

Mission-Critical Internet of Things

Designed, Tested and Secured to Withstand the Rigors of the Real World

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Defining the Internet of Things



“The Internet of Things (IoT) is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment.” – Gartner



The Internet of Things

THIRD PHASE OF THE INTERNET REVOLUTION

1990

**Fixed Internet
+1 Billion**

2000

**Mobile Internet
+2 Billion**

2010-2020

**Internet of Things
+50 Billion**

IoT Market Predictions

Gartner¹

20.4B

connected devices
by 2020

Cisco²

50B

devices will be connected
by 2020

Ericsson³

28B

connected devices
worldwide by 2021

IHS Markit⁴

30.7B

devices in 2020

ABI Research⁵

30B

Connected devices
by 2020

References:

1. <https://www.gartner.com/newsroom/id/3598917>
2. https://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf
3. <https://www.ericsson.com/en/press-releases/2016/6/internet-of-things-to-overtake-mobile-phones-by-2018-ericsson-mobility-report>
4. <https://technology.ihs.com/576648/tech-companies-creating-strategic-platforms-to-support-the-internet-of-things-ihs-says>
5. <https://www.abiresearch.com/press/more-than-30-billion-devices-will-wirelessly-conne/>

Defining “Mission-Critical”

MISSION-CRITICAL IOT & IOT SHARE COMMON TECHNOLOGIES: SENSORS, CLOUD PLATFORMS, CONNECTIVITY AND ANALYTICS. THE SIMILARITIES END THERE

Mission-critical devices span the electrical power systems, industrial, and medical markets. They have specialized requirements dictated by the industry in which they operate.

Robust Performance

to withstand the rigors of the real world

Precision & Accuracy

to work in manufacturing processes synchronized to milliseconds

Reliability

to operate 20-30+ years in harsh environments and remote locations

Security & Resilience

to protect from disruption, and against threats and attacks

Low Latency

where any delay could impact patient outcomes or worker safety

Programmability

to support new manufacturing processes



Interoperability

with legacy devices and operations technologies

Scalability

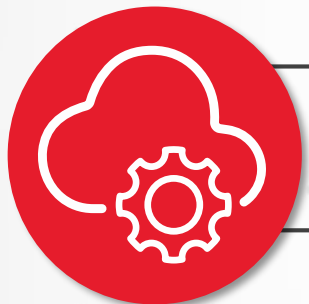
to support large-scale networks with tens of thousands (or more) controllers, robots, machinery, etc.

Mission-Critical IoT

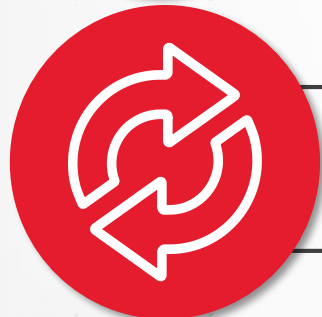
DRIVING FACTORS



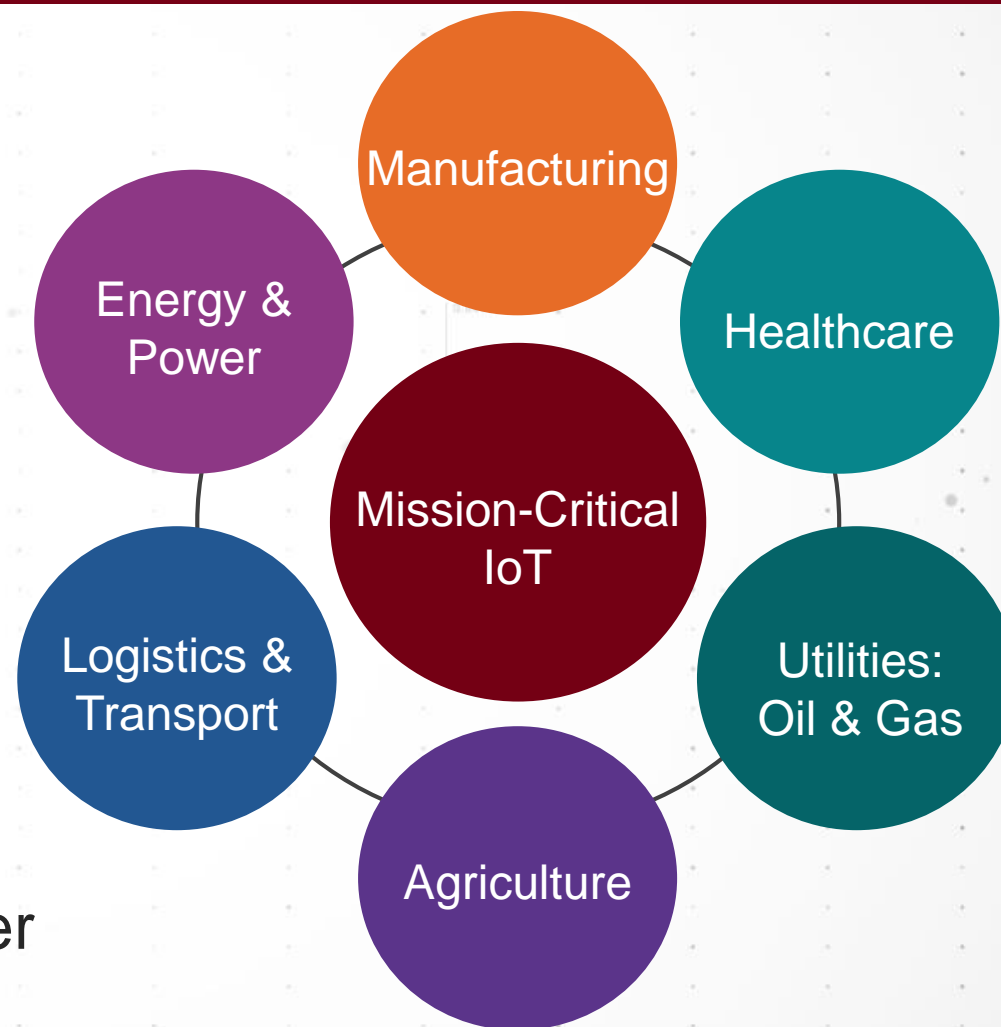
Cost of automation
has declined



Rise in cloud
computing



Significant technology
changes have come together





Mission-Critical IoT

CHALLENGES AND SOLUTIONS

Mission-Critical IoT End-to-End Ecosystem

CHALLENGES IN EACH SEGMENT OF THE ECOSYSTEM

MEDICAL			INDUSTRIAL & ELECTRICAL POWER SYSTEMS			
Healthcare	Wearables	Smart Homes	Smart Cities	Smart Manufacturing	Energy & Utilities	Automotive
			Network & System			
			Wireless Communications			
			Device			



