DATA SHEET

WaveTest Multi-client Traffic Generator / Performance Analyzer

Highlights

- Automation – 10x more efficient
- Cost of ownership minimized
- Repeatability equals confidence
- Goes beyond conformance and interoperability

Powerful WaveTest Traffic Generator / Analyzers are capable of generating thousands of independent client sessions, each representing a unique user of the network. Traffic can be accurately, repeatedly, and precisely created to assess performance in real-world conditions at scale.

WaveTest delivers unique insight into the functionality, quality and performance of the network, or network component, under test. The solution features native IEEE 802.11 a/b/g/n interfaces as well as 10/100/1000 Mbps Ethernet interfaces.

Figure 1: WaveTest 90 and 20

Key Features

- Automation –10x More Efficient
  - Hundreds of tests run unattended
  - Uninterrupted operation for extended periods of time
  - Complete control over large scale deployment scenarios
- Cost of Ownership Minimized
  - Test time reduced from days to minutes
  - Test coverage increased
  - Bugs revealed early in the QA cycle
- Repeatability = Confidence
  - Get to the root cause & solve problems faster
  - Avoid pitfalls when testing with off-the-shelf clients
- Goes Beyond Conformance & Interoperability
  - Scales to thousands of stateful and independent clients
  - Quantifies real world deployment scenarios
  - Stress tests a complete Wireless LAN (WLAN) network

IxVeriWave Master Test Plan

The IxVeriWave Master Test Plan for WLANs establishes guidelines, best practices, and baseline evaluation criteria for testing the performance and scalability of wireless equipment. The plan outlines the goals, procedures, and expected results for thousands of unique test cases while offering insight into the behavior and performance of wireless LANs. The Master Test Plan offers the flexibility of selectively choosing the most appropriate individual tests needed to verify the functionality and performance of each unique system under test. The guide addresses every aspect of required network testing, from functional verification, performance measurement, and network capacity assessment to system testing and stress testing.

Large-scale Testing

WaveTest is a chassis-based test system that utilizes individual WaveBlades for traffic generation and analysis:

- Each WaveBlade supports up to 4 independent traffic generator / performance analyzers
- Each WaveBlade traffic generator / performance analyzer emulates up to 500 WLAN or 1,000 Ethernet clients across single or multiple subnets
- Gigabit Ethernet traffic generation and analysis at full wire-speed
- Each WaveTest 90 supports up to 9 WaveBlades with a combined capacity of 18,000 individual WLAN clients (STAs)
- Traffic generated and analyzed between WLAN clients and Ethernet clients / servers or mobile WLAN clients
- Multiple traffic flows per client supported with each flow offering stateful traffic at layers 2 through 7
- Real-time port statistics, per flow statistics, packet filters, triggers, and capture capabilities for precise analysis
- Built-in client mobility allows precise roaming of each and every client between any access points (APs) at predetermined time or power settings

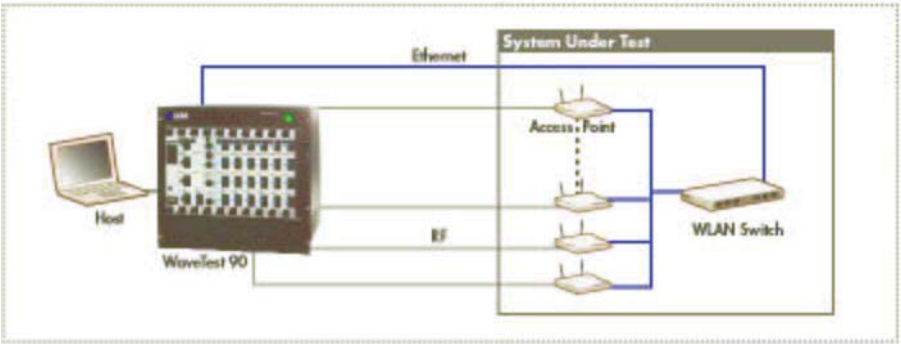

Figure 2: Typical setup supports testing of tens of access points and multiple WLAN switches

Real-World Stateful WLAN Client Traffic Generation

- The WaveBlade traffic scheduler offers fully interleaved traffic flows, creating real mobile clients contending for the shared medium
- The traffic scheduler dynamically adjusts offered load to approximate intended load with load resolution of better than 0.5%
- Client contention can be precisely emulated, guaranteeing real-world behavior in every test iteration
- Client behavior is individually controlled providing accurate control of 802.11, 802.3, and IP characteristics, including power, medium access control, authentication and encryption, frame size, and rate

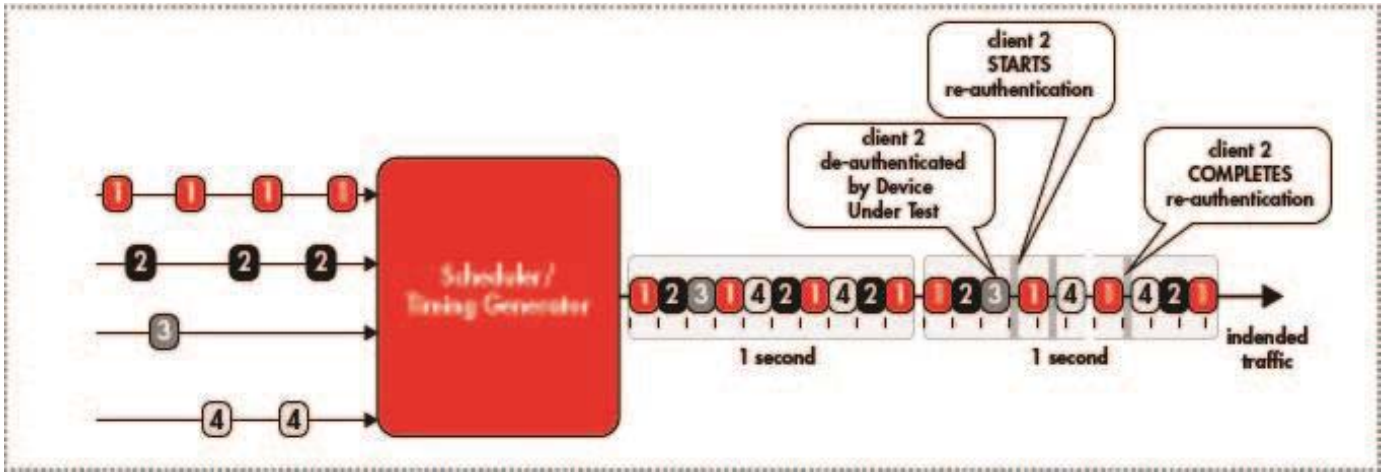

Figure 3: Scheduler interleaves traffic flows contending for the shared mediums

Anatomy of an IxVeriWave Stateful Client

- Each client supports the full MAC per 802.11 standard
- 802.1X supplicant supports full EAP stack per client
- Upper layer protocols (e.g., DHCP and TCP) are implemented using independent protocol state machines
- All state machines for all clients run concurrently
- Every client independently updates its state based on channel conditions e.g. 802.11n clients using protected-mode when .802.11g is detected
- Each Stateful client implements:
    - Carrier deference
    - Collision sensing
    - Random back-off
    - Retransmission
    - Collision emulation
- Multi-level scheduler enables optimum channel utilization, multiple traffic flows per client, and mixing of Constant Bit Rate voice/video traffic with Best Effort data traffic

