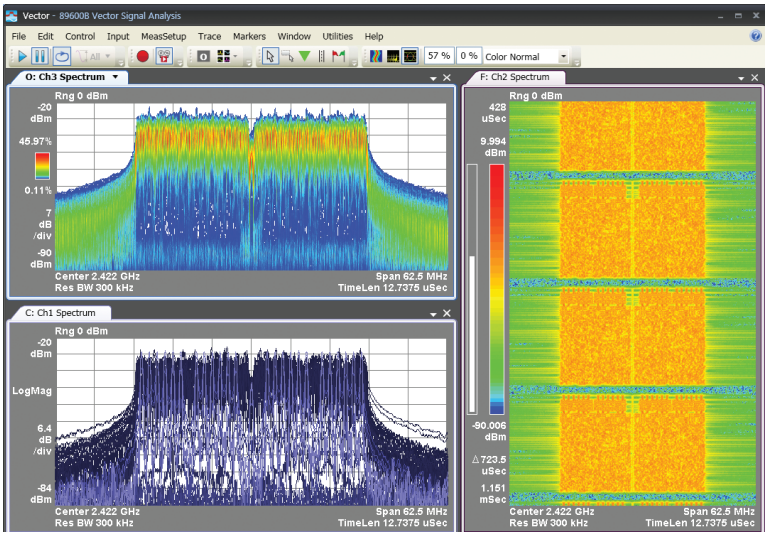
Keysight Technologies

89601B/BN-B7R WLAN 802.11a/b/g Modulation Analysis
89601B/BN-B7Z WLAN 802.11n Modulation Analysis
89601B/BN-BHJ WLAN 802.11ac Modulation Analysis
89600 VSA Software

Technical Overview



Key Features

- Perform measurements on signals from the latest WLAN standards such as IEEE 802.11ac
- Demodulate all standard-specified modulation formats (up to 256QAM) and bandwidths (up to 160 MHz)
- Analyze up to 8x8 MIMO 802.11ac signals and up to 4x4 MIMO 802.11n signals
- View important signal details with unlimited trace displays and markers
- Verify and troubleshoot PHY layer performance and errors down to the bit level

KEYSIGHT TECHNOLOGIES

Table of Contents

WLAN Modulation Analysis 2
Analysis and Troubleshooting 3
Software Features 8
Key Specifications 10
Additional Resources 11

WLAN Modulation Analysis

Gain greater insight into wireless LAN signals with the 89600 VSA software for 802.11a/b/g/n/ac modulation analysis. Option B7R provides spectrum, time and modulation quality measurements for WLAN 802.11a/b/g signals.

Options B7Z and BHJ expand upon the WLAN modulation analysis provided by Option B7R to include 802.11n (Option B7Z) and 802.11ac (Option BHJ). Option B7Z adds an advanced troubleshooting and evaluation toolset specifically designed to handle the challenge of analyzing an IEEE 802.11n MIMO signal. Option BHJ adds the capability to analyze and troubleshoot the latest 802.11ac signals.

802.11 WLAN standards are among over 75 signal standards and modulation types supported by the 89600 VSA software. The 89600 VSA software is a comprehensive set of tools for demodulation and vector signal analysis. These tools enable you to explore virtually every facet of a signal and optimize your most advanced designs. As you assess the tradeoffs, the 89600 VSA software helps you see through the complexity.

Technology overview

The IEEE 802.11 WLAN standard includes several extensions: the IEEE-802.11a/g and the older HiperLAN2 standards, both of which use burst OFDM signals, with 20 MHz bandwidth.

The IEEE 802.11b/g standard defines a direct sequence spread spectrum (DSSS) signal, with complementary code keying (CCK) modulation, plus an optional packet binary convolution code (PBCC) mode, and an optional shorter preamble.