Mission-Critical IoT End-to-End Ecosystem

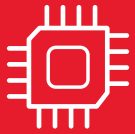
CHALLENGES IN EACH SEGMENT OF ECOSYSTEM

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Network & System						
Wireless Communications						
Device						



IoT Device Test Challenges

SUB-SYSTEMS IN MISSION-CRITICAL IOT DEVICE



Processors

Low-power processors for miniaturizations of IoT devices



Sensors

Accuracy of measurements, reliability and cost concerns



Energy

Power consumption, signal and power integrity analysis



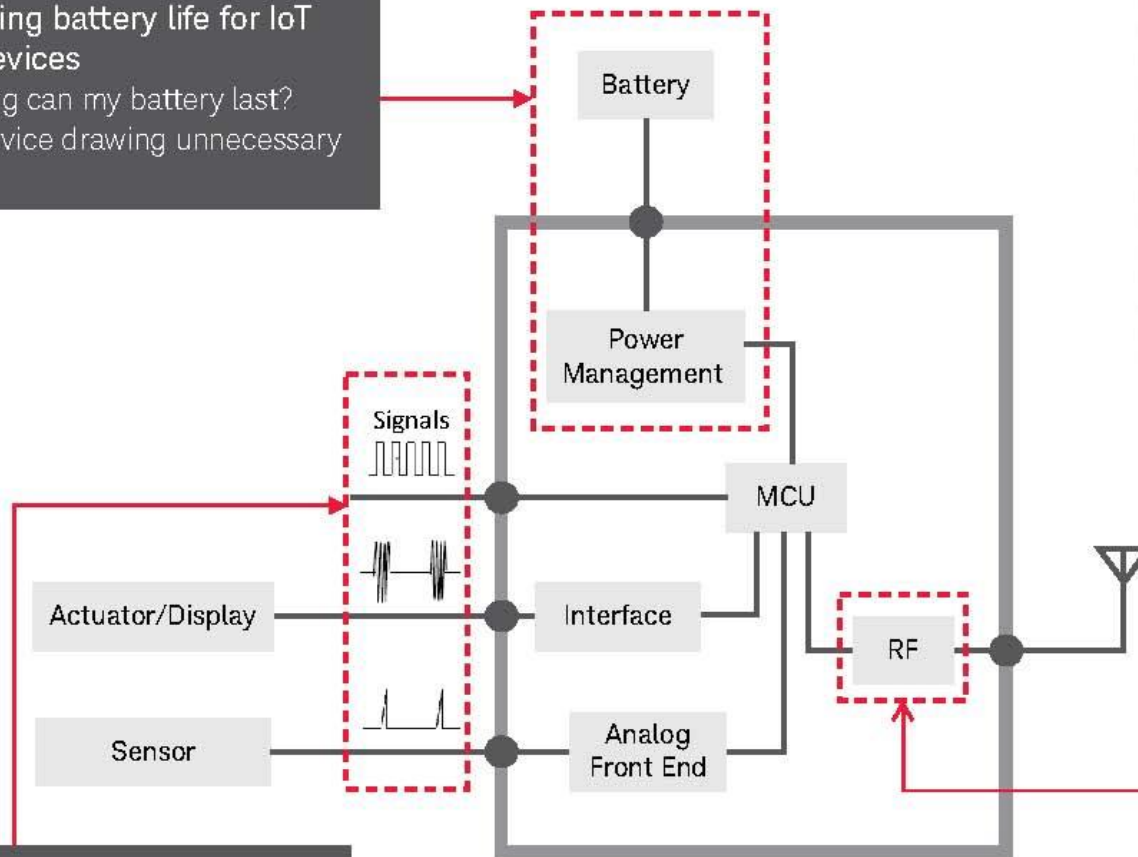
Wireless

Conformance and EMI/EMC compliance test

IoT Device Test Challenges

Maximizing battery life for IoT smart devices

- How long can my battery last?
- Is my device drawing unnecessary power?



EMI compliance and wireless conformance

- How confident am I that my design can pass the conformance test?
- Is my device creating excessive emissions?
- How well can my device tolerate unwanted emissions?

Signal and power integrity issues

- How do I resolve issues involving interference, cross-talk, excessive losses, impedance mismatch, power rail ripples?

Interference due to multi-format wireless connectivity

- Is my device communicating at the right speed and covering the right range?
- Is my device able to work under dense signal environment with multiple wireless signals operating at the same spectrum?

Sensors

RELIABILITY AND DEVICE PERFORMANCE ESSENTIAL TO DENSE DEPLOYMENTS IN REMOTE LOCATIONS

In an IoT device, a smart sensor detects a stimulus and outputs an electronic signal

- Smart sensors are used in lighting, energy/utility management, etc.
- Number of smart sensors per home expected to increase from 7 to 500 by 2022 (Gartner)

Challenges



Dense sensor deployments, remote locations make sensor performance & reliability critical



Broad range of sensors demands scalable test solutions & low cost of test



Remote deployments make battery life a key design factor

Physical parameters

Temperature
Position
Acceleration
Direction
Location
Pressure

Sensor

Electrical signals

DC & AC volts
DC & AC current
Resistance
Capacitance
Frequency
Phase

Energy

LOW-POWER CONSUMPTION, SIGNAL/POWER INTEGRITY IS CRITICAL IN MISSION-CRITICAL IOT

- Increased demand for more functionality in a small form factor
- Need for higher density & speed, lower power, more compact circuit design
- Traces become closer, supply voltage is lowered
- Device power efficiency critical; some run on cell batteries for years