Stateful Behavior of Every Client

- Layer 2 - 802.11
    - Fully stateful MAC implementation as per IEEE 802.11
- Layer 4 - TCP/IP
    - Fully stateful implementation as per IETF RFC-793, with TCP Congestion Control (as per IETF RFC-2581), including slow start, congestion avoidance, fast retransmit, and fast recovery
    - Line / air rate TCP traffic generation / analysis on every WaveBlade port
    - Per flow / client independent state machine
    - 1,000 stateful TCP flows maintained, per WaveBlade port
- Comprehensive set of TCP connection stats
- WaveQoE: Real-world vertical industry deployment scenarios; pre-configured and easy to model real-world deployment scenarios enable assessment of end-user QoE (Quality of Experience)

Advantages

- Exercise and stress AP client state table with various client connection speeds and RSSI levels at unprecedented scales
- Verify AP's ability to handle concurrent 802.1x port authentications and 802.11i key handshakes for high client loads
- Qualify effectiveness of IDS/IPS and DoS security policies and their impact on AP performance
- Evaluate AP's 802.11e/802.1D/VLAN/SSID based QoS mechanisms to prioritize different traffic types
- Assess robustness of AP's buffer management and load balancing schemes with clients at different power management, FER levels, data rates
- Quantify AP's data plane performance using flow packets of different sizes, protocol types, encryptions, and rates

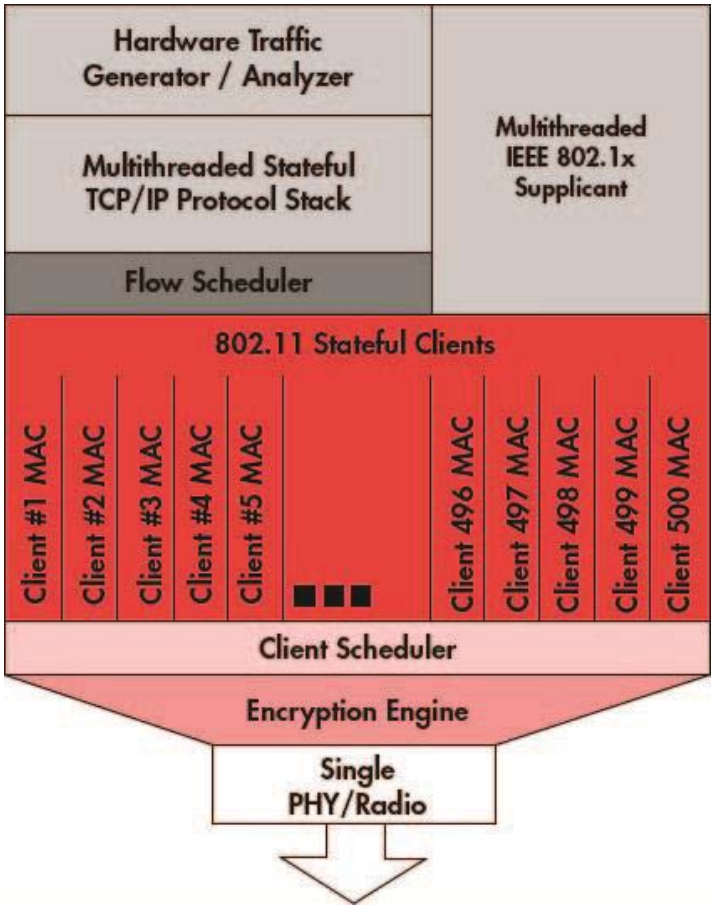

Figure 4: WaveTest Client Stack

Ease of use

- WaveTest offers fully-integrated use-models:
  - WaveDynamix – A user interface offering comprehensive, real-time control and results for functional testing
  - WaveApps - Fully automated tests offering rapid benchmarking and roaming analysis of Network Under Test
  - WaveQoE – End-user Quality of Experience measurements for typical network deployments: corporate office, healthcare, retail, warehouse, hospitality, hot-spot, etc.
- Configuration data, test control, and results are all seamlessly transferable between all use models
- Test results are collected and displayed using an extensive set of predefined counters, user-defined counters, triggers and filters, as well as a 256 MB capture buffer per WaveBlade port
- Comprehensive, management level reports are created automatically in PDF format at the conclusion of each test, and include:
  - Test details; date, version numbers, etc.
  - Measured results
  - Expected results
  - Explanation of how to interpret results

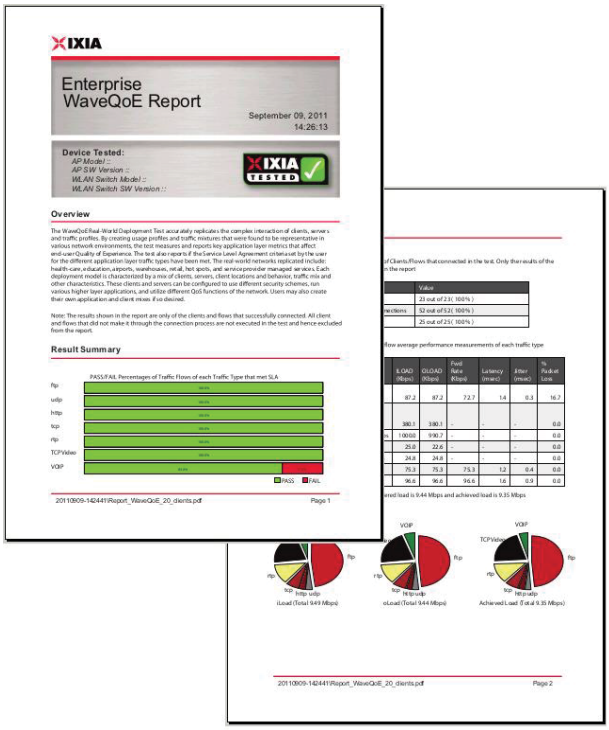

Figure 5: WaveQoE University Report

Testing Issues that Matter Most

Data Plane Test Applications	• Unicast Throughput • Unicast Forwarding Rate • Unicast Packet Loss • Unicast Latency • Multicast Forwarding Rate • TCP Goodput • Power Save Throughput
Control Plane/ Security Applications	• Roaming Benchmark • Roaming Stress • Client Association Database Capacity • AP Load Balancing • Connection Stress Test • Concurrent Connections Test • Thin AP Failover Test • 802.11 Frame Generator / Attack Generator • AAA / RADIUS Server Authentication capacity • Multicast Roaming • TCP Goodput • Power Save Throughput
End-User QoE (Quality of Experience) Including Voice and Video	• WaveQoE – Real-world deployment scenarios & measurement of end-user QoE • VoIP Call Capacity and Performance • Video Capacity and Performance • QoS Service Differentiation • Roaming Service Quality (VoIP Roaming)
WLAN Client Functionality & Performance	• Mobile WLAN client device operation in ideal conditions • Mobile client device operation in real world conditions with ecosystem traffic present • Expected end-user experience • Roaming/mobility impact on end-user experience

Interoperability Testing	• Interoperability of mobile WLAN clients with various access points
	• Wide range of WLAN-enabled client devices supported
	  ○ Laptops
	  ○ VoWLAN Handsets
	  ○ PDAs
	  ○ Scanners
	  ○ WLAN enabled medical monitoring systems
	  ○ WLAN enabled video gateways
	  ○ Healthcare environments

