

Design and Test Solutions for Medical IoT Devices

Develop medical IoT devices with end-to-end, leading-edge solutions that withstand the rigors of the real world.

Keysight – the world’s leading electronic measurement company, and its Ixia product line—provides complete end-to-end solutions for designing, testing and securing medical IoT devices and network infrastructures to meet the robust demands of healthcare facilities. Keysight and Ixia solutions span the entire communication stack, from Layers 1 to 7, and cover the entire product lifecycle, from design creation to manufacturing and beyond.



Medical IoT Device Design and Test

Electronic Components Design and Characterization
Signal and Power Integrity Testing
Power Consumption for Battery-Operated Medical Devices



Wireless Communications Test

RF/Wireless Components Design and Characterization
EMI/EMC Testing
Wireless Conformance Solution
Wireless Technology Design and Test
Wireless Connectivity Testing
Co-Existence and Interference Testing
Network Readiness Testing



Network and System Test

Network Performance Assessment and Monitoring
Network Infrastructure Performance Testing
Applications and Security Testing



Services and Support

Overview

The number of connected medical IoT devices is on the rise, and includes a wide range of products from simple devices like thermometers to more complex devices like smart infusion pumps, patient monitoring systems, and MRI scanners. Communities' expectations have increased in line with the promised advantages such as better access to patients' electronic health records, and improved quality of care through wireless-enabled, real-time monitoring systems.

While the advantages of "everything connected" are undeniable, a healthcare facility densely packed with medical IoT devices can lead to problems such as dropped network connections and failure in the transmission of critical alarms. As far as medical IoT devices are concerned, such incidents are non-negotiable. A medical IoT device needs to work right, unimpeded by interference and at all times.



Medical IoT device design and test solutions include a comprehensive approach and methodology for creating designs that are fully optimized for battery life, tested for any signal or power integrity issues, while ensuring interoperability with other medical IoT devices and in the presence of other wireless technologies in the healthcare facility. Designers can be assured that the products developed are of high standards and quality with Keysight's design test and validation, pre-conformance and pre-compliance test solutions.



Wireless technology design and test solutions help ensure medical IoT devices are designed in accordance to wireless standards, with the reliability to withstand the rigors of the real world once deployed. Keysight solutions emulate complex real-world network traffic and interference conditions to speed performance verification and troubleshooting of multi-mode IoT devices and systems. Product and system designers will be able to release their products with high confidence, without increasing risk to patients in hospitals and other healthcare facilities.



Network and system test solutions qualify medical IoT devices for actual deployment in the healthcare facility, providing you with applications that help you monitor and test network/system performance under the most stressful real-world conditions. Ixia's security solutions also help IT personnel and network engineers protect the network from traffic anomalies and cyberattacks, and ultimately validate the security of sensitive patient information and medical records.

The healthcare industry is undergoing massive changes and Keysight is here to help our customers prepare for the future. Whether you are a design engineer, product/module maker, manufacturer or service provider, we can help you bring your innovative medical IoT device to market faster – robust, secure and compliant to the highest standards.



Medical IoT Device Design and Test

An IoT device is essentially any “thing” in the Internet of Things. It is comprised of several parts, including sensors, power management circuitry, processor as well as the RF/wireless components. Where medical IoT devices are concerned, each of these components needs to be well-designed before being integrated into the final IoT product to ensure it can perform reliably in all applications, especially when lives can be at risk.

Electronic Components Design and Characterization

Scenario: Electrical testing (non-RF wireless testing) can help to characterize medical IoT devices and typically these need to operate at low voltage, current and frequency, while performing at high accuracy. High precision test equipment is required to ensure that the medical device-under-test meets the required regulatory compliance.

Solution 1: Keysight 34465A / 34470A Truevolt Digital Multimeter



Obtaining accurate load current measurements for an implantable medical device can be quite a challenge. Devices such as pacemakers draw very low currents when in sleep or standby mode (as low as microamps), but consume much higher currents during active mode. The 34465A / 34470A Truevolt DMM can capture accurate current profiles for the medical IoT device that’s tested under each mode: sleep, standby, and operating modes.



Benefits:

Gain greater measurement insight quickly with the DMM’s low current resolution and high accuracy, and speed up development and time-to-market.

- Speed up statistical analysis via histogram, bar and trend charts on a color graphical display
- Test low power devices with 1 μ A range and pA resolution
- Patented Truevolt technology provides greater accuracy down to 16 ppm, lower noise and lower measurement error
- With BenchVue software enabled, you can quickly build automated tests and log measurements to PC, saving precious test and development time



Solution 2: Keysight 33500 / 33600 Series Function/Arbitrary Waveform Generators



The arbitrary waveform generation feature in the Keysight **33500B** and **33600A** Series Waveform Generators allows users to generate complex electrocardiogram (ECG) patterns for medical device design and characterization. The waveform generator's sequencing feature enables seamless switching across various ECG signals that are stored in memory, so you can easily simulate abnormalities in heart activities without any discontinuity in test.



Benefits:

Create exact waveforms for accurate testing of your medical devices, thanks to the patented *Trueform* technology. No more approximations, just the certainty you need to accelerate testing and development.

- Signal integrity translates to less uncertainty in your tests, providing precise, low noise signals with the lowest jitter and harmonic distortion in its class
- *Trueform* ensure every waveform point is accurately represented, with up to 64 MSamples per channel
- Simulate a single pulse, a burst of pulses, or a steady pulse train with high bandwidth up to 100 MHz and fast edge times down to 2.9 ns
- Speed up testing with the BenchVue app: Intuitively control instrument, build custom waveforms and automate tests from your PC
- Easy advanced waveform creation and editing capabilities in the embedded Keysight BenchLink Waveform Builder Pro

Solution 3: Keysight 81150A / 81160A Pulse Generator + Oscilloscope

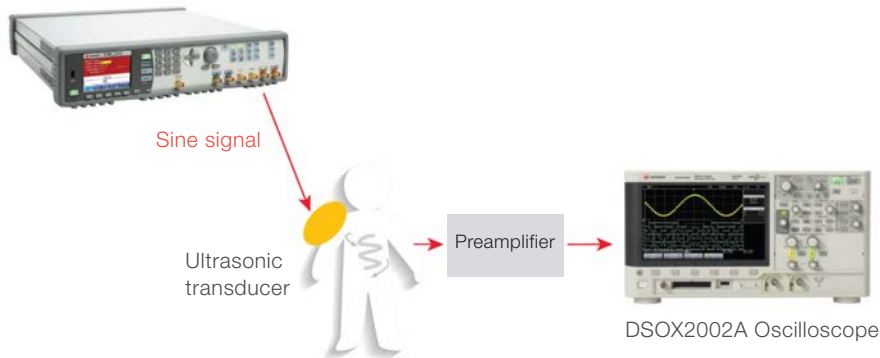
Keysight 81150A / 81160A Pulse Function Arbitrary Noise Generators can simulate distorted sensor signals in fitness wearable devices. These instruments can generate high-precision and repeatable simulations of any kind of clean signals overlaid with distortion. This way, you can generate motion artifacts in the Hz-range and acoustic signals corrupted by ambient acoustic noise. Overshoot and other voltage level effects that occur during wake-up from sleep mode can also be created.

