy faster, with less risk, throughout the product life cycle.

Push the boundaries of engineering and deliver the best product experiences with our fusion of technologies, measurement expertise, and tailored solutions built from a foundation of co-innovation with industry ecosystem leaders. Gather insights sooner to build and go to market with confidence.





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Mess- und Prüftechnik. Die Experten.



Keysight enables innovators to push the boundaries of engineering by quickly solving design, emulation, and test challenges to create the best product experiences. Start your innovation journey at www.keysight.com.