Specifications

Physical Specifications		
	WaveTest 90	**WaveTest 20**
Size	Height: 17.5 inches (44.5 cm) Width: 19.0 inches (48.3 cm) Depth: 21.5 inches (54.5 cm)	Height: 13.5 inches (34.3 cm) Width: 5.6 inches (14.2 cm) Depth: 21.5 inches (54.0 cm)
Weight	Empty: 50.0 lbs (22.7 kg) Fully loaded: 75.0 lbs (34.0 kg)	Empty: 20.0 lbs (9.1 kg) Fully loaded: 27.5 lbs (12.5 kg)
Environmental Specifications		
Temperature	Operating; 0º C to +40º C Storage: -20º C to +70º C	Empty: 20.0 lbs (9.1 kg) Fully loaded: 27.5 lbs (12.5 kg)
Humidity	Operating: 20 % to 80% relative humidity Storage: +40º C at 95% relative humidity, non-condensing	Operating: 20 % to 80% relative humidity Storage: +40º C at 95% relative humidity, non-condensing
Altitude	Operating: -1000 ft. to +6500 ft. (2000 meters) Non-operating: +40,000 ft.	Operating: -1000 ft. to +6500 ft. (2000 meters) Non-operating:+40,000 ft.
Vibration, random	Operating: 5 Hz to 500 Hz, 0.27 Grms Non-operating: 5 Hz to 500 Hz, 2.3G	Operating: 5 Hz to 500 Hz, 0.27 Grms Non-operating: 5 Hz to 500 Hz, 2.3G
Shock	20 G shock tolerance	20 G shock tolerance
Operational Specifications		
WaveBlade Capacity	WaveBlade Management: One WaveBlade Management (WB1000) required in the management slot. (Left most slot in chassis) Traffic generator / RF WaveBlades: Up to 9 traffic generator WaveBlades*	WaveBlade Management: One WaveBlade Management (WB1000) required in the management slot. (Left most slot in chassis) Traffic generator / RF WaveBlades: Up to 2 traffic generator WaveBlades
Power	100/120/230 VAC, 12.5/10.5/5.5 A, 50/60 Hz Automatic line voltage selection	100/120/230 VAC, 4/3/2 A, 50/60 Hz Automatic line voltage selection
AirFlow	Cool air enters at the bottom front and bottom sides Exhaust air exits the top rear	Cool air enters at the base Exhaust air exits at the top
Connectors	Network: Ethernet, RJ-45, 10/100/1000 Base-T LAN Sync In and Sync Out: RJ-45 connectors (Ixia Sync cable required)	Network: Ethernet, RJ-45, 10/100/1000 Base-T LAN Sync In and Sync Out: RJ-45 connectors (Ixia Sync cable required)

	Off load ports (9) RJ45 Connectors, to back plane at each slot AC Power: IEC standard power cord connection External Connections: Other than mains power, all external connections are intended to be to non-hazardous circuits per the requirements of IEC 61010-1	Off load ports (2) RJ45 Connectors, to back plane at each slot AC Power: IEC standard power cord connection External Connections: Other than mains power, all external connections are intended to be to non-hazardous circuits per the requirements of IEC 61010-1
Certifications		
Product Safety Compliance	Listed TUV-USA and TUV-Canada Low Voltage Direction EN6101-1:2010	
Electromagnetic	EU EMC Directive 89/336/ECC, as amended • EN 61000-6-2:2001: Class B Radiated Emissions • EN 55011(AMD. A1:199) Class B Conducted Emissions • EN 61000-3-2:2000: Current Harmonics • EN 61000-3-3:2001: Voltage Fluctuations • EN61000 -6-2:2001: Immunity Class A part 15 FCC Standards for Radiated and Conducted Emissions	

*WaveTest 90 shall not be populated with more than seven RF36024 or WBW3602 cards at one time.

Ordering Information

980-1001

IxVeriWave WaveTest 90 Multi-client Traffic Generator / Performance Analyzer, 9-slot chassis, 19" rack-mountable; includes: 25meter Sync Cable, 5meter Cat5e cable, RJ45 connectors, Power Cord, Installation Guide

980-1002

IxVeriWave WaveTest 20 Multi-client Traffic Generator / Performance Analyzer, 2-slot chassis, portable; includes: 25meter Sync Cable, 5meter Cat5e cable, RJ45 connectors, Power Cord, Installation Guide

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DATA SHEET

RF360xx 802.11ac Test Solution and WBW 360x Traffic Generator / Analyzer

Complete 802.11ac Testing

Incorporating the functionality of three separate test products, Ixia's RF360xx is the world's only test solution capable of testing from the RF layer to the application layer in a single, integrated solution. For the first time, developers will be able to use the same system to:

- Measure RF transmission characteristics such as EVM and spectral compliance
- Benchmark RF receiver performance using highly diverse and realistic traffic
- Generate MAC, IP, and layer 4-7 traffic to characterize a fully integrated device's ability to forward traffic efficiently at rates up to the maximum possible with 802.11ac
- Apply different RF impairments at layer 1 on a frame-by-frame or client-by-client basis

Ixia's 802.11ac solution introduces a radically new architecture that advances the state of the art for RF measurements in communication systems. Built from the ground up to be a full-rate, lab-grade RF and traffic test system without compromise, the solution includes the RF360xx series of RF Traffic Generator /Analyzer modules (L1-7) and WaveBlade Wi-Fi (WBW) 360x Traffic Generator Analyzer (L2-7).

Rather than limit the design by using the memory-buffer techniques common in existing Vector Signal Analyzers (VSA) and Vector Signal Generators (VSG), the RF360xx was engineered with sufficient on-board horsepower to process each and every frame in real time. This approach drives improved testing cycles by dramatically improving test coverage while simultaneously reducing test time.

Highlights

- Real-time PHY layer frame generation and analysis
- Simple point-and-click application support for PHY layer testing
- Up to 500 fully independent, stateful 802.11a/b/g/n/ac clients per port enable precise measurement of critical performance metrics at data rates reaching up to maximum theoretical limits
- Highly scaled setup in a single test-bed to assess real-world deployment levels of controllers, APs, and clients
- Built-in channel models help determine real-world performance in six typical WLAN multi-path scenarios in accordance with recommendations by the IEEE 802.11n task group
- Full support of legacy IEEE 802.11 a/b/g/n traffic generation and analysis for all existing IxVeriWave test suites, applications, and WaveAutomation capabilities.

As a signal generator, the RF360xx is much easier to use than traditional VSG solutions. In combination with Ixia's WaveGen software, users can create a wide range of stimuli --- from simple tones to advanced, time-variant 802.11a/b/g/n/ac frames — using a simple point-and-click user interface. There's no need to develop complex mathematical models to create IQ sequences as this functionality is entirely embedded.

Since the solution has no memory-length limitations, long aggregate frames can be easily created in order to test receivers' ability to handle the performance-boosting aggregate frames. Users can generate complex sequences of frames that test receivers' abilities to dynamically adjust to varying power levels, channel impairments, PHY rates, and so forth as a complex sequence of frames are received. With no need to download waveforms into a memory buffer from the user's PC, the RF360xx performs dramatically faster than previous solutions.

Breakthrough capabilities also result from the RF360xx's architectural advancements and true real-time analysis capabilities lacking in traditional VSAs. Most significantly, the ability to measure every frame means true, worst case measurements can be obtained over extended periods of time.