Oscilloscopes with real-time bandwidth and high measurement accuracy complement the test setup for these wearable devices; helping you quickly monitor and debug any design issues in the medical IoT device.



For non-invasive testing of medical IoT devices inside the body, the pulse generator can be used to emit a continuous sinusoidal signal in the kHz range (depending on the investigated process), which is transmitted into an ultrasonic transducer, as shown in the doppler sonography setup shown below.

81150A/ 81160A Pulse Generator



Benefits:

Together, the 81150A / 81160A pulse generator and oscilloscope offer the best stimulus-and-response solution for medical IoT devices.

- High precision pulse generator with arbitrary noise generator, and high frequency resolution of 1 μ Hz accelerate real-world testing
- Create high precision and repeatable simulations of any clean signal overlaid with distortion to mimic distorted sensor signals in fitness wearable devices.

Solution 4: Keysight B2961A / B2962A Low-Noise Power Source for Precision Voltage and Current Sourcing



To reduce power consumption, battery-powered medical devices continue to reduce their supply voltage levels, which requires ever more precise power sources to accurately characterize device behavior. Noise performance requirements also continue to become more stringent, making the testing of medical IoT devices increasingly difficult. The Keysight **B2961A** and **B2962A** are revolutionary power supplies or power sources with precision low noise voltage/current sourcing.

Benefits:

- Bipolar 210 V/3 A (10.5 A pulse) range, 4-quadrant operation helps you speed up testing as you can flexibly supply voltage or current, and power limit regardless of polarity
- Optional external filter enables ultra-low noise output down to 10 μVrms and 1 $\text{nVrms}/\sqrt{\text{Hz}}$ (at 10 kHz)
- Precise test and evaluation with 100 nV/10 fA resolution



Signal and Power Integrity Testing

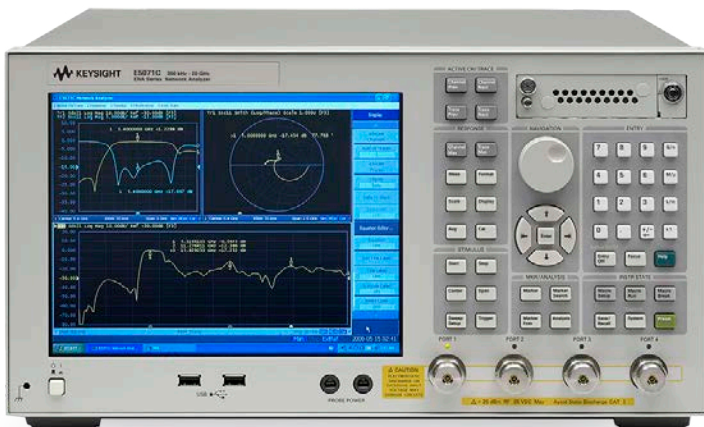
Scenario: With increased demand for expanded functionalities in a small medical IoT device, there is a need for higher density, higher speed, lower power and more compact circuit design. Signal integrity and power integrity issues are becoming more common as traces become closer to each other and supply voltage is lowered.

Testing for signal and power integrity is essential to create a successful, reliable medical IoT device. To ensure the performance of a medical IoT device does not degrade, developers need to characterize and troubleshoot these issues at an early stage of the design cycle to avoid any timeline slip and costly failure at later stages.

Solution 1: Keysight E5071C ENA Vector Network Analyzer with Option TDR

The Keysight E5071C ENA Vector Network Analyzer with Option TDR is a one-box solution for analyzing high-speed serial interconnects. It performs real time signal integrity measurements simultaneously in the time domain (TDR/TDT) and frequency domain (S-parameters), as well as eye diagram tests without requiring an external bit pattern generator.

The Keysight E5071C with optional TDR makes signal integrity design and verification easier, and more impactful by delivering a solution with the look and feel of an oscilloscope, but with the accuracy and speed needed to automatically adjust skew and make measurements in just a few clicks.

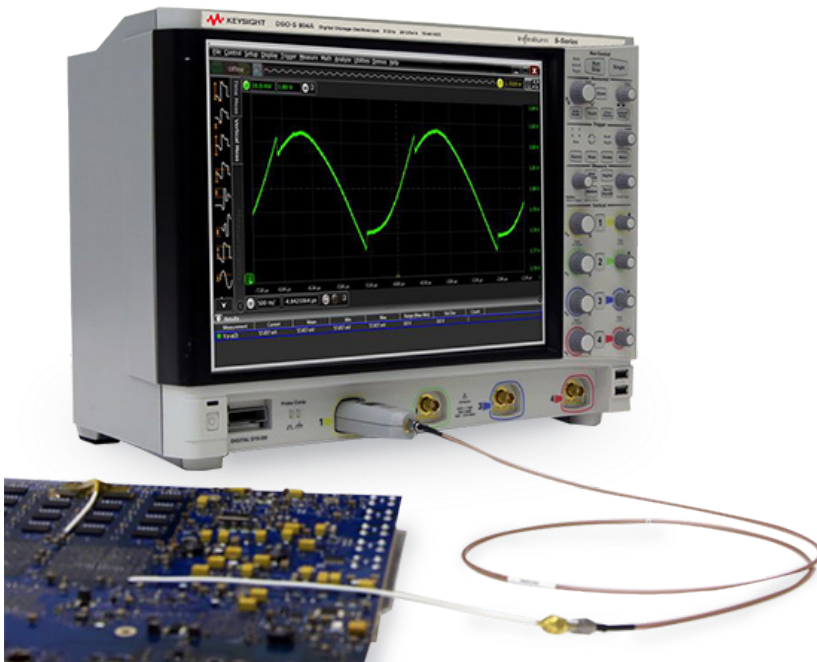


Benefits:

Speed time-to-market and maximize real-world device performance while increasing revenue. Prevent medical IoT device failures and low-yield manufacturing with the accuracy needed to find even the smallest discontinuity.

- Quickly validate and correlate signal integrity (SI) simulation with actual measurement
- Perform real-time measurements without the averaging traditionally needed with TDR oscilloscopes
- Easily implement ESD protection circuits
- Supports compliance test; certified for major communication standards

Solution 2: Keysight Infiniium S-Series Oscilloscope + N7020A Power Rail Probe



The Keysight low-noise **Infiniium S-Series Oscilloscope** is used with a specialized power rail probe (**N7020A**) to perform highly accurate power integrity (PI) analysis. The solution measures periodic and random disturbances (PARD), static and dynamic load response, programmable power rail response, and similar power integrity (PI) measurements.

The Keysight Infiniium Oscilloscope and N7020A probe speeds the design process by making it easier for designers to troubleshoot power integrity issues and ensure their medical IoT products meet tight DC power rail tolerances.



Benefits:

Speed time-to-market and time-to-profit while reducing project risk. Prevent degraded medical IoT device performance or failures with the bandwidth and accuracy needed to find the high-speed transients that can have detrimental effects on clocks and digital data.

