Wireless Connectivity and High Throughput WLAN Modulation Analysis 89600 VSA Software

89601B7RC for 802.11a/b/g/j/p
89601BHXC for 802.11n/ac/ax/be (for existing customers only)
89601BVXC for 802.11n/ac/ax/be (for new customers)
89601QAMC for WLAN 4096QAM

- Perform comprehensive measurements on the latest IEEE 802.11be, 802.11ax, 802.11ac and 802.11n formats, and legacy IEEE 802.11a/b/g/j/p formats
- Demodulate and analyze all WLAN operating modes: from single user to multi-user MIMO (MU-MIMO) with support up to 8 spatial streams for 802.11ac/ax/802.11be signals
- Analyze high date rates up to 4096QAM modulation across the full 802.11be/ax/ac bandwidth
- Verify and troubleshoot PHY layer performance and errors down to the bit level
- Support efficiency modes like trigger-based signal capture for optimized analysis
- 89601BHXC can work with VSA both earlier and later versions but 89601BVXC can only work VSA2024 Update 2.0 Build 28.60 or later versions
- New license 89601QAMC plus 89601BHXC or 89601BVXC together to enable the WLAN demodulation analysis with 4096QAM modulation for 802.11ac/ax/be (for VSA2024 Update 2.0 Build 28.60 or later)

KEYSIGHT

Table of Contents

WLAN Technology Overview

WLAN products and systems started with 802.11b, 802.11g and 802.11a standard amendments, all of which provided throughput enhancements over the original 802.11 standard introduced in 1997. To meet the requirements of new applications and the need for higher data rates, WLAN technology continues to evolve by integrating the latest technologies. The goal is clear: to continuously improve spectrum utilization, throughput and user experience. 802.11n, the High Throughput (HT) amendment to the 802.11 standard, improved throughput through the adoption of Single-User Multiple-Input Multiple-Output (SU-MIMO) with up to 4 spatial streams and wider bandwidth (40 MHz). This improvement was further extended in 802.11ac, the Very High Throughput (VHT) amendment to the 802.11 standard, with new and enhanced technologies including up to 8x8 SU-MIMO, wider channel bandwidth (up to 160 MHz), new downlink Multi-User MIMO (MU-MIMO) technology, and up to 1024-QAM modulation.

WLAN standard, 802.11ax or High Efficiency (HE) WLAN, is an evolutionary improvement to 802.11ac. It adds a significantly higher efficiency, capacity and coverage for a better user experience, especially for dense deployment scenarios in both indoor and outdoor environments (e.g., stadiums, airports and shopping malls). Unlike 802.11ac, 802.11ax operates in 2.4, 5 and 6-GHz bands and employs technology building blocks like Orthogonal Frequency Division Multiple Access (OFDMA) for high efficiency, 8x8 MU-MIMO for high capacity, and uplink scheduling for increased capacity, efficiency and better user experience. Other technologies, such as 1024-QAM modulation, are used to improve throughput.

802.11be or Extremely High Throughput (EHT) WLAN is the next major standard, already seeing early hardware implementations. With dramatically increased throughput and real-time application support, 802.11be introduces 320 MHz bandwidth, 4096-QAM modulation, and enhanced MIMO with more spatial streams across the 2.4, 5, and 6 GHz frequency bands.

New WLAN devices will be required to be backward compatible and coexist with legacy IEEE 802.11 devices operating in the same band. Table 1 compares key physical layer (PHY) technologies of 802.11n, 802.11ac, 802.11ax, and 802.11be.