The 802.11g standard modifies the 802.11b standard, adding the ability to use 802.11a OFDM-formatted signals and an optional 802.11b-compatible DSSS-OFDM mode, plus other modifications.
The IEEE 802.11n standard includes up to 4x4 multiple input, multiple output (MIMO) and 40 MHz channel bandwidth for higher data throughput. High-throughput (Greenfield) mode, non-HT (legacy) mode, and HT mixed mode are three operating modes of 802.11n.

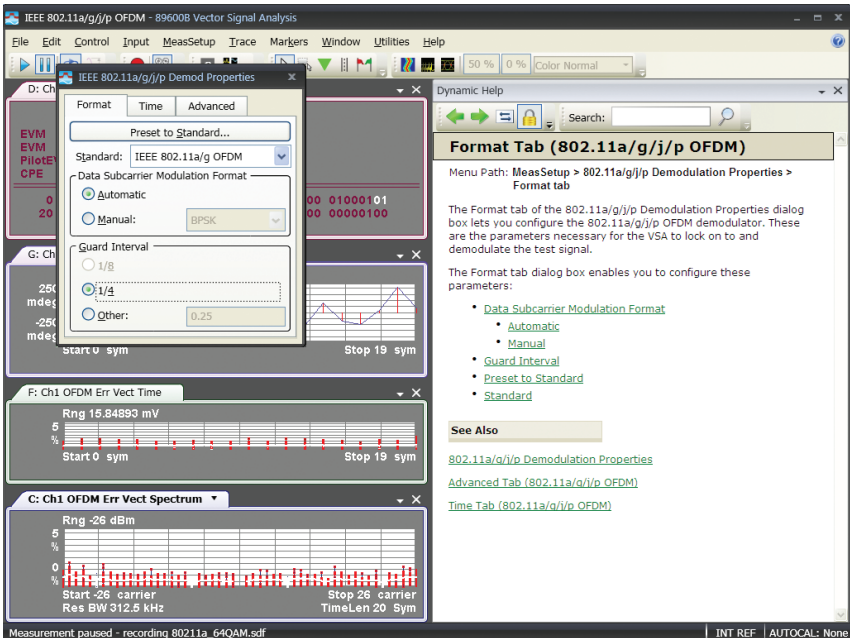
The latest WLAN technology, 802.11ac, achieves very high throughput (VHT) of 1Gb/s with wider channel bandwidths (up to 160 MHz), higher density modulation format (up to 256QAM) and higher order MIMO (up to 8x8).

Analysis and Troubleshooting

Analyze a wide range of WLAN formats

Option B7R analyzes IEEE 802.11a/g/j/p/, HiperLAN2 OFDM formats, as well as IEEE 802.11b DSSS/CCK/PBCC formats. Optional PBCC modes, short preamble, and CCK preamble of the CCK-OFDM format in IEEE 802.11g are also supported.

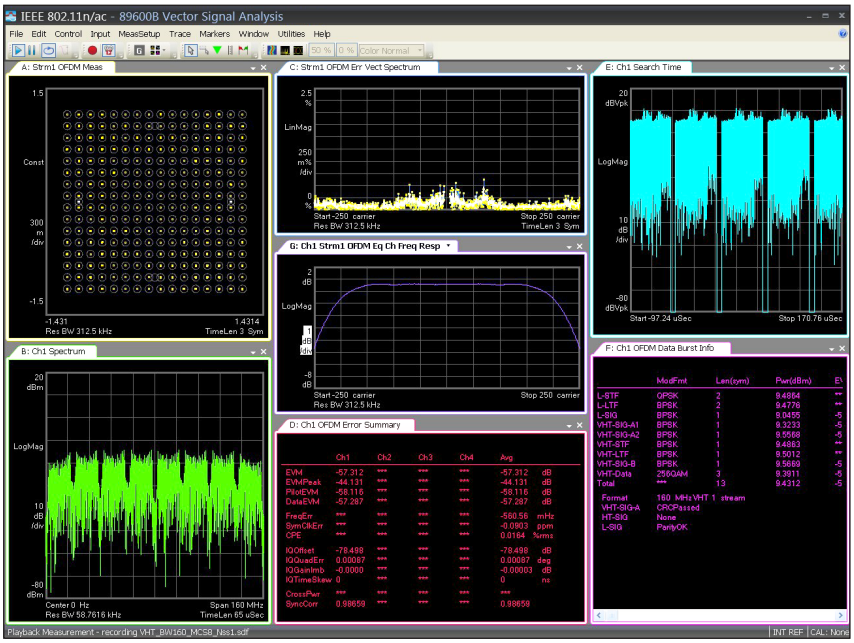
Use Option B7Z with the appropriate 2- or 4-channel front end to measure 802.11n MIMO signals with HT-greenfield, HT-mixed, HT-duplicate, and non HT-duplicate 20 and 40 MHz systems.