RF engineers must often determine whether a critical but infrequent issue has been fully resolved. Traditional memory-based VSAs limited by short sample intervals simply miss many events. The RF360xx continues to run all measurements at full rate and can therefore produce min, max, and average results over time. This approach provides RF engineers with a much improved level of confidence in measurements as, without the limits of memory buffers, long aggregate frames critical to 802.11n and 802.11ac performance boosts can be received and analyzed to ensure they are being transmitted coherently for their entire duration.

As with all IxVeriWave products from Ixia, the RF360xx WaveBlade also functions as a Layer 2 to 7 load module. Once RF testing is complete, users can begin leveraging the same load module to assess the performance of the fully integrated design. Capable of behaving as up to 500 fully independent, fully stateful clients, the RF360xx is the fastest, most complete method of verifying the functionality, benchmarking the performance, and conducting system testing of 802.11ac access points (APs).

Engineers can immediately leverage the full suite of existing IxVeriWave applications in conjunction with RF360xx WaveBlades and utilize the IxVeriWave solution's wide array of test tools and methodologies. As an added bonus, users can switch between RF metrics and L2-7 metrics without having to change test setups or re-cable, thus dramatically improving test coverage while reducing test times once again.

RF / PHY Layer Test Configuration

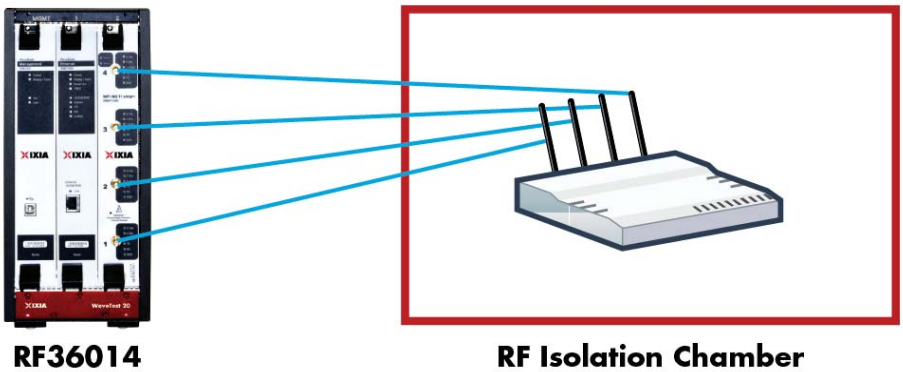

Figure 1: When used for RF testing, the RF36014 is typically directly connected to the device under test via RF cables.

L2-7 Test Configuration

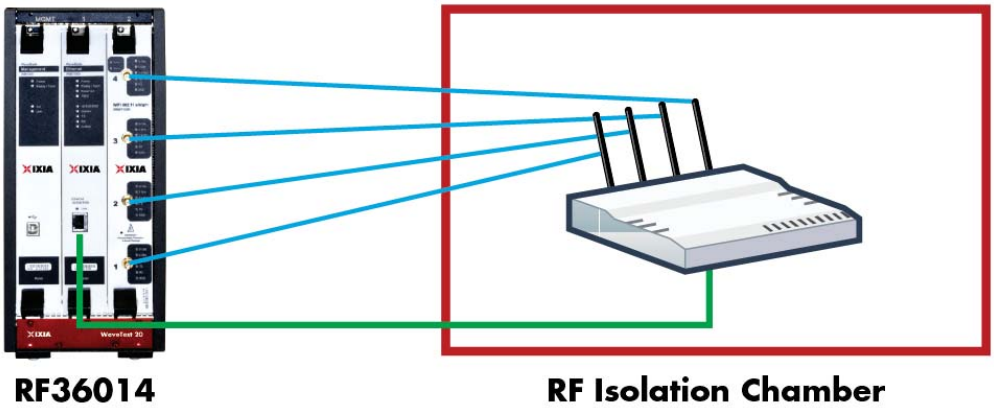

Figure 2: When used for L2-7 testing, the RF36014 is typically directly connected to the 802.11 antennas via RF cables and an Ethernet port used to source and sink traffic from the LAN infrastructure.

Key Features

- Real-time PHY layer frame generation and analysis
- Simple point-and-click application support for PHY layer testing
- Up to 500 fully independent, stateful 802.11a/b/g/n/ac clients per port enable precise measurement of critical performance metrics at data rates reaching up to maximum theoretical limits
- Highly scaled setup in a single test-bed to assess real-world deployment levels of controllers, APs, and clients
- Built-in channel models help determine real-world performance in six typical WLAN multi-path scenarios in accordance with recommendations by the IEEE 802.11n task group
- Full support of legacy IEEE 802.11 a/b/g/n traffic generation and analysis for all existing IxVeriWave test suites, applications, and WaveAutomation capabilities.

Specifications

General Parameters		
802.11 versions supported	802.11a/b/g/n/ac	
Frequency Range / Channels Supported	2.4 GHz	1-14
	4.9 GHz	21, 25
	5.0 GHz	34, 36, 38, 40, 42, 44, 46, 48, 52, 56, 60, 64
		100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140
		149, 153, 157, 161, 165
RF Connectors	Male 50 Ω SMA Connector	

Baseband Control Characteristics	
Supported Modulation Schemes	DBPSK DQPSK CCK (4bits) CCK (8bits) BPSK (1/2) BPSK (3/4) QPSK (1/2) QPSK (3/4) 16-QAM (1/2) 16-QAM (3/4) 64-QAM(2/3) 64-QAM (3/4) 64-QAM (5/6) 256-QAM (3/4) 256-QAM (5/6)
Supported CCK Preamble Types	Short and long
OFDM guard Intervals	400 and 800 nS
PLCP Type	Legacy and Mixed Mode
IEEE Channel Models	• Model A - typical home/small office environment • Model B - typical medium office environment • Model C - typical large office environment • Model D - typical open space environment • Model E - typical large open space environment • Model F - complex environment with many scatters • By-pass mode - to not impose any channel conditions

NOTE: Specifications listed are maximum values unless otherwise noted.

RF Frequency Control		
Frequency Accuracy	Initial Accuracy	+/- 0.2 ppm
	Aging per year	+/- 0.05 ppm

RF Receivers					
Rx Maximum Input Power Level	+15dBm				
RSSI Accuracy	+/- 0.25 dBm TYP, +/- 0.4 dBm MAX (over input range of 0 to +15 dBm)				
	+/- 1 dBm (over input range of -1 to -60 dBm)				
	+/- 1.25 dBm (over input range of -60 to -82 dBm)				
Rx Minimum Sensitivity (typical)	Modulation	Coding Rate	Minimum sensitivity (dBm) 20 MHz channel Spacing	Minimum sensitivity (dBm) 40 MHz channel Spacing	Modulation
	BPSK	½	-82	-79	BPSK
	BPSK	¾	-81	-78	BPSK
	QPSK	½	-79	-76	QPSK
	QPSK	¾	-77	-74	QPSK
	16-QAM	½	-74	-71	16-QAM
	16-QAM	¾	-70	-67	16-QAM
	64-QAM	2/3	-66	-63	64-QAM
	64-QAM	¾	-65	-62	64-QAM
	64-QAM	5/6	-64	-61	64-QAM
	256-QAM	¾	-59	-56	256-QAM
	256-QAM	5/6	-57	-54	256-QAM
	Receiver performance criteria are based on achieving a frame error rate of less than 10% using 4096 octet frames.				
RX EVM	The relative constellation RMS error, averaged over subcarriers, OFDM frames and packets for a data rate of 64-QAM with a coding rate of 5/6 is less than -41dB(0.891%) TYP, -40dB(1%) MAX for power levels less than -10dBm.				