Challenges



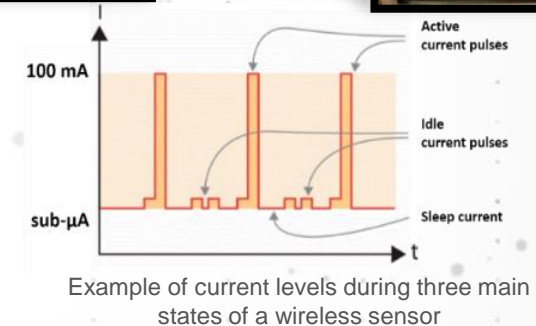
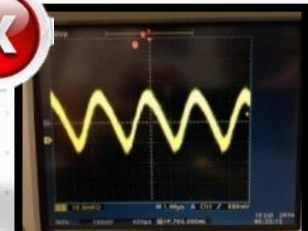
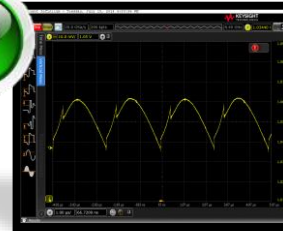
Accurately measuring dynamic current drain across different operating modes over time



Measuring a small AC signal on top of a large DC signal



Identifying & mitigating signal integrity issues that can degrade device performance



Wireless

ENSURING INTEROPERABILITY AND COEXISTENCE IS KEY

- Many wireless standards and technologies have emerged to support a wide variety of IoT applications
- Common technologies include Bluetooth, Zigbee, Z-Wave, WiFi, NFC and LPWA technologies such as NB-IoT, Cat-M1
- All devices need to pass wireless certification test to ensure interoperability within the ecosystem

Challenges



Ensuring devices play well together & in a wide range of environments



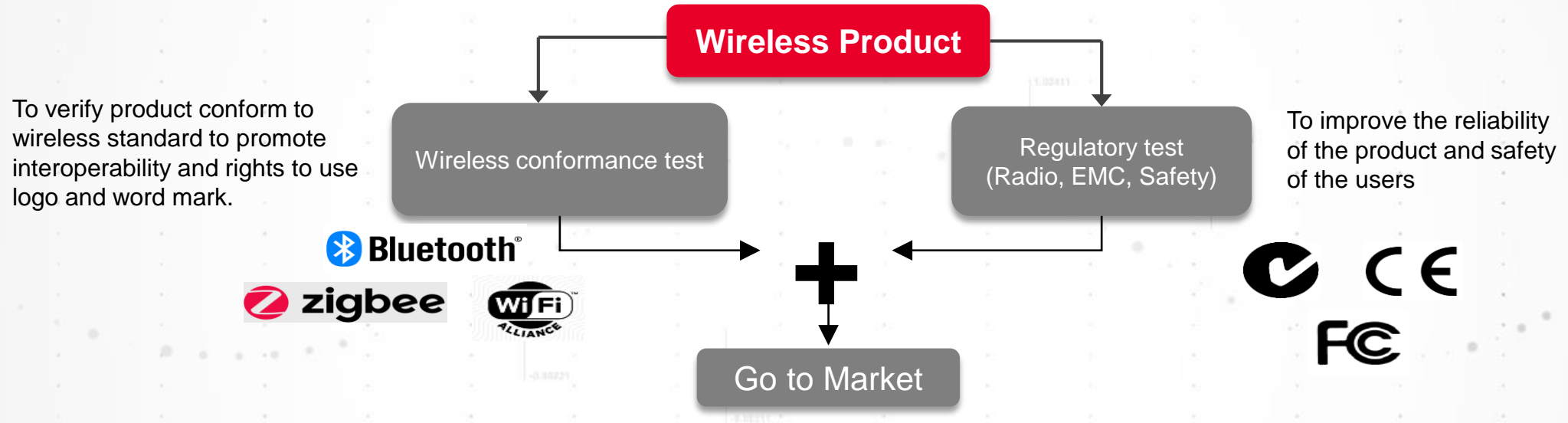
Quickly & cost-effectively testing given manufacturing volumes & market cost demands



Wireless

ENSURING INTEROPERABILITY AND COEXISTENCE IS KEY

Wireless IoT devices must go through wireless conformance and regulatory testing before gaining market entry



Challenges



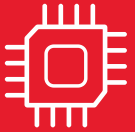
Ensuring devices pass compliance & conformance tests to avoid costly redesigns and delays