Use Dynamic Help to access the Help text on the Demod Properties Format tab and learn about WLAN formats and presets available for Option B7R, Option B7Z or Option BHJ. Detach the Dynamic Help window and move it to the side for easier viewing as it follows your menu choices. Lock it to stay on important Help data topics.

Option BHJ, which requires Option B7Z, provides 802.11ac modulation analysis. Option BHJ enables you to view and troubleshoot the entire breadth of the 802.11ac modes, providing greater insight and confidence in validating chipsets and devices regardless of the 802.11ac format implemented.

- Support of all signal bandwidths, including 20, 40, 80 and 160 MHz. The 160 MHz bandwidth is supported in both contiguous and non-contiguous modes
- Support of all 802.11ac modulation formats, from BPSK up to 256QAM
- Support for up to 8x8 MIMO
- Support for multi-user MIMO

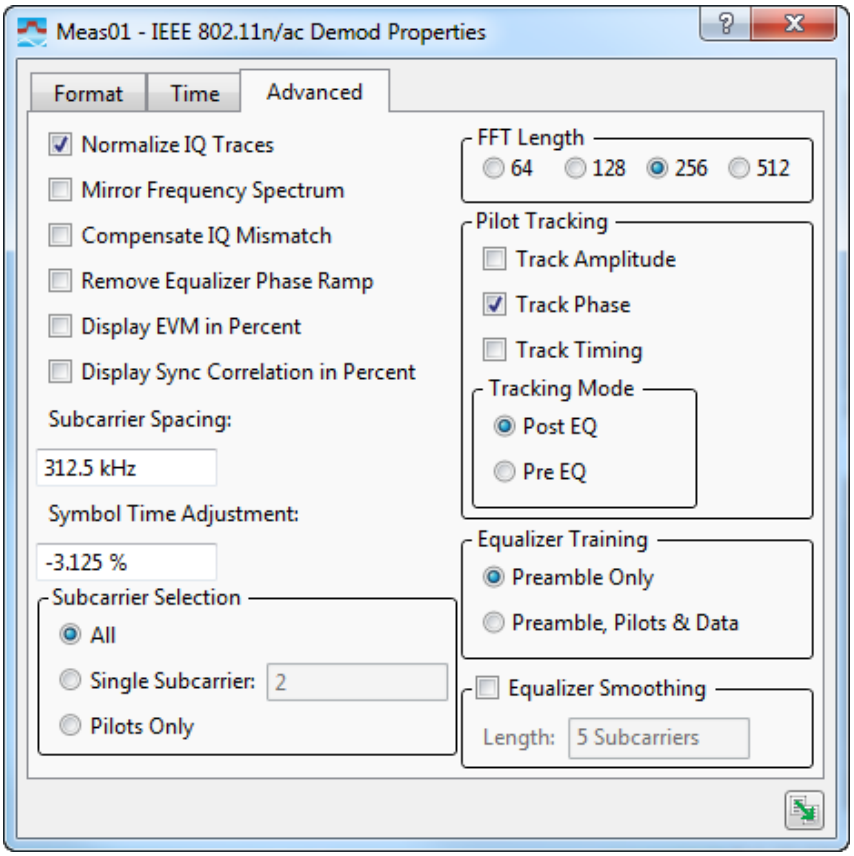


Troubleshoot and analyze 802.11ac signals with 160 MHz bandwidth and 256QAM.