RF Transmitter				
Transmit Center Frequency Tolerance	Typical, 2.5ppm over all operating conditions			
Transmit Power	+14dBm to -50dBm			
Transmit Power Control Resolution	1 db			
Transmit Power Absolute Accuracy	Any single frame shall be generated with an absolute accuracy of +/- 1.0dB measured over the burst of that frame. Multiple consecutive frames from the same client shall be generated such that the initial frame shall have an absolute accuracy of +/- 1.0dB. Subsequent frames from that client shall be generated with an absolute accuracy of +/- 0.8dB.			
Transmit Constellation Error*	The relative constellation RMS error, averaged over subcarriers, OFDM frames and packets for a data rate of 64-QAM with a coding rate of 5/6 is less than:			
	Power level greater or equal to -10dbm		Power level less than -10dBm	
	Typical	Max	Typical	Max
	-36dB (1.585%)	-34db (1.995%)	-36dB (1.585%)	-34db (1.995%)
	*Measured on a per radio basis transmitting a single 20MHz spatial stream.			
Minimum Signal to Noise Ratio	**Power**	**Bandwidth (MHz)**		
	(dBm)	**20**	**(dBm)**	**20**
	-34 to +15	62 db	-34 to +15	62 db
	-40 to -35	57 db	-40 to -35	57 db
	Below -41	Power + 97 (db)	Below -41	Power + 97 (db)

Analyzer Measurements	
Power	Average Power
	Peak Power
	Power Spectral Density
	Power Peak Excursion
Frequency	Center Frequency Tolerance
	Symbol Clock Frequency Tolerance
	Preamble Frequency Error
	RF Carrier Suppression
Spectral	Transmit Spectrum Mask
	Spectral Flatness
	Transmit Center Frequency Leakage
	CCDF
	Occupied Bandwidth
Modulation	Constellation Error
	Error Vector Magnitude (EVM)
	Transmitter Modulation Accuracy
I/Q	Gain Mismatch
	Phase Mismatch

Generation Controls	
Frame Generation	Encoding
	Length
	Frame Transmission Rate
Modulation	a/b/g/n /ac PHY Rates
	Preamble
	FEC
Impairments	Frequency Offset
	Pre/post Encoder Bit Errors
	IEEE Channel Models A-F

Generation Controls					
	RF36011	**RF36012**	**RF36013**	**RF36014**	**RF36024**
Antenna Connections per Test Port	1	2	3	4	4
Number of Test Ports per WaveBlade	1 x 802.11 a/b/g/n/ac				2 x 802.11 a/b/g/n/ac
MIMO Configuration	1x1	1x1 or 2x2	1x1, 2x2, or 3x3	1x1, 2x2, 3x3, or 4x4	1x1, 2x2, 3x3, or 4x4
PLCP Mode	Legacy or Mixed Mode				
IEEE Channel Models	• Model A - typical home/small office environment • Model B - typical medium office environment • Model C - typical large office environment • Model D - typical open space environment • Model E - typical large open space environment • Model F - complex environment with many scatters • By-pass mode - to not impose any channel conditions				
Guard Interval	400 or 800 nS				
Maximum Number of Spatial Streams	1	2	3	4	4
Channel Bandwidth	20 MHz, 40 MHz, 80 MHz				
Aggregation	Tx and Rx: A-MPDU and Block-ACK Rx only: A-MSDU				
Traffic Timestamp Accuracy	50 nS				
Maximum Number of Stateful Clients	500				
Maximum Number of Traffic Flows Generated per Port	1000				

Maximum Number of Traffic Flows Analyzed per Port	131,000
802.11 MAC Control (all parameters)	Independent per client
802.1ax Authentication	PEAP/MSCHAPv2, TLS, LEAP/EAP-FAST, TTLS
Encryption Support	WEP-40 and WEP-104, TKIP (WPA), AES-CCMP (WPA2)
OSI Layer 3 and Layer 4 (IP, UDP, TCP, etc.) Control (all parameters)	Independent per client
Port Counters	Comprehensive set of layer 2, 3 and 4 frame types
Flow and Flowgroup Counters	Frames sent / received, bytes sent / received, out-of-order frames, payload integrity, latency histogram
IPv6	• NDP: Neighbor/router discovery and address assignment • ICMPv6 & DHCPv6 • Multicast Listener Discover (MLDv1. MLDv2) • Dual stack operation of both IPv4 and IPv6 • UDP, RTP, stateful TCP, and multicast flows • Max of 32 IPv6 addresses per client: One Link-local, up to 31 Global
Capture Buffer	256 Mbytes Captures all transmitted and received frames during normal testing Adds IxVeriWave RadioTap header to provide additional debugging information such as PHY rate, RF power, aggregation, detected errors on per-frame basis

Calibration

IxVeriWave chassis and management modules do not require periodic adjustment or calibration. RF360xx modules are calibrated at the factory, and must be recalibrated every 12 months to maintain compliance with stated RF specifications. RF blades that are not calibrated periodically will still meet WBW specifications for as long as they remain in use.

Ordering Information

980-2039
IxVeriWave WBW3601 1 Port, 4 SS, TGA IxVeriWave WBW3601, single port, four spatial stream per port, IEEE 802.11ac multi-client Traffic Generator and Performance Analyzer

980-2040
IxVeriWave WBW3602 2 Port, 4 SS, TGA IxVeriWave WBW3602, dual port, four spatial stream per port, IEEE 802.11ac multi-client Traffic Generator and Performance Analyzer

980-2041
IxVeriWave RF36011 1 Port, 1 SS RF Test, TGA IxVeriWave RF36011, single port, one spatial stream per port, IEEE 802.11ac multi-client Traffic Generator and Performance Analyzer, IEEE 802.11ac Signal Generator and Signal Analyzer WaveBlade.

980-2042
IxVeriWave RF36012 1 Port, 2 SS RF Test, TGA IxVeriWave RF36012, single port, two spatial stream per port, IEEE 802.11ac multi-client Traffic Generator and Performance Analyzer, IEEE 802.11ac Signal Generator and Signal Analyzer WaveBlade.

980-2043
IxVeriWave RF36013 1 Port, 3 SS RF Test, TGA IxVeriWave RF36013, single port, three spatial stream per port, IEEE 802.11ac multi-client Traffic Generator and Performance Analyzer, IEEE 802.11ac Signal Generator and Signal Analyzer WaveBlade.

980-2044
IxVeriWave RF36014 1 Port, 4 SS RF Test, TGA IxVeriWave RF36014, single port, four spatial stream per port, IEEE 802.11ac multi-client Traffic Generator and Performance Analyzer, IEEE 802.11ac Signal Generator and Signal Analyzer WaveBlade.

980-2045
IxVeriWave RF36024 2 Port, 4 SS RF Test, TGA IxVeriWave RF36024, dual port, four spatial stream per port, IEEE 802.11ac multi-client Traffic Generator and Performance Analyzer, IEEE 802.11ac Signal Generator and Signal Analyzer WaveBlade.

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DATA SHEET

WaveBlade Wi-Fi 802.11 a/b/g/n

Highlights

- Up to 500 fully independent stateful clients per port
- Highly scaled setup in a single test-bed to test real-world deployment levels of controllers, APs, and clients
- Ease-of-use through simplified setup including single-click selection of desired channel model
- Built-in channel models help determine real-world performance in six typical WLAN multi-path scenarios

IxVeriWave's Wi-Fi 802.11 a/b/g/n WaveBlade series provides a state-of-the-art, industry-first test solution for evaluating the functionality and performance of IEEE 802.11n-based WLAN networking products. Designed for testing network infrastructure devices including consumer access points (AP) and reference designs, enterprise/carrier grade access points and controllers, and entire Wireless LAN (WLAN) networks, WaveBlades integrate both traffic generation/analysis and multi-path channel emulation capabilities on a single platform.