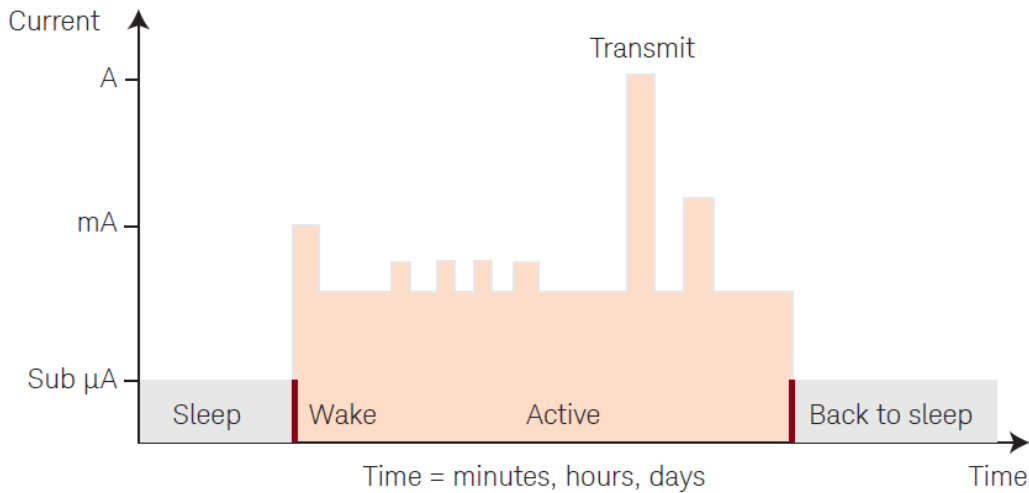
- Provides mV sensitivity for noise, ripple and transients on DC power rail measurements
- Accurately measures large power rail transitions
- Enables designers to set oscilloscope to maximum sensitivity and center their signal on the screen
- Delivers exceptional signal purity with support for compliance applications like DDR, eMMC, MIPI, USB, and more



Power Consumption for Battery-Operated Medical Devices

Scenario: Battery life is critical in medical IoT devices, especially devices such as pacemakers and implantable cardioverter defibrillators (ICD). Serious consequences could follow if these devices fail or if their batteries are prematurely depleted. Not only would this cost manufacturers and developers a lot of money, it can also cause serious injuries or deaths. The convergence of wireless connectivity, high-speed digital processing, and real-time monitoring capabilities on a medical IoT device has led to the need to better understand battery current drain profile and for better, more accurate instruments to sufficiently perform the needed measurements and characterization.

Long periods of sleep/idle, wakeup/active, and short RF bursts can be demanding on a battery. Knowing how much current is consumed at critical RF events and identifying which part of a device circuitry is consuming the most current will help developers better optimize the design of battery-operated medical IoT devices.



Example of a battery current drain profile

Solution 1: Keysight N6705C DC Power Analyzer + N6781A / N6785A Source Measure Unit (SMU) + 14585A Control and Analysis Software

The Keysight N6705C DC Power Analyzer, N6781A / N6785A SMU and 14585A software are collectively a solution to perform battery run-down tests of actual medical IoT devices. The N6705C provides a platform for power, waveform capture, long-term current drain data-logging and display, as well as analysis of results. The N6781A/N6785A SMU operates within the N6705C mainframe and is used for battery drain analysis during R&D or design verification. With the N6781A/N6785A SMU module configured as a virtual logging ammeter to digitize current drain, the SMU's Aux DVM input is connected across the battery to record battery voltage.

When used with the 14585A software, the N6781A/N6785A SMU becomes an even more powerful solution for battery-drain analysis. Through a familiar PC interface, the 14585A software provides you with advanced controls and capabilities including waveform capture, long-term data logging, CCDF statistical analysis, and creation of arbitrary waveforms that range from basic to complex.



Benefits:

Maximize battery life by preventing unnecessary current drain, while speeding time-to-market and increasing revenue, with the confidence that comes from precision measurement integrity.

- Measures a wide range of current from nA to A through patented innovative measurement called Seamless Measurement Ranging
- Functions as both a current/voltage source and e-load
- Offers high accuracy for low current measurements; can also be used for high-power IoT devices
- Minimizes transient voltage drop for pulsed currents drawn by wireless devices with a fast-transient response
- Provides detailed measurement insight with a 200-kHz sampling rate



Solution 2: Keysight CX3300 Series Device Current Waveform Analyzer



The Keysight CX3300 Current Waveform Analyzer captures current waveforms from current or differential sensors with 14- to 26-bit resolutions, and sampling rates of up to 1 GSa/s. Specifically built for low-power IoT device and chip characterization, it measures current down to 100 pA and up to 100 A—the industry’s lowest current measurements—with a maximum of 200 MHz bandwidth. It is well suited for use during R&D or design verification of medical IoT devices.

The CX3300 makes achieving critical power and current consumption reductions possible by precisely measuring previously unmeasurable or undetectable wideband low-level current waveforms.



Benefits:

Optimize battery life and battery performance in the real-world, and avoid unnecessary risks to patients as a result of battery-related failures in medical IoT devices. Prevent premature battery failures and faulty operation with the ability to make low current and high bandwidth measurements with precision.

- Covers sleep to active mode with a single measurement
- Provides excellent visibility of the dynamic current waveform in sleep mode
- Enables precise estimation of power consumption by capturing the voltage waveform
- Greater insight with built-in analysis tools designed to improve characterization and debug efficiency without requiring external analysis tools
- Future-proof with easily upgradable memory depth and maximum bandwidth



Solution 3: Keysight Infiniium S-Series Oscilloscope + N2820A High Sensitivity 3 MHz/50 μ A Current Probe



The Keysight **N2820A** 2-channel AC/DC current probe, coupled with the **Infiniium S-Series Oscilloscope**, provides the ideal solution for measuring small current levels in battery-powered medical IoT devices, especially with the probe's wide dynamic range and high sensitivity. The probe comes with physically small connections, which is an advantage in the testing of medical IoT devices in small form factors.



Benefits:

Prolong the lifespan of implantable medical devices, like pacemakers and Implantable Cardioverter Defibrillators (ICD). High-sensitivity, low-level current measurements will ensure the current consumption of these devices is within acceptable limits.