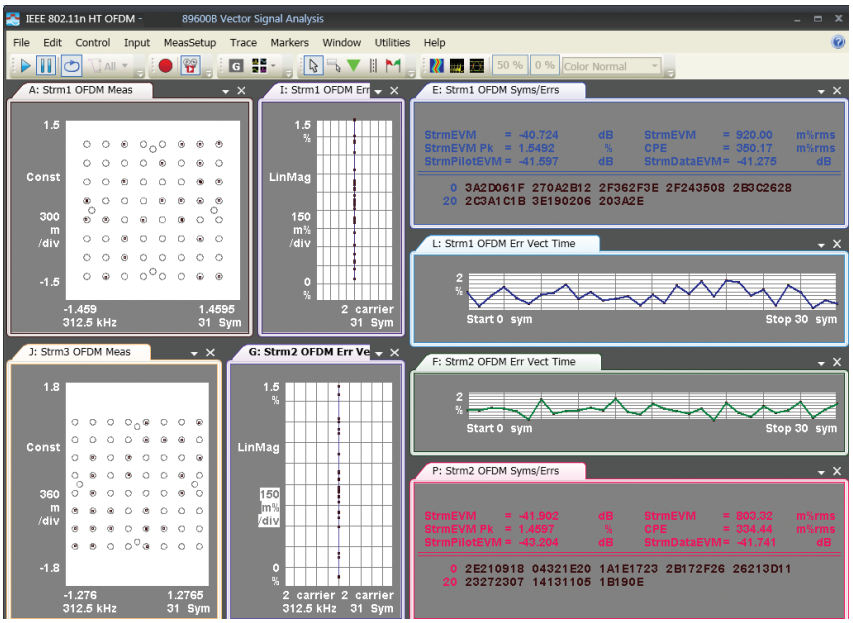
Easy set-up with complete parameter control

Quickly set up measurements with standard presets, while maintaining the ability to adjust a wide range of signal parameters for troubleshooting. For example, with OFDM systems, you can modify sub-carrier spacing, symbol timing offset, synchronization reference, pilot tracking, equalizer training sequence and more. For IEEE 802.11b/g signals, you can adjust the clock timing and track phase, and you can select the descramble mode. Automatically detect, despread, descramble and demodulate payload data for IEEE 802.11b/g WLAN-DSSS/CCK/PBCC formats.

For 802.11n/ac, in addition to standard presets and automatic detection, Option B7Z and Option BHJ provide key parameter detection from SIG symbols for fast and easy demodulation.



Each option lets you adjust many format-specific parameters using the Advanced tab, providing greater insight into your signal under different conditions, and uncovering anomalies you won't see any other way.