- The WBW2000 generates traffic from hundreds of independent stateful clients and makes it easy to determine the effects of complex MIMO propagation on 802.11n access point and controller performance by subjecting each individual client to any of the IEEE-defined channel emulation models
- The WBW1104N generates more than 500 Mbps of traffic from 2000 fully stateful clients per blade to enable cost-effective, feature-rich functional and performance testing of 802.11n controllers
- The WBW1001P is a single-port, high-power 802.11 module suitable for open air testing
- WaveBlade Wi-Fi 802.11a/b/g/n line-cards fit into IxVeriWave's WT90 and WT20 chassis and interwork seamlessly with WaveBlade Ethernet line-cards. Modules provide the essential tools necessary to complete various types of testing ranging from functional testing at the AP level to scale testing a large 802.11n infrastructure network.

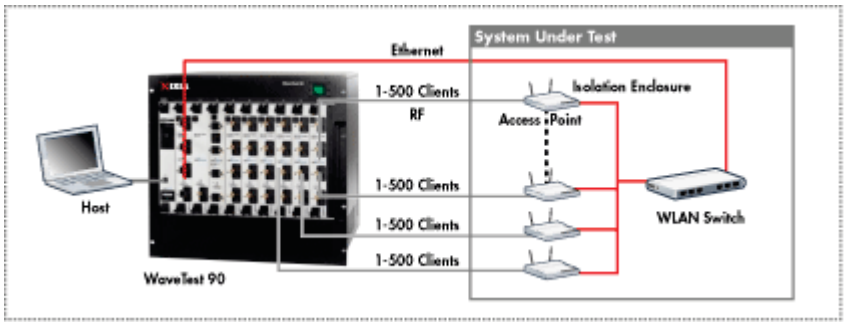

Figure 1: Typical lab test setup using WBW1104

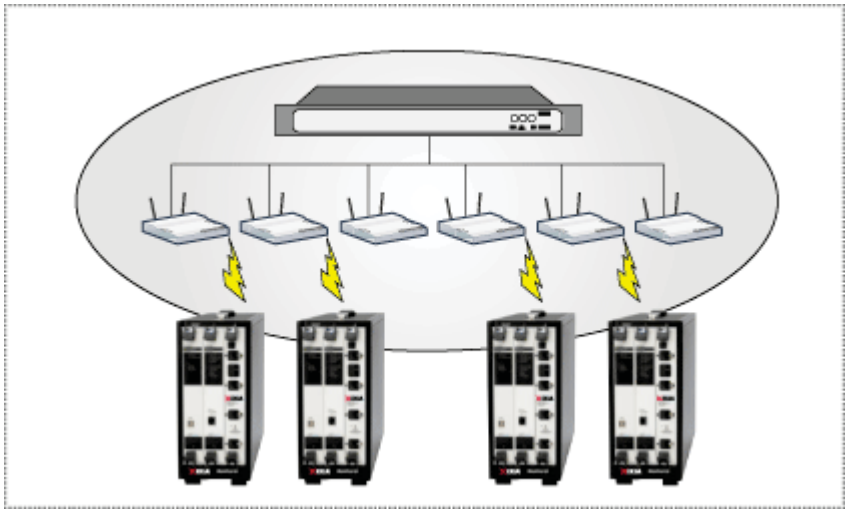

Figure 2: Open-air field test using WBW1101P

Key Features

- Up to 500 fully independent, stateful 802.11n clients per port enable precise measurement of critical performance metrics at data rates reaching up to maximum theoretical limits
- Highly scaled setup in a single test-bed to test real-world deployment levels of controllers, APs, and clients
- Ease-of-use through simplified setup including single-click selection of desired channel model to be used on clients in a wide-array of IxVeriWave Test Suites
- Built-in channel models help determine real-world performance in six typical WLAN multi-path scenarios, per recommendations of IEEE 802.11n task group (WBW2000 only)
- Full support of IEEE 802.11 a/b/g/n traffic generation and analysis simplified setup in a wide array of IxVeriWave Test Suites, applications, and WaveAutomation

Specifications

	WBW1101 WBW1101P	WBW2000	WBW1104N	WBW1601 WBW1601P	WBW2600	WBW1601N
Number of ports	1 x 802.11 a/b/g/n port	1 x 802.11 a/b/g/n port	4 individual and independent 802.11 a/b/g/n ports supporting multi-user and multi-test beds	1 x 802.11 a/b/g/n port	1 x 802.11 a/b/g/n port	4 individual and independent 802.11 a/b/g/n ports supporting multi-user and multi-test beds
Maximum number of ports per chassis	9	9	36	9	9	36
MIMO configuration	Single spatial stream per port	Support for 2x2, 2x3, 3x3 with spatial multiplexing	Single spatial stream per port	Single spatial stream per port	Support for 2x2, 2x3, 3x3 with spatial multiplexing	Single spatial stream per port
PLCP mode	Legacy, Mixed-mode					
Operating frequency	2.4 GHz, 4.9 GHz and 5 GHz					
IEEE channel models	Model A – typical home/small office environment Model B – typical medium office environment Model C – typical large office environment Model D – typical open space environment Model E – typical large open space environment Model F – complex environment with many scatters By-pass mode – to not impose any channel conditions					
Guard interval selection (per client control)	800 / 400 ns					
Spatial streams (NSS)	1	1 to 3	1	1	1 to 3	1
HT PHY rates	6.5 Mbps to 157.5 Mbps (MCS Index 0 to 7)	6.5 Mbps to 450 Mbps (MCS Index 0 to 23)	6.5 Mbps to 157.5 Mbps (MCS Index 0 to 7)	6.5 Mbps to 157.5 Mbps (MCS Index 0 to 7)	6.5 Mbps to 450 Mbps (MCS Index 0 to 23)	6.5 Mbps to 157.5 Mbps (MCS Index 0 to 7)
FEC coding rates	1/2, 2/3, 3/4, 5/6					
Channel bandwidth	20 MHz, 40 MHz					
Legacy PHY rates	1, 2, 5.5, 6, 9, 11, 18, 24, 36, 48, 54 Mbps					
Aggregation types	• Tx and Rx: A-MPDU and Block-Ack • Rx only: A-MSDU					
Transmit power control	• -50 dBmto 0 dBmin 1 dB steps (WBW1101) • 0 dBm to +15dBm in 1 dB steps (WBW1101P)	-50 dBm to 0 dBm in 1 dB steps	-50 dBm to 0 dBm in 1 dB steps	• -50 dBmto 0 dBmin 1 dB steps (WBW1601) • 0 dBm to +15dBm in 1 dB steps (WBW1601P)	-50 dBm to 0 dBm in 1 dB steps	-50 dBm to 0 dBm in 1 dB steps