- High sensitivity current measurement with resolution as low as 50 μ A
- Wide dynamic range from 500 nA to 5A
- View simultaneous high- and low-gain view for wider dynamic range measurement

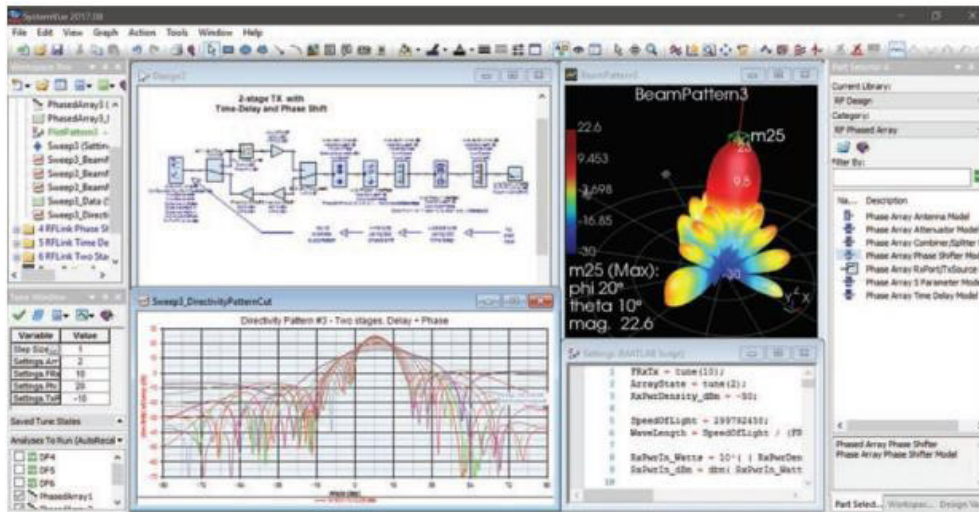


RF/Wireless Components Design and Characterization

Scenario: RF component design and characterization is just as challenging as electrical component design. RF components must meet specific quality levels to achieve overall design parameters. RF device and component manufacturing test requires a balanced mix of time, coverage and cost per device-under-test (DUT). Finding your balance starts with the right combination of speed and performance in your test system.

Design and simulation software can help designers gain a better understanding of the RF/wireless components' real-world operation and underlying physics, bringing product to market faster and avoiding costly delays.

Solution 1: Keysight SystemVue Electronic System-Level (ESL) Design Software



Keysight **SystemVue** is an electronic design automation software that is used to model and simulate system designs early in the development process. It enables system architects and algorithm developers to innovate the physical layer (PHY) of wireless communications systems and provides unique value to RF, DSP, and FPGA/ASIC implementers.

SystemVue enables device designers to develop better products by allowing them to visualize the RF and eliminate any excess margin to keep system performance at peak.



Benefits:

Innovate faster. Create better products with greater insight into performance. Speed time-to-market by cutting PHY development and verification time in half.

- Best-in-class RF fidelity allows designers to virtualize the RF and eliminate excess margin
- Accelerates real-world product maturity and streamlines design flow through tight integration with test
- Priced for networked workgroups to maximize design re-use, capitalize on baseband and RF synergies



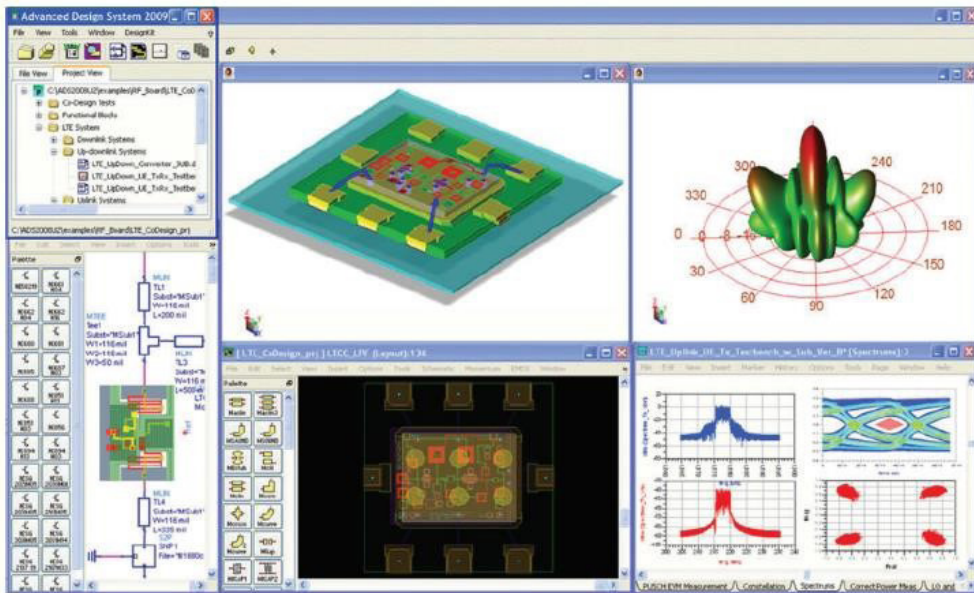
Solution 2: Keysight Advanced Design System (ADS)



Benefits:

Develop better designs faster with accurate easy-to-use simulators and a streamlined flow. Gain the confidence in first-pass design success that comes with measurement integrity.

- Application-specific DesignGuides encapsulate years of expertise in an easy-to-use interface
- Optimization cockpit enables real-time feedback and control
- Up-to-date wireless libraries allow designers to work with the latest emerging wireless standards
- Allows for easy design flow integration with Cadence, Mentor, and others



Keysight **Advanced Design System (ADS)** software provides fast and accurate system, circuit and electromagnetic (EM) simulation for RF, microwave, and high-speed digital applications. It's in a design simulation environment for the co-design of IC, package and board, so designers can make tradeoffs interactively.

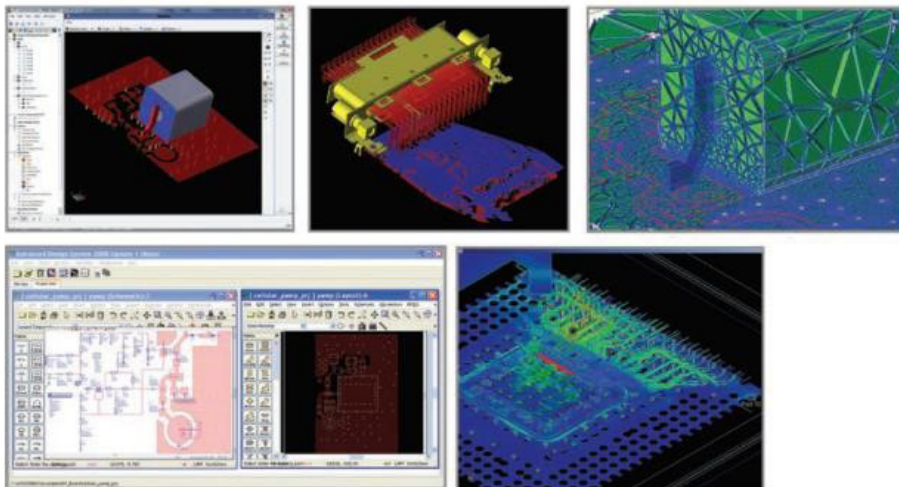
Keysight ADS software helps save time and reduces errors introduced when using multiple tools by allowing circuits designed in multiple technologies to be combined and simulated at both the circuit and full 3D EM level.

EMI/EMC Testing

Scenario: Electromagnetic interference (EMI) or radio-frequency interference (RFI) is one of 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.

EMI occurs when the electromagnetic radiation emitted by electrical circuits causes unwanted signals or interference in other circuits. Most electronically-controlled medical devices do not have adequate protection against EMI, and the challenge is exacerbated by the increase of RF sources used both inside and outside of the hospital. Portable wireless communication devices, such as cellular phones and tablets, are one of the largest sources of EMI.