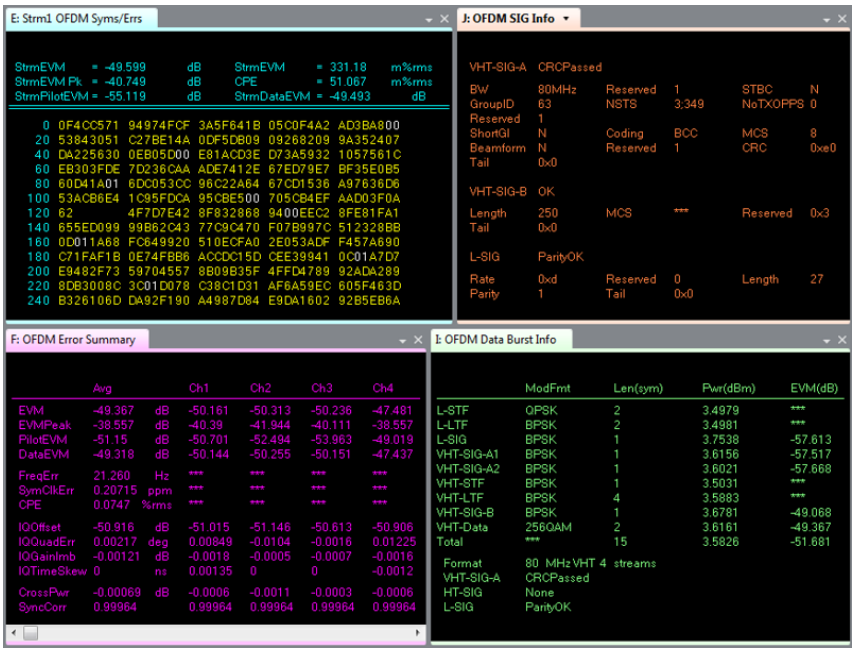


Here the Advanced tab was used to select a single carrier. The constellation, EVM and symbols/error table all show results for only the chosen carrier.

Evaluate modulation quality down to the bit level

Make EVM measurements at the level needed: overall burst, per symbol, or per each subcarrier in a symbol. Examine the symbols and error table for information on average EVM, peak EVM, demodulated bits, detected header information and more.

For MIMO systems, Option B7Z and Option BHJ provide detected stream bits, a MIMO channel matrix, data burst information, multiple data streams, cross channel results, plus NxN channel matrix values. Automatically determine spatial mapping matrix, subcarrier modulation format, burst length and more.



Options B7Z and BHJ provide in-depth, bit-level analysis for 802.11n/ac MIMO signals with error summary tables, detected burst info and decoded SIG info.

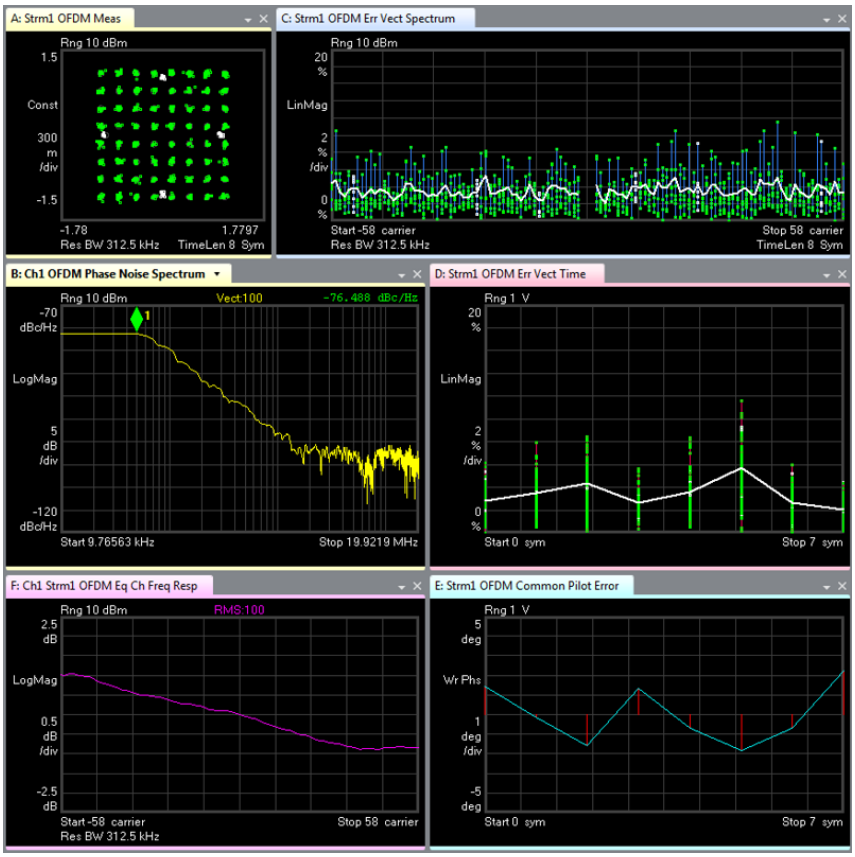
View key 802.11ac MIMO parameters such as multiple constellations, error summary and multi-user info for up to 8 transmit streams simultaneously.