Transmit power accuracy	+/-1.0 dB (Typical)					
Optional in-path attenuation	• 20 db (WBW1101) • No (WBW1101P)	20 db	20 db	• 20 db (WBW1601) • No (WBW1601P)	20 db	20 db
Receive Sensitivity	• -82 dBm min for 8x10-2 FER (1Mbps CCK) • -65 DBm min for 10x10x2 PER (64-QAM 5/6))					
Operation Channels	• 2.412 to 2.484 GHz: 1 to 14 • 4.940 to 4.990 GHz: 21, 25 • 5.180 to 5.320 GHz: 36, 40, 44, 48, 52, 56, 60, 64 • 5.500 to 5.700 GHz: 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140 • 5.740 to 5.825 GHz: 149, 153, 157, 161, 165					
Antenna interface connector configurations	1 connector	3 connectors	• 1 connector per port • 4 total per blade	1 connector	3 connectors	• 1 connector per port • 4 total per blade
Antenna interface connectors	• SMA female connector, standard thread • AC coupled, 50 Ohms					
Traffic timestamp accuracy	50ns					
Maximum number of stateful clients per port	500	500	• 500 per port • 2,000 total per WaveBlade	500	500	• 500 per port • 2,000 total per WaveBlade
Maximum number of traffic flows generated per port	1,000	1,000	• 1,000 per port • 4,000 total per WaveBlade	1,000	1,000	• 1,000 per port • 4,000 total per WaveBlade
Maximum number of traffic flows analyzed per port	131,000	131,000	• 131,000 per port • 524,000 total per WaveBlade	131,000	131,000	• 131,000 per port • 524,000 total per WaveBlade
802.11 MAC control (all parameters)	Independent per client					
802.1x authentication support	PEAP/MSCHAPv2, TLS, LEAP/EAP-FAST, TTLS					
Encryption support	WEP-40 and WEP-104, TKIP (WPA), AES-CCMP (WPA2)					
OSI layer 3 and layer 4 (IP, UDP, TCP, etc.) control (all parameters)	Independent per client					
Port counters	Comprehensive set of layer 2, 3 and 4 frame types					
Client control	Control frames, management frames, action frames					
Flow and flowgroup counters	Frames sent / received, bytes sent / received, out-of-order frames, payload integrity, latency histogram					
IPv6				• NDP: Neighbor/router discovery and address assignment • ICMPv6 & DHCPv6 • Multicast Listener Discover (MLDv1. MLDv2) • Dual stack operation of both IPv4 and IPv6 • UDP, RTP, statefulTCP, and multicast flows • Max of 32 IPv6 addresses per client: One Link-local, up to 31 Global		

Calibration

IxVeriWave chassis and management modules do not require periodic adjustment or calibration. Similarly, WBW modules are calibrated at the factory and maintain advertised specifications without requiring additional calibration.

Minimum Requirements

IxVeriWave Test System	1 x IxVeriWave WaveTest 90™ or WaveTest 20™ system
Host Computer	x86 based PC with 1 GHz processor and 256 MB RAM Windows XP SP2, or Linux (2.6 or higher kernel level) with Web Browser installed to manage the WaveBlade

Ordering Information

980-2008
IxVeriWave WBW (WaveBlade Wi-Fi) 1601 802.11 a/b/g/n Multi-client Traffic Generator/Performance Analyzer for wireless IEEE 802.11 a/b/g/n networks; low-power SISO single port; includes Standard Accessory Package A; IPv6-capable

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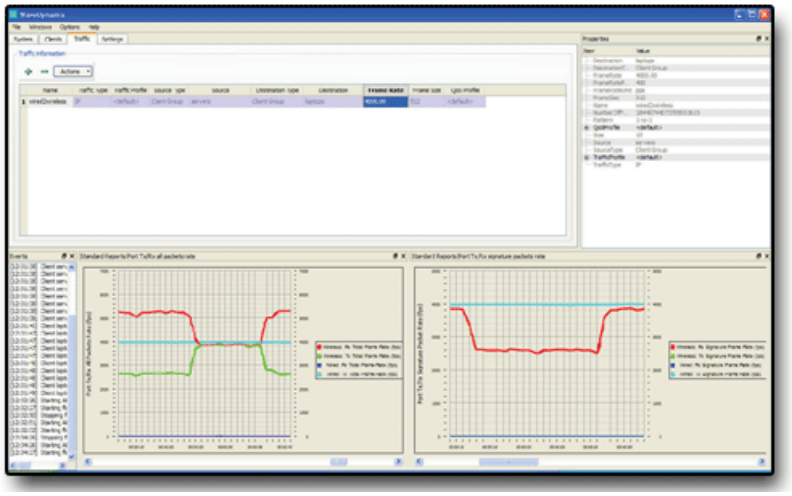
WaveDynamix

An application that works with the WaveTest system, WaveDynamix helps development and test engineers at network equipment manufacturers (NEMs) and service providers quickly create a broad range of functional and scalability tests for 802.11 and Ethernet devices. More than 2500 pages in length, the base 802.11, 802.11n and 802.11ac standards encompass a great deal of complexity necessitating new high-quality products to be thoroughly tested to verify performance and stability. WaveDynamix greatly simplifies this process by allowing functional components to be easily tested in isolation and then integrated and tested as part of the complete system.

Highlights

- **Decoupled Management and Data Planes**: First 802.11 test tool that allows the tester to control the management plane and the data plane independently.
- **Highly Interactive Interface**: Networks are highly dynamic and intelligently respond to changing conditions.
- **Generates Normal and Custom Traffic**: Generate either fully compliant UDP or stateful TCP traffic, or create fully customized packets.
- **Integrated Trouble-shooting**: A wealth of diagnostic information and troubleshooting tools are available to facilitate problem isolation.



WaveDynamix screenshot

Key Features

- **Decoupled Management and Data Planes**: WaveDynamix is the first 802.11 test tool that allows the tester to control the management plane and the data plane independently to deliver unprecedented control. This capability can be particularly useful for hardware engineers who can send and receive frames without first having to form an association between a client and an access point (AP).
- **Highly Interactive Interface**: Networks are highly dynamic and intelligently respond to changing conditions. With WaveDynamix, testers can easily change network conditions on the fly by adding new clients or changing flow rates, and immediately view the results in real-time charts and graphs.
- **Generates Normal and Custom Traffic**: Users can generate either fully compliant UDP or stateful TCP traffic, or create fully customized packets independently or concurrently. For developers, the custom frame capability can be very useful in testing content-specific features such as filters and rogue AP detection. Custom frames can also be used to generate DoS attacks on a network infrastructure while simultaneously viewing the forwarding behavior of compliant traffic.
- **Integrated Troubleshooting**: A wealth of diagnostic information and troubleshooting tools are available to facilitate rapid problem identification and isolation. An integrated capture/decode capability runs on every port during the test session and allows users to view physical and logical layer information in the protocol decodes using the IxVeriWave radio tap header whenever unexpected events occur.
- **Exploratory Testing**: While it is often clear that a device under test (DUT) is not producing the expected results, the cause of the unexpected behavior can be difficult to isolate. Experimentation may be necessary to identify the source of problems before fixes can be created or a more formal regression suite can be introduced. WaveDynamix provides a flexible and efficient tool for trialing different test conditions and examining responses both in the test equipment and the device being tested.
- **“Over time” Results**: Many problems in wireless networks can be traced to the stateful interaction between clients and servers, and show up as system instabilities. WaveDynamix provides the user the ability to create these dynamic interactions and to view the device’s response over time. The network’s ability to gracefully handle these various conditions is critical to delivering a high-quality system.
- **Functional Testing**: The granular control of WaveDynamix makes it very easy to support a variety of functional and negative testing. The interactive control of WaveDynamix allows the user to halt the state changes in the test bed and to verify that the DUT is in the proper state during each step of the test. In addition to identifying functional failures, this WaveDynamix capability also facilitates rapid identification of the cause of any functional failures.
- **802.11ac Testing**: For 802.11ac networks to approach the advertised rates of the technology, it is necessary to understand how well each acceleration mechanism works independently and as part of a standard configuration. WaveDynamix enables users to quickly assess the static and dynamic performance of 802.11ac networks with a variety of client types, traffic flows, QoS configurations, and physical layer conditions during all stages of product development.