Table 1. Key PHY comparison of 802.11n, 802.11ac, 802.11ax, and 802.11be

	802.11n High Throughput (HT) WLAN	802.11ac Very High Throughput (VHT) WLAN	802.11ax High Efficiency (HE) WLAN	802.11be Extremely High Throughput (EHT)
Frequency band (GHz)	2.4 and 5	5	2.4, 5, and 6 GHz	2.4, 5, and 6
Multiplexing scheme	OFDM	OFDM	OFDMA	OFDMA
Channel bandwidth (MHz)	20, 40	20, 40, 80, 160, 80+80	20, 40, 80, 160, 80+80	20, 40, 80, 160, 320
Subcarrier spacing (for non-legacy portion)	312.5 kHz	312.5 kHz	78.125 kHz	78.125 kHz
Symbol duration, not including guard interval (µsec)	3.2	3.2	3.2, 6.4 or 12.8	3.2, 6.4 or 12.8
Guard interval/cyclic prefix (µsec)	0.8	0.4 or 0.8	0.8, 1.6 or 3.2	0.8, 1.6 or 3.2
Number of spatial streams	4	8	8	16
Multi-user (MU) technology	Not available	MU-MIMO: downlink only, up to 4 users	MU-MIMO: downlink and uplink, up to 8 users OFDMA: downlink and uplink	MU-MIMO: downlink and uplink, up to 8 users OFDMA: downlink and uplink, with multiple RUs (MRU) to a STA
# of subcarriers per RU, also known as tones	Full channel bandwidth	Full channel bandwidth	26, 52, 106, 242, 484, 996, 2*996	Small size: 26, 52, 78, 106, 132 Large size: 242, 484, 996, and combinations
Data subcarrier modulation	BPSK, QPSK, 16QAM, 64QAM	BPSK, QPSK, 16QAM, 64QAM, 256QAM	BPSK, QPSK, 16QAM, 64QAM, 256QAM, 1024QAM	BPSK, QPSK, 16QAM, 64QAM, 256QAM, 1024QAM, 4096QAM
Channel coding	BCC (mandatory) LDPC (optional)	BCC (mandatory) LDPC (optional)	BCC (mandatory) LDPC (mandatory)	BCC (mandatory) LDPC (mandatory)
Maximum theoretical data rate	600 Mbps	6933.3 Mbps	9607.8 Mbps	> 30 Gbps

WLAN Modulation Analysis

Modulation analysis is crucial for WLAN design and troubleshooting, enabling engineers to assess signal quality, identify issues, and optimize performance. The 89600 Vector Signal Analysis (VSA) software offers comprehensive support for WLAN modulation analysis, covering a broad spectrum of formats across different 802.11 amendments, including 802.11a/b/g/j/p/n/ac/ax/be.

Unlock deeper insights into the latest wireless LAN signals with the VSA software, meticulously crafted for 802.11n/ac/ax/be modulation analysis. The VSA's WLAN measurement extensions provide in-depth spectrum, time, and modulation quality measurements for 802.11n/ac/ax/be with option 89601BVXC, and for the legacy 802.11a/b/g/j signals with option 89601B7RC. These options offer an advanced troubleshooting and evaluation toolset specifically designed to handle the challenges of analyzing both new and legacy WLAN signals, covering technologies such as MU-MIMO and OFDMA used in the latest standards.

The 89600 VSA software encompasses over 75 signal standards and modulation types, including the full suite of 802.11 WLAN standards. As a comprehensive set of tools, the VSA enables you to explore.

virtually every facet of a signal and optimize even the most advanced designs. Just as critically, the software helps you cut through the complexity as you assess your design tradeoffs.

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Analysis and Troubleshooting

Analyze a wide range of WLAN formats

The 89600 VSA software, with options 89601BVXC and 89601B7RC, offers comprehensive tools to measure and troubleshoot WLAN signals across a broad spectrum of IEEE 802.11 standards. Option 89601BVXC supports the latest 802.11n/ac/ax/be standards and works with 89601QAMC to enable 4096QAM, while option 89601B7RC covers the legacy 802.11a/b/g/j/p standards.

IEEE 802.11a/b/g/j/p

- Supports standards defined in IEEE 802.11a/g OFDM, 802.11g DSSS-OFDM, 802.11a/g turbo mode, 802.11p DSRC, 802.11j 10 MHz and HiperLAN2
- Channel bandwidths: 10 MHz, 20 MHz, and 40 MHz
- Modulation formats: BPSK to 64 QAM

IEEE 802.11b/g DSSS/CCK/PBCC

- Support standard defined DSSS, CCK, and PBCC
- Modulation formats: Barker1, Barker2, CCK5.5, CCK11, PBCC5.5, PBCC11, PBCC22, PBCC33

IEEE 802.11n

- All operating modes: legacy, mixed and greenfield
- Channel bandwidth: 20 MHz and 40 MHz
- Up to four spatial streams