Powerful error measurements let you look at signal performance in detail

Error vector spectrum, error vector time, channel frequency response, correction, common pilot error per symbol, and more, are available for WLAN formats. Compound constellation displays let you determine and display all modulation formats in the burst.

For MIMO systems, Option B7Z and Option BHJ add channel, stream, and cross channel data, providing the most complete and robust signal and error characterization in the industry.

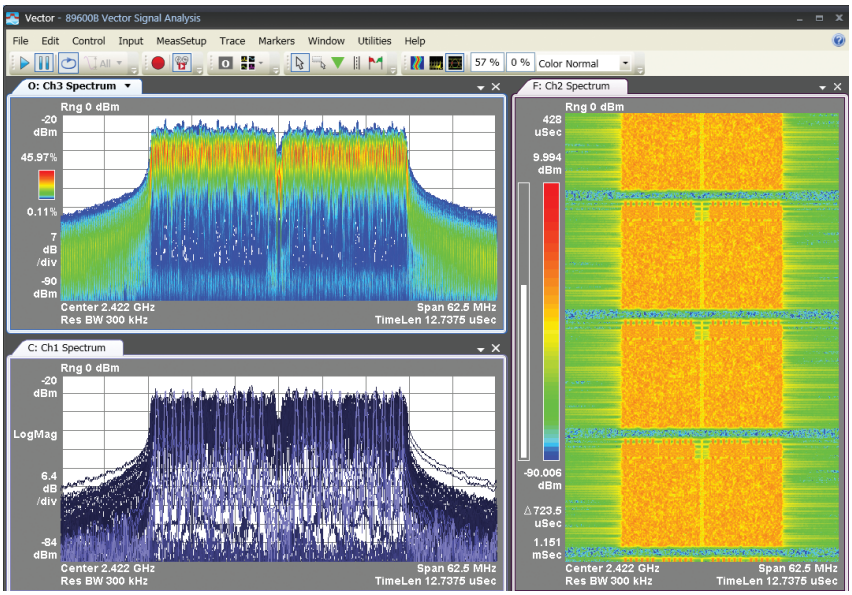
Phase noise, often the dominant cause of EVM in OFDM systems, can be characterized within the 802.11n/ac demodulation measurement directly using the phase noise spectrum trace.



The 89600 VSA software lets you view an unlimited number of simultaneous traces, showing results such as EVM vs. frequency or time, IQ errors, equalizer channel frequency response, common pilot error, phase noise spectrum and more.

Troubleshoot with insightful tools

Powerful display modes include cumulative history, spectrogram, and digital persistence. Use signal capture to capture and record transient events, or share the signal for collaborative analysis with remote colleagues. Additional tools, like overlap processing, let you effectively "slow down" the apparent measurement for more in-depth analysis.



All 3 displays show the spectrum of this WLAN signal recorded using signal capture. Digital persistence (lower left) highlights the signal's amplitude behavior over a short time period. The spectrogram (right) provides information on frequency behavior over time. The cumulative history (upper left) provides statistical analysis details on the signal's amplitude and frequency behavior over very long times.