Solution 1: Keysight EMPro 3D Electromagnetic (EM) Simulation Software



Keysight **EMPro** is a simulation software design platform for analyzing the 3D EM effects of components such as high-speed and RF IC packages, bondwires, antennas, on-chip and off-chip embedded passives, and PCB interconnects. Early in the development cycle, it can be used to simulate the radiated emissions of electronic circuits and components. Calculated results help designers determine if emissions are within levels specified by common EMC standards, such as CISPR, FCC Part 15 and MIL-STD-461G. Modeling helps designers estimate emission levels before hardware is developed.



Benefits:

Eliminate costly failures in compliance by simulating before hardware is developed.

- Enables 3D components to be simulated with 2D circuit layouts and schematics within Keysight ADS, using EM-circuit co-simulation
- Provides analyses using both frequency-domain and time-domain 3D EM simulation technologies
- Quick creation of arbitrary 3D structures; possible with a modern, simple GUI

Solution 2: Keysight N6141A / W6141A EMI Measurement Application + X-Series Signal Analyzers



The Keysight **N6141A / W6141A** EMI Measurement Application is an EMI-specific software that runs on an **X-Series Signal Analyzer**. It is used 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.

The Keysight **N6141A / W6141A** EMI Measurement Application saves time and money by allowing designers to find and fix problems before they enter the test chamber.



Benefits:

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

- Easily identify out-of-limit device emissions via signal list, frequency scan, and active detector meters that are all displayed on a single screen
- Collect emissions suspect lists rapidly using built-in testing to limit lines
- Simplify and automate data collection, analysis, and report generation for commonly tested emissions

Solution 3: Keysight N9038A MXE EMI receiver



The Keysight **N9038A** MXE EMI receiver is a CISPR 16 and MIL STD compliant, EMC compliance test solution. It provides fast time-domain scanning, enhanced built-in EMC measurements, advanced diagnostic capability, and real-time spectrum analysis (RTSA) for diagnosing high-speed transient signals.

The MXE simplifies the setup process for compliance measurements with setup tables to create specific measurement configurations for a variety of frequency ranges and antennas.



Benefits:

Maximize throughput in compliance testing and increase productivity while achieving measurement integrity. Keep your test queue flowing with the accuracy, repeatability and reliability you need to test medical IoT devices with confidence.

- Reduce overall scan time
- Easily identify the frequencies of peak emissions prior to final measurement
- Perform enhanced diagnostics with spectrum and real-time analysis
- Gain insight with extensive diagnostic capabilities, switching between receiver and spectrum analyzer modes

Wireless Conformance Solution

Scenario: Conformance testing is carried out by specialized laboratories and is mandatory for all wireless products. Companies must confirm that their products comply with supported wireless standards and often do so in-house first, prior to sending the product to the lab. Failure to comply means the product cannot be advertised as having been certified by the organization that defined the standards and the lab that conducted the tests. It can also lead to lost revenue caused by a potentially costly redesign and delayed product launch.

Solution: Keysight T4010S Conformance Test System



The **T4010S** conformance test system covers conformance testing according to 3GPP TS 36.521-1 LTE, NB-IOT RF, CAT-M1 RF and 3GPP TS 36.521-3 LTE RRM for FDD and TDD, 1CC, 2CC, 3CC and 4CC, as well as LTE device acceptance test plans from major network operators. It allows designers to perform design verification during R&D using the same hardware utilized for conformance testing.



Benefits:

Perform full UE certification prior to conformance testing, with support of GCF/PTCRB validated test cases (TP 195). Speed time-to-market with the test case parameterization environment, test automation, and remote control you need for RF parametric testing, margin search, and complete system validation.

- Execute test cases with parameters other than those required by 3GPP
- Test all LTE, NB-IOT, FDD CAT-M1 frequency bands at no additional cost
- Easily and quickly analyze and report on test case results
- Remote test system operation

Wireless Technology Design and Test

Using wireless technologies in medical devices provides many benefits, including always-on patient monitoring, seamless communication (person-to-machine and machine-to-machine) and wireless sensing. In addition to dedicated medical wireless technologies, the medical industry is widely adapting off-the-shelf wireless connectivity technologies such as WLAN, *Bluetooth*® Low Energy, Zigbee, Near Field Communication (NFC) and cellular technologies, including HSPA and LTE, for better wireless connections among medical devices and systems.

The Federal Communications Commission recommends the following frequency bands for medical devices:

	Technologies	Major application	Frequency	Coverage (m)
Dedicated medical devices	Inductive coupling implants	Low data rate monitoring/control with implanted devices	Less than 1 MHz	Less than 1
	Medical device radiocommunication service	Medium data rate communication with implanted/on/near body devices	401-406 MHz	2-10
	Medical micropower networks	Implanted micro stimulators for artificial nervous system	413-419, 426-432, 438-444, 451-457 MHz	Less than 1
	Medical body area networks	Personal Area Network (“PAN”) for multiple on/near body sensors for patient monitoring; not for implanted sensor	2360-2400 MHz	Less than 1
	Wireless medical telemetry	The measurement and recording of physiological parameters and patient information	608-614, 1395-1400, 1427-1429.5 MHz	Up to 60
Off-the-shelf medical devices	WLAN 802.11a/b/g/n/ac/ad	Communication within medical sensors/devices/ hubs for healthcare data systems	2.4/5 GHz	250
	<i>Bluetooth</i> Low Energy	Low power medical sensors/ devices connection	2.4 GHz	~ 50
	Zigbee	Low power medical sensors/ devices mesh connection	868 MHz (EU), 915 MHz (US), 2.4 GHz	10 to 20
	NFC	Low power medical sensors/ devices connection	13.56 MHz	< 20 cm

Wireless Connectivity Testing

Scenario: With the availability of many heterogeneous wireless technologies today, developers will need to ensure a medical IoT device is designed in accordance to the wireless standards and interoperate between different wireless technologies, and still be able to carry out the life-critical applications the device is tasked to do, without fail.

To drive down the cost of test, speed development and deliver robust, reliable IoT devices, design engineers can replace their multiple wireless test instruments with a single instrument capable of testing all the necessary standards, and supporting the addition of new standards as they emerge.

Solution 1: Keysight X-Series Signal Analyzers + Signal Generators



The **X-Series Signal Analyzers** are high-performance benchtop solutions for comprehensive frequency domain, time domain, and modulation analysis during IoT design and prototype evaluation. The **X-Series Signal Generators** produce the signals needed—from simple to complex, from clean to impaired—to perform parametric testing of components during R&D and for functional verification of receivers with industry-leading ACPR, EVM, and output power. The X-Series Signal Analyzers simplify and speed analysis of signals during wireless test with front panel capabilities that enable fast one-button measurements, while the X-Series Signal Generators' fast and easy signal generation ensure faster test throughput and greater uptime.



Benefits:

Take medical IoT device performance to the limit with signal purity and precision fine-tuned for the highest performance. Keep your production line running efficiently and cost-effectively with the speed and reliability you need to accurately produce and analyze wireless signals every time.