Finding & fixing problems early in the design process

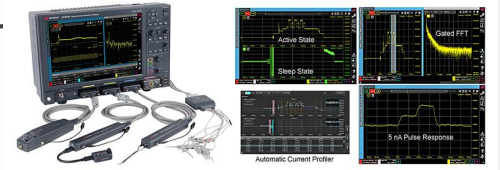
Solutions for IoT Device Tests

SOLUTIONS FOR EACH CHALLENGE IN IOT DEVICE TESTING



Processors

Low-power processors for miniaturizations of IoT devices



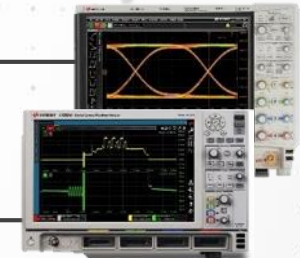
Sensors

Accuracy of measurements, reliability and cost concerns



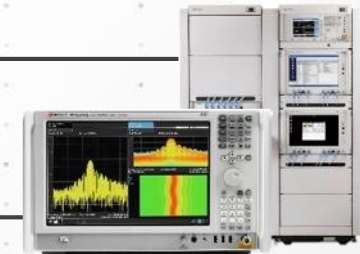
Energy

Power consumption, signal and power integrity analysis



Wireless

Conformance and EMI/EMC compliance test



Solutions for IoT Devices

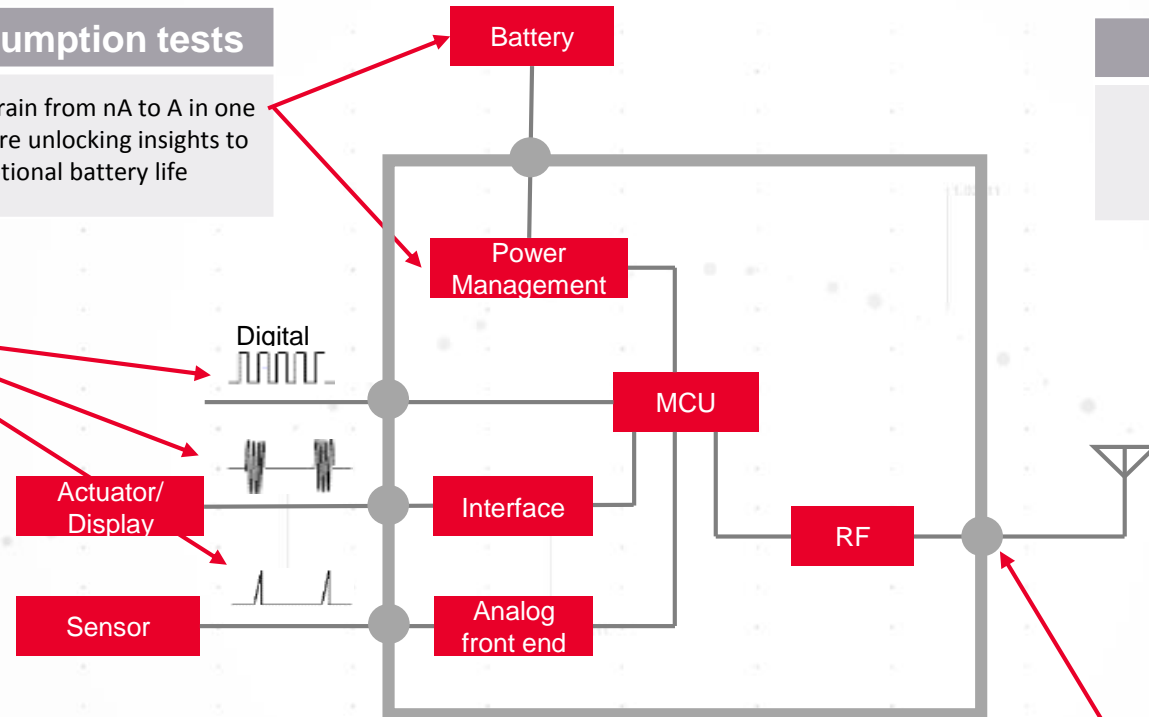
KEYSIGHT OFFERS SOLUTIONS FOR EACH CHALLENGE IN IOT DEVICE TESTING

Power consumption tests

Visualize current drain from nA to A in one pass and one picture unlocking insights to deliver exceptional battery life

Signal & power integrity

Best visibility of your signal and data integrity issues



Regulatory & Conformance tests

One box for EMI and spectrum regulatory pre-compliance tests; conformance test systems for operator acceptance test

Simulation & design software

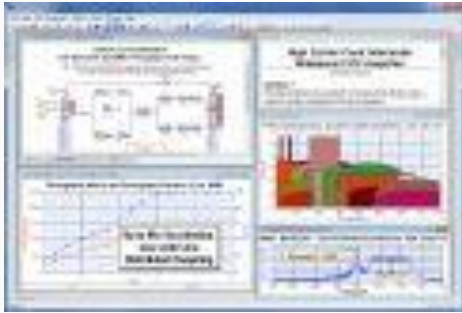
Complete tools for ecosystems from component, IC, Board to System level to ensure reliable operation & robust performance

Wireless & interference tests

Broadest format coverage, wide range of solutions for R&D, manufacturing to field deployment

Simulation and Design Solutions

GAIN A BETTER UNDERSTANDING OF YOUR DEVICE OPERATION AND ITS UNDERLYING PHYSICS



SystemVue

Electronic design automation software used to model and simulate system designs early in the development process

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



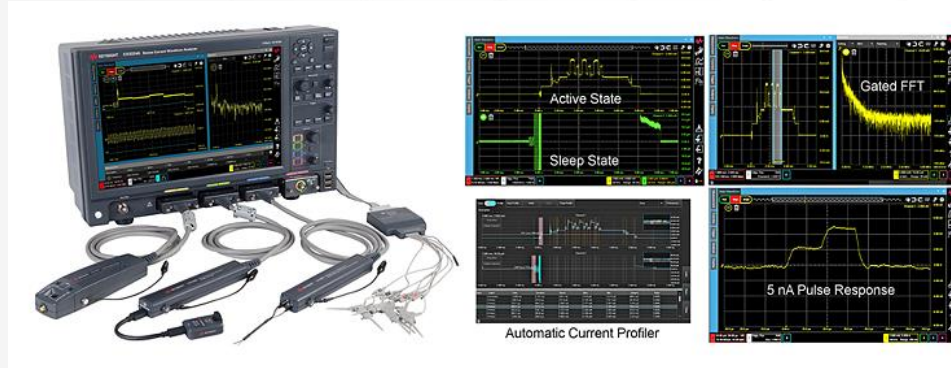
ADS

Fast and accurate system, circuit, and electromagnetic (EM) simulation for RF, microwave, and high-speed digital applications

- 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

Battery Life Test Solutions

FIND THE OPTIMAL BALANCE BETWEEN BATTERY, PROTOCOL & SOFTWARE FUNCTIONALITY TO GET GOOD PERFORMANCE & SERVICE LIFE



CX3300 Series Device Current Waveform Analyzer

Captures waveforms from current or differential sensors with 14- to 26-bit resolution and sampling rates of up to 1 GSa/s.