IEEE 802.11ac

- VHT operating mode
- Channel bandwidths: 20 MHz, 40 MHz, 80 MHz, 80 + 80 MHz and 160 MHz
- Modulation formats: BPSK up to 256QAM
- Up to eight spatial streams
- Downlink MU-MIMO with up to four simultaneous users

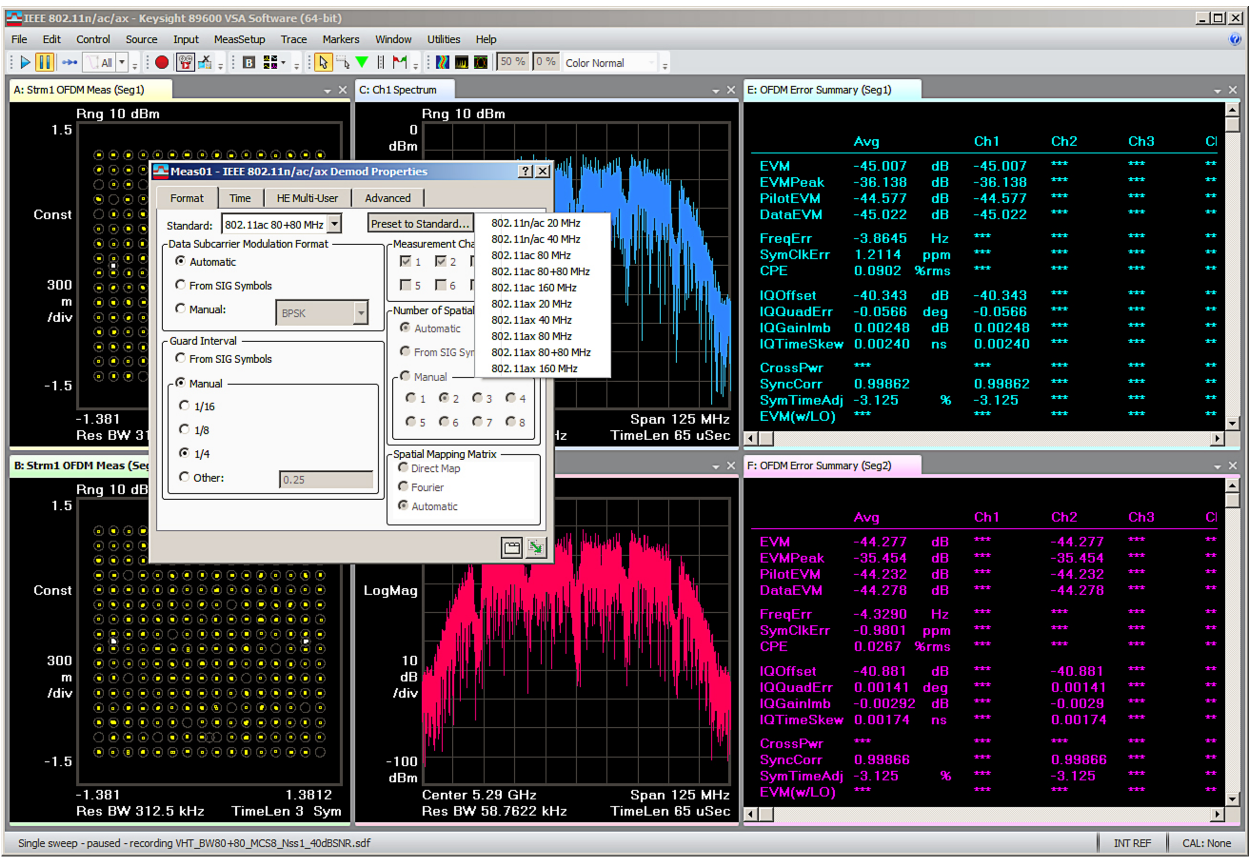

Figure 4. Troubleshoot and analyze 802.11ac signals with 80 + 80 MHz bandwidth and 256QAM