- Accurately perform advanced receiver testing with the latest standards and everything from wide-open real-time analysis to low-cost essential measurements
- Achieve faster throughput and greater manufacturing uptime
- Realize greater performance to help mitigate interference, accelerate data throughput or enhance receiver sensitivity
- Realize deeper troubleshooting and insight with the broadest set of application-specific software
- Drive consistent measurements across your organization with 100% code-compatibility from R&D to manufacturing

Solution 2: Keysight M9420A VXT PXIe Vector Transceiver



The **VXT PXIe Vector Transceiver** is a modular solution for testing wireless components and IoT devices during manufacturing. The VXT drives rapid solution creation and faster throughput in manufacturing test with open-source test libraries and reference solutions.



Benefits:

Speed wireless test with faster test development and optimization time.

- Increase test density and reduce footprint with up to four VXT instruments in one 18-slot chassis
- Speed test with built-in real-time FPGA accelerated measurement
- Optimize test routines with proven software for standard-specific signal creation and analysis

Solution 3: Keysight E6640A EXM Wireless Test Set



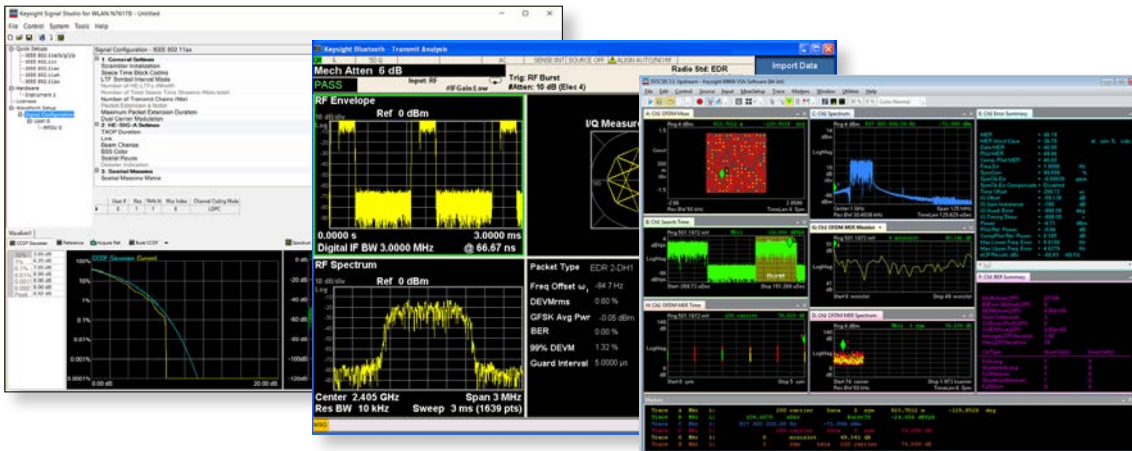
The **EXM Wireless Test Set** is a one-box tester for use in wireless device manufacturing, when test speed, flexibility and footprint are critical. It provides the broadest multi-format coverage of any one-box tester in its class, with regular updates that add new formats. Current supporting formats include 2G/3G/4G cellular formats, WLAN, ZigBee, *Bluetooth*®, and Wi-SUN. The EXM simplifies and accelerates the wireless test process with its ability to quickly scale to meet production needs, while keeping in sync with the latest cellular and WLAN chipsets.

Benefits:

Maximize production throughput and yield with the speed, accuracy and port density you need to ramp up rapidly, accelerate test execution, and optimize full-volume manufacturing.

- Optimize multi-device testing with up to four TRX channels per EXM, with up to 6 GHz bandwidth on each TRX
- Test multi-format devices with the broadest range of multi-format coverage of any one-box tester in its class
- Get up and running in hours, not days, with validated turnkey chipset solutions

Solution 4: Keysight Signal Studio, X-Series Measurement Applications and 89600 VSA Software



To accelerate wireless design and test of medical IoT devices, Keysight offers three popular software applications to be used with the benchtop, modular and one-box tester platforms. **Signal Studio software** enables the creation of custom and standard-compliant waveforms, while the **X-Series measurement applications** enable one-button testing for the various IoT wireless formats. The **89600 VSA software** is the industry-leading tool for digital modulation analysis and is useful for deeper troubleshooting of wireless formats.



Benefits:

Keysight Signal Studio: Speed testing of wireless signals with the confidence that generated signals are current with the latest emerging technologies.

- Create performance-optimized reference signals
- Validate component, transmitter and receiver testing
- Ensure designs meet the latest standards
- Speed signal creation and reduce simulation time

Keysight X-Series Measurement Applications: Accelerate from data to information to actionable insight with ready-to-use measurement software designed to simplify complex tasks and deliver repeatable results.

- Gain greater insight into signals and device performance with parametric and standard-compliant wireless measurements
- Speed time-to-insight with consistent measurements at your fingertips
- Speed time-to-market by leveraging the same measurements across design, verification and production

Keysight 89600 VSA: Gain quick insight in the frequency, time and modulation domains, to optimize your IoT designs.

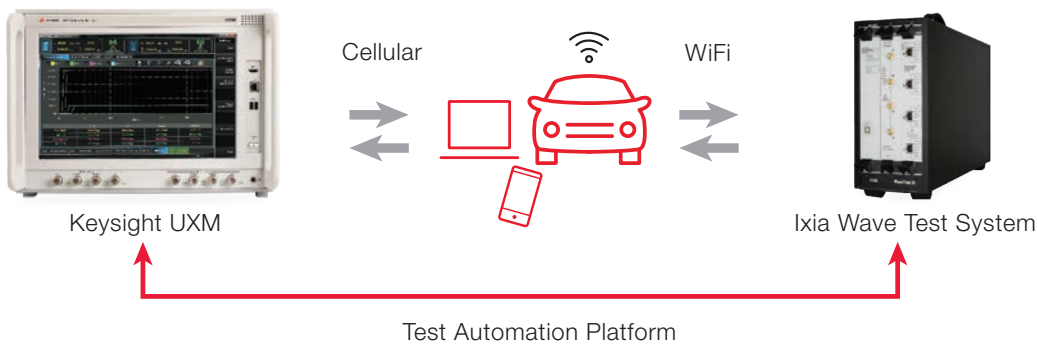
- Quickly pinpoint signal problems
- Measure proprietary signals, in addition to more than 75 signal standards and modulation types
- Customize measurement displays to get greater information clarity
- Produce consistent, comparable results in simulation, prototyping and design validation

Co-Existence and Interference Testing

Scenario: Many mission-critical IoT devices and systems are today connected via a broad range of wireless technologies, many using unlicensed shared spectrums, and operating in complex deployment scenarios. Interference problems have become increasingly common and severe as wireless devices, be it commercial or medical devices, are densely packed in a hospital.

Co-existence testing is vital to limit risk and ensure mission critical IoT devices and systems perform their functions as expected. Robust co-existence testing must be performed to validate device behavior in the presence of multiple users and multiple wireless technologies in the same spectrum.