- Covers sleep to active mode with a single measurement
- Provides excellent visibility of the dynamic current waveform in sleep mode & a precise estimation of power consumption
- 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



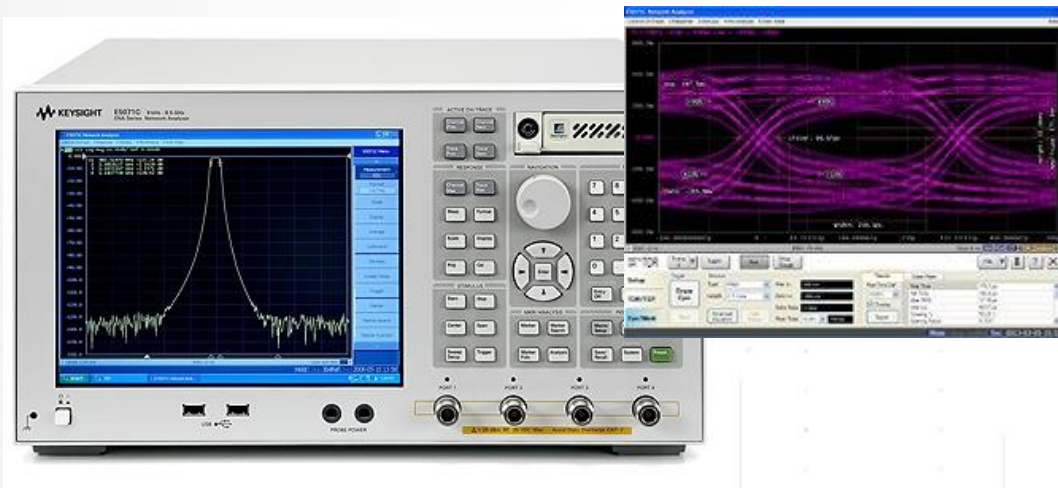
N6705C DC Power Analyzer and N6781/85A Source Measure Unit

Enables fast and accurate power consumption analysis

- Measures a wide range of current from nA to A in one pass
- 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

Signal and Power Integrity Solutions

MITIGATE SIGNAL AND POWER INTEGRITY ISSUES TO CREATE SUCCESSFUL, RELIABLE IOT DESIGNS



E5071C ENA with Option TDR

One-box solution for analyzing high-speed serial interconnects

- Quickly validate and correlate signal integrity 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



Infiniium S-Series Oscilloscope + N7020A Probe

Performs highly accurate power integrity analysis

- Measures periodic and random disturbances, static & dynamic load response, programmable power rail response, and similar power integrity measurements
- Provides mV sensitivity for noise, ripple and transients on DC power rail measurements
- Accurately measures large power rail transitions
- Delivers exceptional signal purity with support for compliance applications like DDR, eMMC, MIPI, USB, and more

Wireless Conformance Solution

CONFIRM PRODUCTS COMPLY WITH SUPPORTED WIRELESS STANDARDS
DURING R&D

T4010S Conformance Test System

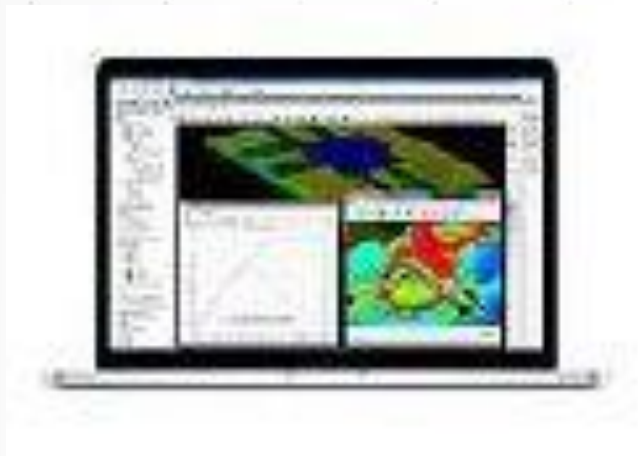
*For design verification during R&D using the same hardware
utilized for conformance testing*

- Performs conformance testing 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 & LTE device acceptance test plans from major network operators.
- Executes test cases with parameters other than those required by 3GPP
- Tests all LTE, NB-IOT, FDD CAT-M1 frequency bands at no additional cost
- Easily and quickly analyzes and reports on test case results
- Allows for remote test system operation



EMI/EMC Test Solutions

ENSURE PRODUCTS MEET EMI/EMC COMPLIANCE REGULATIONS



EMPro Software

Simulation software design platform for analyzing the 3D electromagnetic effects of components such as high-speed and RF IC packages, bondwires, antennas, on-chip and off-chip embedded passives, and PCB interconnects

- 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 create of arbitrary 3D structures possible with a modern, simple GUI



N6141A/W6141A EMI Measurement Application + X-Series Signal Analyzers

Performs pre-compliance radiated and conducted emissions measurements to any international EMC standard and diagnostic evaluation of IoT designs early in the design cycle.

- Features built-in CISPR and MIL-STD compliant bandwidths, detectors and band presets
- Provides automated testing to regulatory Limit Lines with user-selected margins
- Amplitude correction for antennas, LISNs, cables, preamps
- Built-in report generation

EMI/EMC Test Solution

ENSURE YOUR PRODUCTS MEET EMI/EMC COMPLIANCE REGULATIONS

N9038A MXE EMI Receiver

CISPR 16 and MIL STD compliant, EMC compliance test solution

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



Mission-Critical IoT End-to-End Ecosystem

CHALLENGES IN EACH SEGMENT OF THE ECOSYSTEM

MEDICAL			INDUSTRIAL + ELECTRICAL POWER SYSTEMS			
Healthcare	Wearables	Smart Homes	Smart Cities	Smart Manufacturing	Energy & Utilities	Automotive
Network & System						
Wireless Communications						
Device						



Wireless Communications Test Challenges

MAKING SURE MISSION-CRITICAL IOT DEVICES COMMUNICATE
EFFICIENTLY



Wireless Connectivity and Network Readiness

Ensuring network changes does not disrupt quality and performance



Coexistence Interference

Ensuring devices work in a wide range of environment

Wireless Connectivity and Network Readiness

BROAD FORMAT SUPPORT AND EXTREME COVERAGE IS CRITICAL

- Most IoT devices in the market support a range of different wireless communication technologies, such as ZigBee, Bluetooth LE, NFC, and LPWAN
- Devices and network must also support all of these different communication technologies and in a range of different environments where RF conditions may differ dramatically



Challenges



Verifying devices & networks can support a broad range of formats; operate in extreme environments & remote locations



Ensuring networks can support growing numbers of devices and subsequent increase in web traffic

Coexistence & Interference

ACCURATE, EFFICIENT, COST-EFFECTIVE TESTING IS ESSENTIAL

- Increased use of wireless technologies to connect critical equipment (e.g., healthcare, transportation, public safety, smart grid, etc.) and intensive use of unlicensed shared spectrums
- Robust testing protocols for co-existence are needed to verify wireless equipment can perform in the presence of multiple users, with different wireless technologies, in the same spectrum