Port Specifications

Label	Description
Port Type	**802.11 or Ethernet**
Ethernet autonegotiation	On, forced, or manual
Ethernet Speed	10, 100, or 1000 Mbps
Ethernet duplex	Half or full
802.11 channel	1-14, 21, 25, 36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140, 144, 149, 153, 157, 161, 165 or deferred to client configuration
802.11 contention	On or off
Event and Event Rate Counters	**All Counters Maintain an Event Count and One Second Rate Per Port Unless Otherwise Noted**
Addressing	Tx/Rx unicast, tx/rx multicast, and tx/rx broadcast frames
Basic	• Tx/Rx total, tx/rx signature, tx/rx FCS errored, tx failed, tx failed ACKs, rx beacon and rx PAUSE • 1>Tx / Rx total rate in Mbps • Min, max, 1 second average, and total test average latency in mS
Statistical Chart	**All charts Display Per Port Results Once Per Second**
Available charts	Tx/Rx all frames rate (fps), tx/rx all frames rate (Mbps), tx/rx signature frame (fps), tx/rx average signature frame latency over the last 1 second

Client Specifications

Label	Description	
Client Type	**802.11 or Ethernet**	
802.11 client PHY	802.11ag, 802.11b, 802.11n, or 802.11ac	
802.11ag or 802.11b settings	Tx Flow Bit Rate, Tx Management Bit Rate, Tx Power, Frame Error Rate	
Maximum supported Spatial Streams for 802.11ac	4	
	80.211n	802.11ac
MCS index	0-23	0-9
Bandwidth	20 or 40 MHz	20 or 40 or 80 MHz
Guard interval	Short or Standard guard interval	
A-MPDU aggregation	Enabled or disabled	
Channel model	Bypass or IEEE models A-F	
802.11 MAC		
CTS-to-self	Enabled or disabled	
Management retries	0 – 10	
Data retries	0 – 10	

802.11 Performance		
Probe before association	Unicast, broadcast, or disabled	
Reauthenticcte if deauthenticated	Enabled or disabled	
Advertise WMM support	Enabled or disabled	
Power save	Enabled or disabled	
Power save listen interval	1 – 65535 beacon intervals	
WMM uAPSD	Enabled or disabled	
WMM uAPSD service period length	Request delivery 2, 4, 6, or all buffered frames per service period	
Layer 2 General		
MAC address	Fully configurable	
Layer 2 802.11		
SSID	Fully configurable	
Channel	1-14, 21, 25, 36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140, 144,149, 153, 157, 161 or 165	
Authentication	Open, shared, WPA, WPA2, DWEP, or LEAP	
Encryption	None, WEP40, WEP104, TKIP, AES-CCMP	
Type	PSK, EAP-TLS, EAP-TTLS, PEAP-MSCHAPv2, LEAP, EAP-FAST, EAP-SIM, EAP-AKA	
Credentials	Credentials fully configurable by client, configurable parameter determined by encryption and type	
Layer 2 Ethernet		
VLAN tag	Enabled or disabled	
VLAN ID	0 - 4094	
VLAN CFI	Enabled (1) or disabled (0)	
Layer 3		
Address acquisition	DHCP or static	
ARP timeout	1 - 20,000 mS, configurable to 1 mS resolution	
Static IP Addresses		
IP address	Fully configurable	
Subnet mask	0 to 32 bit netmask	
Default gateway	Fully configurable	
Authentication	Open, shared, WPA, WPA2, DWEP, or LEAP	

Event Counters	**All Counters Maintain an Event Count Per Client Since the Start of the Test Session**	
Client statistics	• ARP handshakes: successful, failed and retries • DHCP handshakes: successful, failed and retries • Authentication handshakes: successful, failed and retries • Association handshakes: successful, failed and retries • Probe handshakes: performed and retried • Tx Pings, Rx Pings, Rx Deauthentication frames, and Rx Disassociation frames	

Test Specifications

Label	**Description**
Traffic General	
Traffic type	IP or custom
Intended frame rate	1 – 1,488,095 frames per second
Custom Traffic	
Custom frame contents	Fully specifiable except IEEE 802.11 sequence number and frame control fields and FCS fields on Ethernet and 802.11 interfaces
Custom traffic source	Any port in the test configuration
IP Traffic	
Frame size	64 – 1518 bytes
IP traffic source	Client or client group
IP traffic destination	Client, client group, or user-specified IP address
L4 protocol	ICMP, UDP, or stateful TCP
TCP source port	1 - 65535
TCP destination port	1 - 65535
TCP window size	2 - 65535
UDP source port	1 - 65535
UDP destination port	1 - 65535
ICMP type	Echo request, echo reply, destination unreachable, source quench, redirect
ICMP code	0 – 255
L4 Payload Fill	
Mode	Fixed or repeating
Contents	Custom, all zeroes, all ones, F0:F0:F0:F0, A0:A0:A0:A0, 70:70:70:70, or 50:50:50:50
QoS	Configurable Per Flow

State	Enabled or disabled
WMM or VLAN user priority	0 - 7
WMM EDCA parameters	Adopt from BSS advertisements, or manually specify AIFSN, ECWmin, ECWmax, and retry limit
WMM ADDTS handshake	Enabled or disabled
TSPEC configurable parameters	TID / TSID, nominal MSDU size, minimum PHY rate, mean data rate, surplus bandwidth allowance, and flow direction
IP diffserv	Enabled or disabled
IP DSCP	0 - 63
Event Counters	Counters Maintained Per Flow Since the Start of the Test Session Unless Otherwise Noted
Flow statistics	• Tx/Rx counters: frames, frame rate, frame bytes, IP packets, IP bytes • Offered load (Mbps), forwarding rate (Mbps) • Instantaneous packet loss and instantaneous packet loss rate • Packet loss, lost n sequential frames (n=2, 3, 4, and 5) • Max Latency, total latency, average latency over last 1 second , latency of last rx frame (mS) • Rx out of sequence frames, sequence number of last rx frame • Rx frames with bad payload • Rx smoothed inter-arrival jitter (mS)
Statistical tables	Multiple flow statistics are updated once per second in a tabular view
Number of flows in table	1 - 16
Data displayed per flow	Any of the flow statistics
Statistical charts	All charts display per flow results once per second
Number of flows in table	1-16
Flow statistics	Tx frame rate, rx frame rate, Rx smoothed inter-arrival jitter (mS), packet loss, packet loss rate, lost n sequential frames (n=2, 3, 4, and 5), offered load (Mbps), forwarding rate (Mbps)

Ordering Information

980-3027

IxVeriWave WaveDynamix Functional Test Tool,1 port; tests the functional behavior and performance of 802.11a/b/g/n WLAN and Ethernet network devices; supports a flexible configuration, high degree of test control, and the ability to dynamically change test conditions and plot results over time; license sold on a per WaveBlade port basis; includes one WaveAgent license for each WaveDynamix port license purchased

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