Software Features

	Option B7R		Option B7Z	Option BHJ
Technology	**IEEE 802.11a/g/j/p OFDM**	**IEEE 802.11b/g DSSS/CCK/PBCC**	**IEEE 802.11n**	**IEEE 802.11ac**
Supported standards	IEEE 802.11-2012	IEEE 802.11-2012	IEEE 802.11-2012	IEEE P802.11ac-D3.0
Operating modes supported		IEEE 802.11b long or short preamble/PBCC IEEE 802.11g PBCC22/ PBCC33	HT-greenfield HT-mixed Non-HT duplicate HT duplicate	VHT
MIMO supported			Up to 4 spatial streams	Up to 8 spatial streams Up to 4 users
Preset to standard	IEEE 802.11a/g OFDM HiperLAN2 IEEE 802.11g DSSS-OFDM IEEE 802.11a/g turbo mode IEEE 802.11p DSRC IEEE 802.11j 10 MHz	DSSS CCK PBCC	802.11n 20 MHz 802.11n 40 MHz	802.11ac 20 MHz 802.11ac 40 MHz 802.11ac 80 MHz 802.11ac 80+80 MHz 802.11ac 160 MHz
Data modulation format	BPSK QPSK 16QAM 64QAM	Barker1/Barker2 CCK5.5/CCK11 PBCC5.5/PBCC11/ PBCC22/PBCC33	BPSK QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM 256QAM
Measurement Results				
Time	▪	▪	▪	
Spectrum	▪	▪	▪	
Search time	▪	▪	▪	
CCDF	▪	▪	▪	
CDF	▪	▪	▪	
Equalizer impulse response	▪	▪	▪	
Channel frequency response	▪	▪	▪	
CPE (common pilot error)	▪		▪	
Correction	▪	▪	▪	
Error vector spectrum	▪	▪	▪	
Error vector time	▪	▪	▪	
IQ measured	▪	▪	▪	
IQ reference	▪	▪	▪	
Marker data	▪	▪	▪	
PDF	▪	▪	▪	
Preamble error	▪			
Preamble frequency error	▪		▪	
Phase noise spectrum			▪	
OFDM eq MIMO condition number			▪	
MIMO channel matrix			▪	

Table Results	
IEEE 802.11a/g/j/p OFDM	
Symbols/errors	Symbol data bits, EVM, pilot EVM, CPE (common pilot error), IQ (origin) offset, frequency error, symbol clock error, sync correlation, number of symbols, modulation format, code rate, bit rate, IQ gain imbalance, IQ quadrature skew
IEEE 802.11b/g DSSS/CCK/PBCC	
Symbols/errors	Symbol data bits, IEEE 802.11b 1,000-chip peak EVM, EVM, magnitude error, phase error, IQ offset, frequency error, sync correlation, burst type, bit rate, number of data octets, data length
IEEE 802.11n, IEEE 802.11ac	
Symbols/errors	Symbol data bits, stream EVM, stream peak EVM, stream pilot EVM, CPE, stream data EVM
OFDM error summary	EVM, EVM peak, pilot EVM, data EVM, frequency error, symbol clock error, CPE, IQ offset, IQ quadrature error, IQ gain imbalance, IQ time skew, cross power, sync correlation results per channel and averaged
OFDM data burst info	Detected symbols for active burst (L-STF, L-LTF, L-SIG, L-Data, HT-STF, HT-LTF, HT-SIG, HT-Data, VHT-SIG-A1, VHT-SIG-A2, VHT-SIG, VHT-STF, VHT-LTF, VHT-SIG-B, VHT-Data) with modulation format, length, power and EVM; total burst length, power, EVM, format, number of streams, VHT-SIG-A and HT-SIG CRC pass/fail and L-SIG status
OFDM SIG info	Decoded fields of the L-SIG, HT-SIG, and/or VHT-SIG symbols present in the burst, as described in the 802.11a/n/ac standards
OFDM multi-user info	EVM, MCS, format, number of streams, length, power for all detected users in the burst

Key Specifications[1]

This technical overview provides nominal performance specifications for the software when making measurements with the specified platform. Nominal values indicate expected performance, or describe product performance that is useful in the application of the product, but is not covered by the product warranty.

For a complete list of specifications, refer to the measurement platform literature.