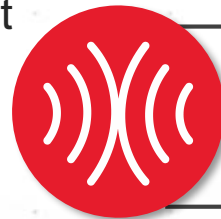
Challenges



Communication standards don't always explain how to perform co-existence test



Some test methods are susceptible to ambient signals; others may not resemble the deployment environment



Performing co-existence testing in a way that is efficient & cost effective

Wireless Communication Solutions

MAKING SURE IOT DEVICES COMMUNICATE EFFICIENTLY



Wireless Connectivity and Network Readiness

Ensuring network changes does not disrupt quality and performance



Coexistence Interference

Ensuring devices work in a wide range of environment



Wireless Connectivity Testing

VERIFY DEVICES CAN INTEROPERATE AND ARE ABLE TO HANDLE MULTIPLE STANDARDS CONCURRENTLY

X-Series Signal Analyzers + Signal Generators

High-performance benchtop solutions for comprehensive frequency domain, time domain, and modulation analysis during IoT design and prototype evaluation

- Accurately perform advanced receiver testing with the latest standards & everything from wide-open real-time analysis to low-cost essential measurements
- Achieve faster throughput & 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



Wireless Connectivity Testing

VERIFY DEVICES CAN INTEROPERATE & HANDLE MULTIPLE STANDARDS CONCURRENTLY



M9420A VXT PXIe Vector Transceiver

Modular solution for testing wireless components and IoT devices during manufacturing

- 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 & analysis
- 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

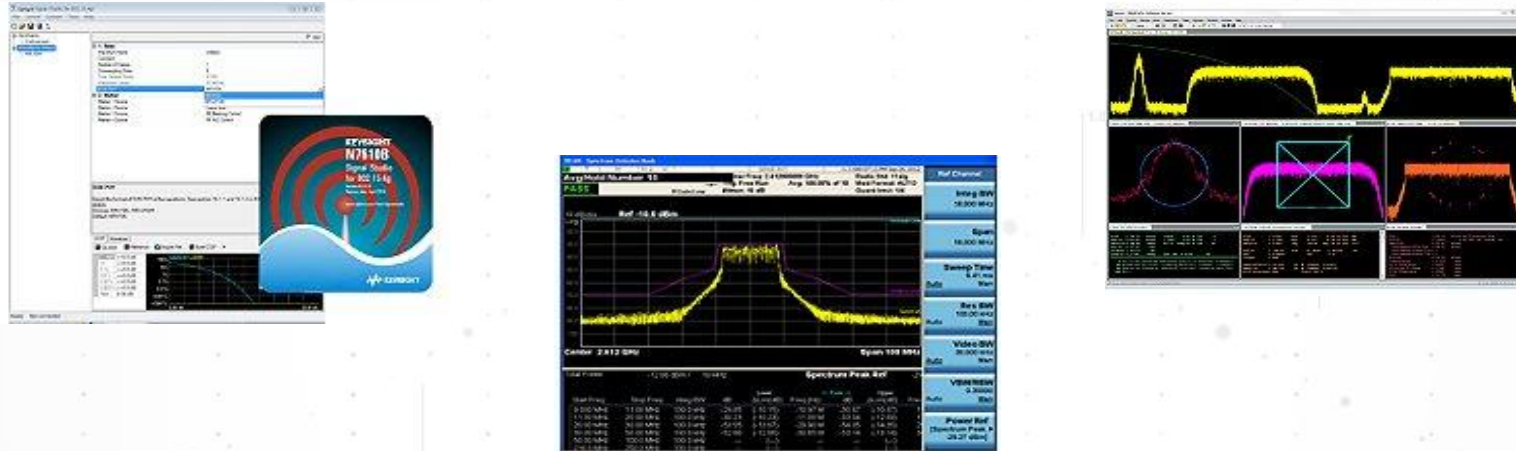


E6640A EXM Wireless Test Set

One-box tester for use in wireless IoT device manufacturing

Wireless Connectivity Testing

VERIFY DEVICES CAN INTEROPERATE & HANDLE MULTIPLE STANDARDS CONCURRENTLY



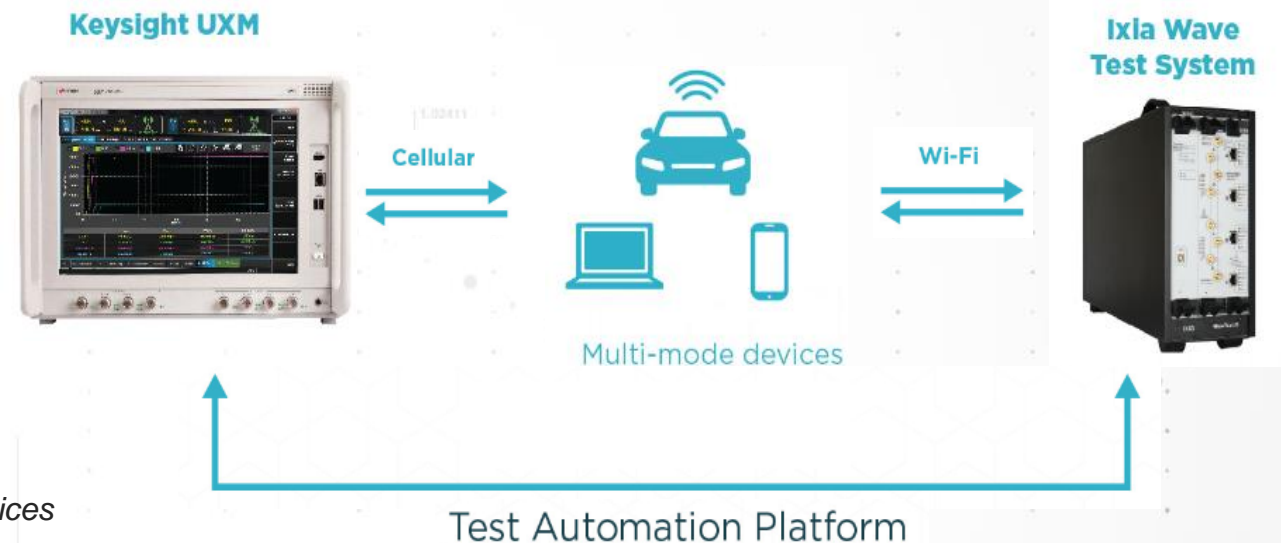
Signal Studio, X-Series Measurement Applications & 89600 VSA Software