Solution 1: Keysight T5510S Cellular + Wi-Fi Emulation System



The Keysight T5510S Cellular and Wi-Fi Emulation System consists of Keysight's UXM network emulator and the Ixia Wave Test System. This solution is designed to address interoperability challenges for multi-mode medical devices. It employs a comprehensive test automation platform with emulation that can rapidly simulate, program, and monitor the unified ecosystem for rapid verification of new test scenarios. The test system helps find complex protocol implementation errors under repeatable real-world traffic and interference conditions for faster troubleshooting, benchmarking, and calibration of multi-mode devices to improve user experience

Benefits:

- Perform comprehensive testing and verify interoperability of medical IoT devices that operate in licensed and unlicensed spectrums to detect real-world problems.
- Measure user experience in realistic diverse interoperable test environments
- Improve productivity by finding issues rapidly before end-users find them
- Reduce costs by eliminating the need for a life-sized Wi-Fi and cellular testbed
- Accelerate time-to-market by testing multi-mode devices in a unified ecosystem

Solution 2: Keysight FieldFox Handheld RF and Microwave Analyzers



The Keysight **FieldFox Handheld RF and Microwave Analyzer** can detect wireless signal coverage and find unexpected wireless interference in a healthcare facility. With FieldFox's Real Time Spectrum Analysis (RTSA) software, the network test engineer or technician can effectively 'hunt' for interference and perform signal monitoring easily during device and systems maintenance.



Benefits:

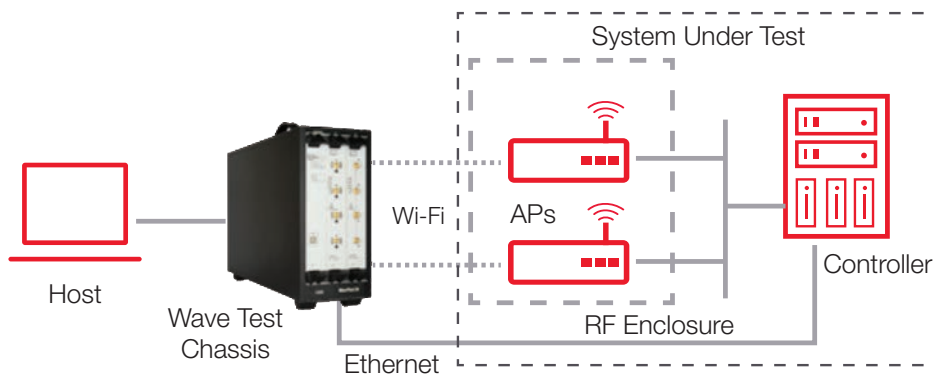
Detect wireless signals easily and find unexpected wireless interference in healthcare facilities.

- With real-time spectrum analysis features, you can identify multiple types of signals in the same frequency band, like *Bluetooth* and *WLAN* signals
- Interference analysis tools enable biomedical and clinical engineering teams to quickly pinpoint and mitigate electromagnetic interference
- Portable and easy to carry around during service calls

Network Readiness Testing

Scenario: High-performing Wi-Fi networks are critical, especially in a healthcare facility. Great Wi-Fi networks are stable, with high capacity and performance that exceed our quality of experience (QoE) expectations. However, most Wi-Fi networks today are only qualified for coverage with basic access and interoperability testing. This woefully inadequate testing exposes healthcare facilities to the risk of their medical applications failing.

Solution 1: Ixia IxVeriWave



The Ixia **IxVeriWave** solution provides comprehensive testing to validate the entire Wi-Fi ecosystem. It delivers powerful independent Wi-Fi benchmarking and real-world ecosystem simulations, as well as functional, soak, and stability testing for wireless local area networks (WLANs). Testing is done in a controlled, repeatable, automatable, and easily configured environment to provide extensive visibility and debugging of results.

The comprehensive test approach of Ixia IxVeriWave helps deliver great Wi-Fi networks and ensure world-class delivery and operation.



Benefits:

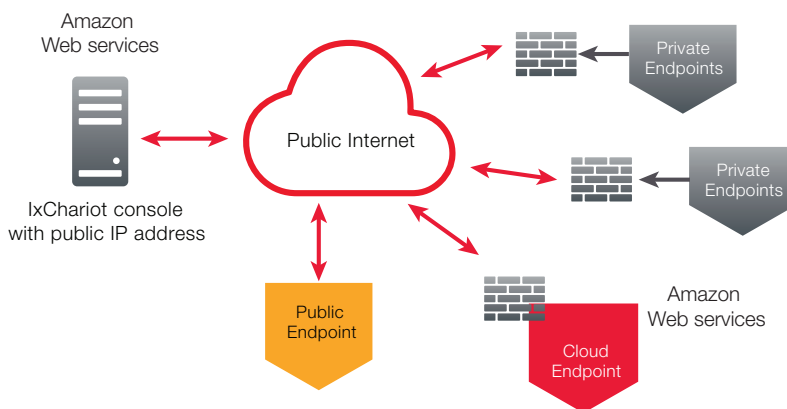
Deliver superior networks, and proactive problem resolution with the confidence that comes from comprehensive testing.

- Build robust, high-performance WLAN equipment using an automated, repeatable, easily controlled test environment
- Limits costs associated with real devices and their management using simplified test bed
- Easily scale; determine maximum performance and capacity in a variety of simulated environments
- Reduce debugging cycles with extensive Layer 1-7 statistics and key performance indicators
- Improve release cycles with automatable, comprehensive test types and scenarios from functional to soak testing

Network Performance Assessment and Monitoring

Scenario: Hospitals networks are in constant flux. In order to support new wireless medical devices, network equipment undergoes continual updates and upgrades. Whether existing network devices are capable of supporting a new service is a question often left to chance. To avoid blunders, organizations need to qualify the network, assess performance, and predict the quality of experience (QoE) of newly deployed services. For quality assurance engineers and IT teams, it is critical to have fast and efficient ways to verify and quantify performance before shipping products or rolling out services. Network performance monitoring post-deployment is key to successful day-to-day operations and provides valuable capabilities for troubleshooting.

Solution: Ixia IxChariot and Hawkeye



The Ixia **IxChariot** and **Hawkeye** solutions provide instant performance and reliability assessment and troubleshooting of complex networks from pre- to post-deployment using software agents to simulate application traffic and deliver key performance metrics to a central console for easy management. They can be used to provide efficient, software-based testing to check device and network readiness, then monitor the network services when they go live.

With Ixia IxChariot, “What-if” scenarios predict an application’s impact on devices or the network pre-deployment with in-depth validation. Ixia Hawkeye helps IT ensure networks are ready and monitored 24/7, validating that any network changes do not disrupt the network’s quality and performance. Ixia Hawkeye also provides visibility and diagnostics into cloud access performance, which is particularly relevant with the roll-out of cloud-based IoT services.



Benefits:

Ensure reliable operation of your production network even as your network and client technologies change and go through upgrade cycles.

- Fast, efficient way to verify and quantify performance before deploying products or rolling out services
- Trusted solution for testing reliability of networks and applications running on a wide variety of transport interfaces, including wired, wireless, virtual data centers and cloud
- Fast assessment and monitoring of wireless performance and geo-location; access to and troubleshooting of cloud services
- Emulates a real-world application traffic used on today’s networks in pre-deployment (IxChariot) and live networks (Hawkeye)

Network Infrastructure Performance Testing

Scenario: A large hospital or healthcare facility needs to continuously have their network tested and monitored for scale and performance. As networks become increasingly complex, so too do the challenges of ensuring peak network performance and resiliency. It's not about simply testing for sluggish response times—the right testing tool must now assess complex network topologies with thousands of network devices, emulate sophisticated traffic flows, and conduct stress tests under countless scenarios and network conditions.