X-Series signal analyzers	PXA	MXA	EXA
IEEE 802.11a/b/g/n/ac			
Performance	**RF input level = -10 dBm, input range 1 step below overload, RMS averaging set to average count = 20, input phase noise optimization = best wide offset, single channel**		
Residual EVM	Equalizer training: Channel estimation sequence only/channel estimation sequence + data		
2.4 GHz center frequency			
20 MHz signal	–53.0 dB/–55.8 dB	–51.3 dB/–54.1 dB	–49.0 dB/–51.8 dB
40 MHz signal	–50.0 dB/–52.8 dB	–48.4 dB/–51.2 dB	–46.5 dB/–49.3 dB
5.8 GHz center frequency			
20 MHz signal	–50.7 dB/–53.5 dB	–49.3 dB/–52.1 dB	–47.0 dB/–49.8 dB
40 MHz signal	–48.0 dB/–50.8 dB	–47.5 dB/–50.3 dB	–45.5 dB/–48.3 dB
80 MHz signal	–48.0 dB/–50.8 dB	–47.5 dB/–50.3 dB	
160 MHz signal	–47.0 dB/–49.8 dB	–47.0 dB/–49.8 dB	
Frequency lock range	± 624 kHz = ± 2 × sub-carrier spacing		
Frequency accuracy	± 10 Hz + tfa (tfa = transmitter frequency × frequency reference accuracy)		
Maximum capture length			
20 MHz span	20.93 sec	20.93 sec [1]	
40 MHz span	10.46 sec		
80 MHz span	5.23 sec		
160 MHz span	2.61 sec		
IEEE 802.11b/g DSSS			
Performance	**Total power within 2 dB of full scale, 10 averages, reference filter = transmit filter = Gaussian with BT = 0.5**		
Residual EVM	Equalizer off/on		
	1.0%/0.5%	1.5%/0.5%	
Frequency lock range	± 2.5 MHz		
Frequency accuracy	± 8 Hz		
Maximum capture length			
34.375 MHz span	6.1 sec		
25 MHz span		44 ms [2]	

1. With Option MPB, DP2 or B40.
2. Option B25 only, not DP2, MPB, or B40.

80000, 90000 Series Infiniium oscilloscopes	
IEEE 802.11n/ac	
Performance	**Up to 4 channels, input range within 2 dB of full scale on all input channels, RMS averaging with average count = 20, at least 16 data symbols analyzed in each burst, analyzer span set to default**
Residual EVM	Equalizer training: Channel estimation sequence only/channel estimation sequence + data
2.4 GHz center frequency	User rate mode = 10 GHz
20 MHz signal	–41 dB/–43 dB
40 MHz signal	–40 dB/–42 dB
5.8 GHz center frequency	User rate mode = 20 GHz
20 MHz signal	–38 dB/–41 dB
40 MHz signal	–37 dB/–40 dB
Frequency lock range	± 2 x Subcarrier Spacing = ± 625 kHz at default subcarrier spacing
Frequency accuracy	± 1 kHz
Maximum capture length	**Model, memory option and sampling mode dependent**

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Additional Resources

Literature

89600 VSA Software, Brochure, literature number 5990-6553EN

89600 VSA Software, Configuration Guide, literature number 5990-6386EN

89601B/BN-200 Basic Vector Signal Analysis
89601B/BN-300 Hardware Connectivity
89600 VSA Software, Technical Overview, literature number 5990-6405EN

Option B7Z IEEE 802.11n MIMO Modulation Analysis
89600 Vector Signal Analysis Software Self-Guided Demonstration,
literature number 5989-7267EN

Keysight Equalization Techniques and OFDM Troubleshooting for Wireless LANs, Application Note, literature number 5988-9440EN

RF Testing of Wireless LAN Products Application Note, literature number 5988-3762EN

IEEE 802.11 Wireless LAN PHY Layer (RF) Operation and Measurement Application Note, literature number 5988-5411EN

Making 802.11G Transmitter Measurements, Application Note, literature number 5988-7813EN

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