Software applications for use with the benchtop, modular and one-box tester platforms

- Signal Studio enables creation of custom and standards-compliant waveforms
- X-Series Measurement Apps provide ready-to-use measurement software for one-button testing of various IoT wireless formats
- 89600 VSA is an industry-leading tool for digital modulation analysis used for deeper troubleshooting of wireless formats

Coexistence & Interference Test Solutions

ENSURE DEVICES & SYSTEMS CAN PERFORM CRITICAL FUNCTIONS IN THE PRESENCE OF MULTIPLE USERS, USING DIFFERENT WIRELESS TECHNOLOGIES



T5510S Cellular + Wi-Fi Emulation System

Comprehensive solution for validating and modeling multi-mode devices in a cellular and WLAN ecosystem

- Measures user experience in realistic diverse interoperable test environments
- Improves productivity by finding issues rapidly before end-users find them
 - Reduces cost by eliminating the need for a life-sized Wi-Fi and cellular test bed
 - Accelerates time-to-market by testing multi-mode devices in unified ecosystem

Network Simulation Test Solution

UNDERSTAND THE REAL-WORLD PERFORMANCE OF WIRELESS IOT DEVICES



Keysight Anite SAS Interoperability Test Solution

Lab-based, easy-to-use network simulation solution currently employed by major Tier 1 carriers in their device acceptance programs

- Verification of Cat M1 capable products to ensure compliance with a North American carrier's Cat M1 focused Test Plan Provides the broadest test coverage for device acceptance programs mandated by Tier-1 mobile operators including, AT&T, Telefónica, T-Mobile (USA), Verizon and China Mobile
- Easy to use interface with cutting-edge functionalities and test cases
- Offers future-proof interoperability

Network Readiness Testing

ACHIEVE HIGH QUALITY AND QOE WITH COMPREHENSIVE TEST



Ixia IxVeriWave

Comprehensive testing to validate the entire Wi-Fi ecosystem

- Build robust, high-performance WLAN equipment using an automated, repeatable, and easily controlled test environment
- Simplified test bed
- Reduce debugging cycle with extensive Layers 1-7 statistics and key performance indicators (KPIs)
- Automated, comprehensive test and scenarios from functional to soak testing.

Software test suites:



Network Readiness Testing

ACHIEVE HIGH QUALITY AND QOE WITH COMPREHENSIVE TEST

Nemo Outdoor Drive Test Solution

Performs indoor/outdoor coverage measurements, measuring and visualizing (with Nemo Analyze) to the operator, the coverage and quality of the network

- Quality-of-experience (QoE) metrics for the services and applications customers are actually using
- Supports all stages of the wireless network lifecycle, network rollout, optimization and network benchmarking, network monitoring and control, network data post-processing and analytics
- Extremely easy to set up, configure and use
- Provides advanced analytics for easy comparison of terminals, IoT devices and networks
- Delivers automated measurements of wireless networks with extensive scripts and large-scale measurement



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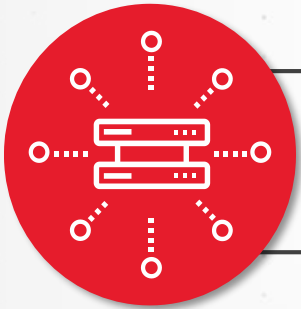
Network and System Test Challenges

ENSURE NETWORK INFRASTRUCTURE IS ROBUST AND SECURE



Applications and Network Security

Verify the stability, accuracy and quality of networks and network devices



Network Monitoring

Know what is happening in your network

Applications and Network Security Test

APPLICATIONS AND NETWORKS HAVE TO SURVIVE & THRIVE IN THE REAL-WORLD

- The wide variety of security solutions used to protect networks from cyber-attacks and traffic anomalies make security infrastructure more complex, difficult to verify
- Complex system interactions pose a serious risk to security performance and network resilience.



Challenges



Validating the security posture of the network with real applications and a complete range of threat vectors



Verifying the stability, accuracy & quality of networks & network devices

Network Monitoring

PRE-DEPLOYMENT ASSESSMENT AND PROACTIVE MONITORING IS CRITICAL FOR MISSION-CRITICAL IOT

- Continuous updates, upgrades to network equipment keep networks in constant flux. Whether existing network devices are capable of supporting a new service is a question often left to chance.
- Continuous and proactive monitoring is also crucial to ensuring reliable, consistent network access & improving response time and user satisfaction.



Challenges



Ensuring network changes do not disrupt service quality & performance



Verifying the network deployed is reliable and provides the best possible quality of experience (QoE)

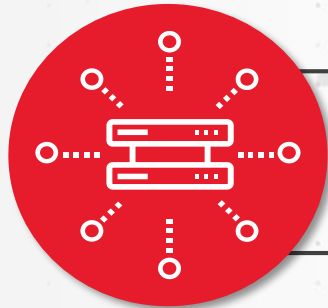
Network and System Test Solutions

GET INSIGHT INTO YOUR NETWORK INFRASTRUCTURE



Applications and Network Security

Verify the stability, accuracy and quality of networks and network devices



Network Monitoring

Know what is happening in your network



Network Performance Assessment & Monitoring

ENSURE NETWORK PERFORMANCE PRE AND POST DEPLOYMENT

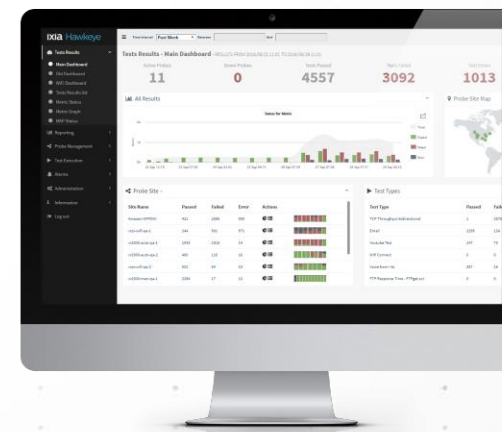
Ixia IxChariot and Hawkeye

Instant performance and reliability assessment and troubleshooting of complex networks from pre- to post-deployment