To reduce test times and save capital expenditure in testing, companies must use a test solution that is able to handle complex and unpredictable networks, and can scale to handle the most powerful devices and the largest networks.

Solution: Ixia IxNetwork



The Ixia IxNetwork solution delivers performance testing under the most challenging conditions. Capable of generating multiple terabytes of data and analyzing up to 4 million traffic flows simultaneously, it scales to handle the most powerful devices and the largest networks. Enhanced real-time analysis and statistics enable IxNetwork to emulate everything from routing and switching, data center Ethernet and SDN to broadband access and industrial Ethernet.

The IxNetwork ensures the reliability of network infrastructure with comprehensive testing that scales to handle most powerful devices and largest networks.



Benefits:

Quickly identify problems in the lab before deployment in production by emulating a very large number of routers/switches without using real devices.

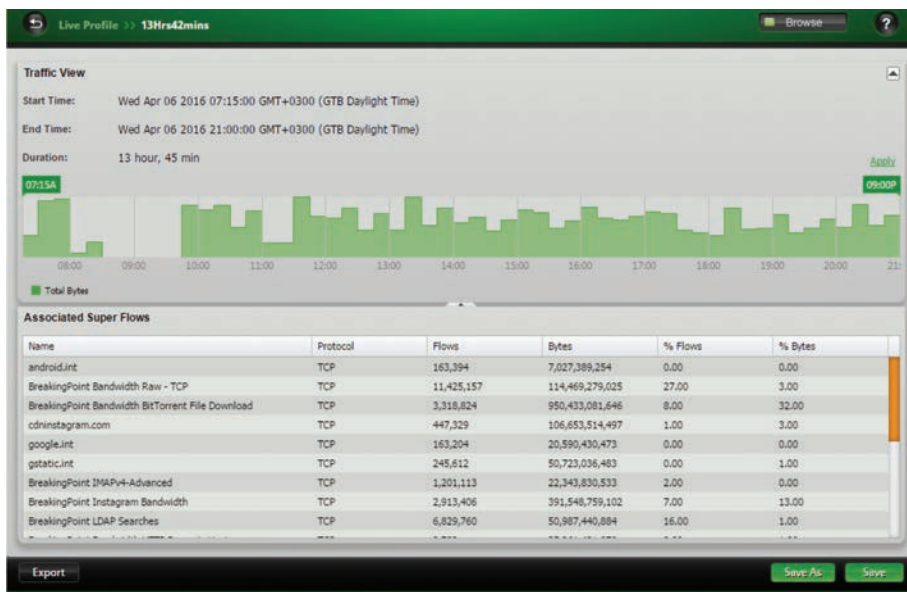
- Reduce test time using visual topology-based protocol configuration and comprehensive analytics with drill-down and learned information
- Realistically mimic real-world conditions with granular traffic generators and stateful AppLibrary
- Provides a deeper understanding of performance and scaling bottlenecks
- Easy to use GUI wizards enable users to meet a wide range of performance requirements with minimal resources

Applications and Security Testing

Scenario: Hospitals and healthcare facilities rely on a wide variety of security solutions to protect their networks from cyberattacks and traffic anomalies, especially since sensitive patient health data is involved. However, the more tools that are deployed, the more complex a security infrastructure becomes. What results is a mix of security solutions that are tough to verify and challenging to scale. Worse yet, these complex system interactions pose a serious risk to security performance and network resiliency. In life-critical IoT, such risks cannot be tolerated.

To ensure networks are robust and safe and to mitigate risk, hospitals and healthcare facilities must utilize a testing system that is powerful enough to measure and harden the performance of networks and security devices, while delivering ease of use that breaks through the complexity.

Solution: Ixia BreakingPoint



The Ixia **BreakingPoint** solution validates an organization's security infrastructure by simulating real-world legitimate traffic, distributed denial of service (DDoS), exploits, and malware attacks. It verifies network security with onsite network-specific, proof-of-concept (PoC) validation and attack simulation to validate and optimize next-generation firewalls (NGFWs), intrusion prevention systems (IPS), and other security devices.



Benefits:

Reduce the risk of network degradation and increase attack readiness with an easy-to-use testing ecosystem for modern networks.

- Measures and hardens the performance of network and security devices
- Validates network and data center performance by recreating busy hour internet traffic at scale
- Stresses network infrastructures with 37,000+ security attacks, malware, botnets, and evasion techniques
- Finds network issues and prepares for the unexpected with the industry's fastest protocol fuzzing capabilities
- Emulates sophisticated, large-scale DDoS and botnet attacks to expose hidden weaknesses
- Ensures an always-on user experience in the midst of complexity and exploding traffic volume



Keysight Services Can Help in the Design and Manufacturing of Medical IoT Devices

Keysight Services offers a broad portfolio of services and support to assist engineers working on the design and manufacturing of IoT devices. We understand design engineers count on repeatable measurements across work groups to avoid discrepancies that can impact development cycle time, time-to-market, and budgets. In manufacturing, inaccurate measurements and system uptime can affect yield and product quality.

For IoT manufacturing, where meeting time-to-volume and product quality goals are critical, you can:

- Achieve fast ramp times with test system installation
- Manage downtime with loaner services, onsite calibration, and onsite resident professionals
- Improve product quality by ensuring data correlation between NPI and manufacturing teams via Keysight's calibration services
- Have confidence your instruments are performing to spec by utilizing Keysight's global network of 36 services centers in 19 countries

For design engineers, where measurement accuracy and repeatability is required, you can:

- Exchange older assets for newer, more reliable Keysight instruments with the Keysight Trade-in Program
- Keep your instruments operating to specification with repair and calibration agreements
- Let us help solve your toughest problems by leveraging our consulting services

For lab or manufacturing managers looking to minimize capital and operating expenses, you can:

- Improve asset usage over time through instrument management solutions
- Use Keysight's Technology Refresh Services to extend, upgrade, or migrate existing test systems
- Lower your purchasing cost or use flexible financing with Keysight Premium Used, Instant Buy, or the Keysight Store on eBay
- Manage all of your instruments regardless of manufacturer with Infoline Instrument Management



To learn more about Keysight's complete service offerings, please visit our Services webpage at

www.keysight.com/us/en/products/services.html



EMI/EMC

The CISPR 16 standard specifies test equipment must be calibrated by labs accredited to ISO 17025. Keysight has a global network of service centers accredited to ISO 17025, spanning a wide range of electronic parameters and featuring industry-leading measurement uncertainties. Whether you are doing pre-qualification or qualification testing, you can trust your equipment will continue to meet its warranted specifications and comply with the CISPR standards.

For more information about how Keysight and Ixia can help in designing, testing and securing your medical IoT devices and network infrastructures, go to www.keysight.com/find/healthcareiot

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