- Fast, efficient way to verify and quantify performance before shipping 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, monitoring access and troubleshooting to cloud services
- Emulates real-world application traffic used on today's networks in pre-deployment (IxChariot) and live networks (Hawkeye)



With Ixia IxChariot, “what-if” scenarios predict an application’s impact on devices or the network pre-deployment



Ixia Hawkeye helps ensure networks are real-world ready and monitored 24/7 to check/improve QoE of existing and newly deployed services

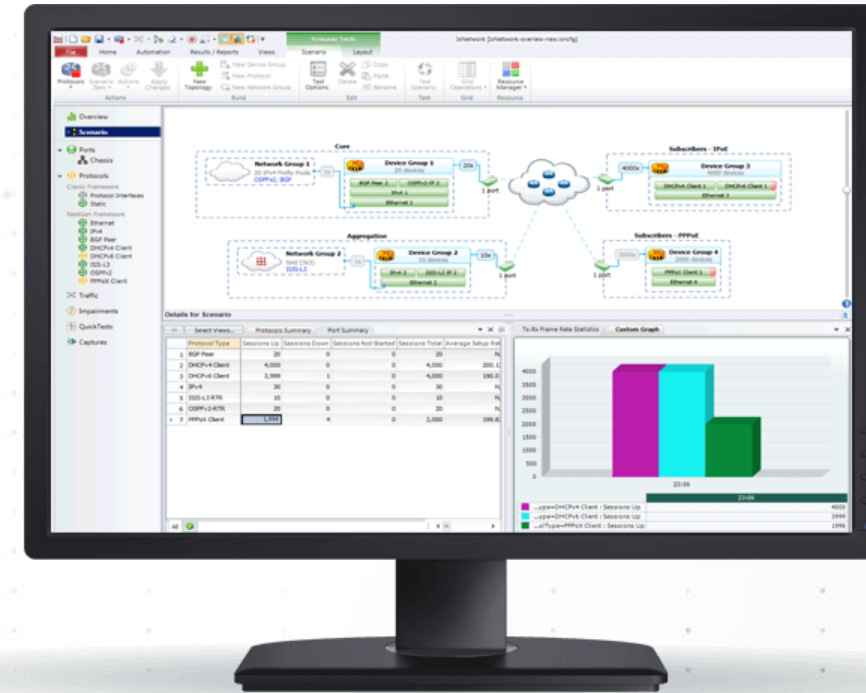
Network Infrastructure Performance Test Solution

ENABLE RELIABLE NETWORKS; PEAK NETWORK PERFORMANCE AND RESILIENCY

Ixia IxNetwork

Tests performance under the most challenging conditions

- 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 make enables users to meet a wide range of performance requirements with minimal resources



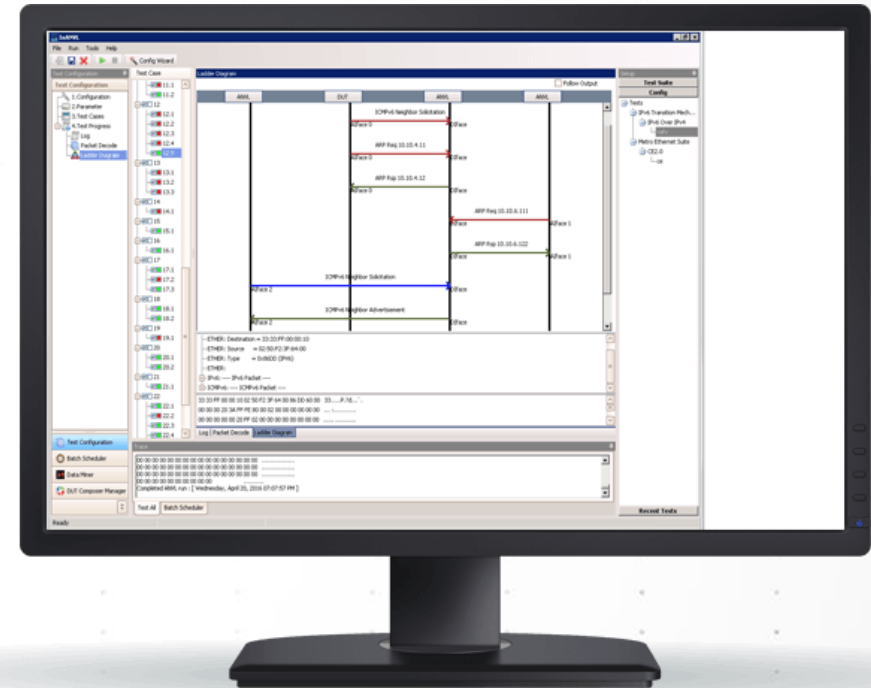
Network Validation Test Solution

VALIDATE PROTOCOL COMPLIANCE & INTEROPERABILITY DURING A PRODUCT'S LIFECYCLE

Ixia IxANVL

Validates protocol compliance and interoperability using a vast array of protocol libraries and utilities

- Emulates large, multi-node networks that previously were cost prohibitive—resulting in more efficient tests and faster product release times, and reduced cost
- Provides fast visibility into how well a device handles traffic from non-complying network components
- Easily expands to accommodate new interface types, protocols, and/or test cases
- Validates a broad set of protocols: including bridging, routing, PPP, TCP/IP, IPv6, IPsec, VPN, MPLS, Carrier Ethernet, Automotive Ethernet, and multicast.



Applications and Network Security Test Solution

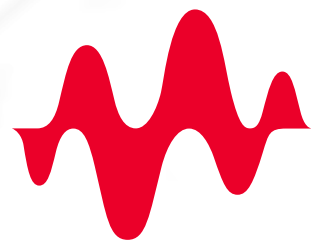
EASY-TO-USE ECOSYSTEM TEST FOR MODERN NETWORK NEEDS



Ixia BreakingPoint

Network security testing and application performance testing from a single platform to harden the performance of network and security devices

- Emulates more than 300 real-world application protocols; model 37,000 security attacks and malware
- Optimizes security tools, including NGFWs and IPS
- Validates service provider networks
- 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



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