IEEE 802.11ax

- All operating modes: HE SU, HE extended range, HE MU, and HE trigger-based
- Channel bandwidths: 20 MHz, 40 MHz, 80 MHz, 80 + 80 MHz and 160 MHz
- Modulation formats: BPSK up to 4096QAM (4096QAM requires the 89601QAMC license)
- OFDMA in uplink and downlink
- MU-MIMO in uplink and downlink with up to eight simultaneous users
- Up to 8 spatial streams
- Color coded measurement results by RU and user

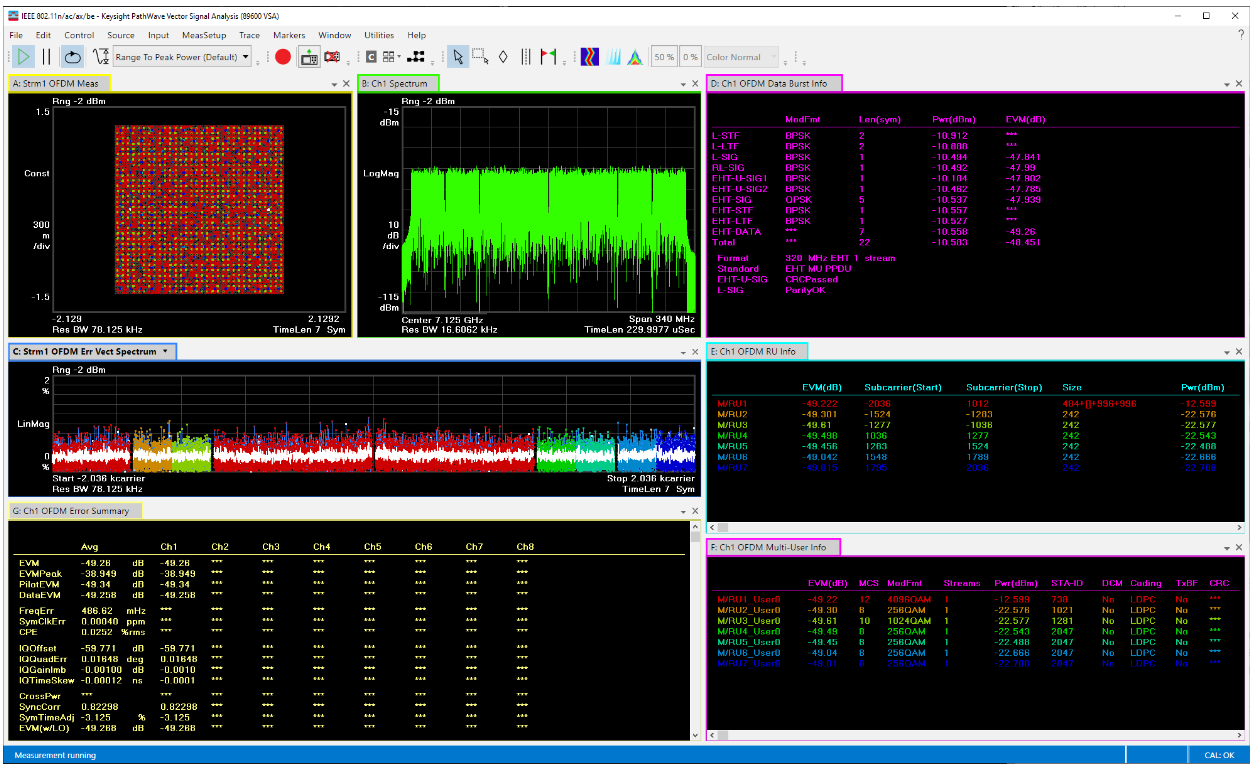

Figure 5. Evaluate signal quality and perform error vector measurements of 802.11ax signal with up to 160 MHz BW, 1024QAM and multi-user technologies such as OFDMA and MU-MIMO

IEEE 802.11be

- All operating modes: EHT Multi-User (MU) PPDU, compressed and non-compressed modes with resource unit (RU) puncturing, EHT trigger-based
- Channel bandwidth of 20 MHz, 40 MHz, 80 MHz, 160 MHz and 320 MHz
- Modulation formats of BPSK up to 4096QAM (4096QAM requires the 89601QAMC license)
- MU-MIMO with up to eight simultaneous users
- Up to 8 spatial streams
- Color coded measurement results by RU

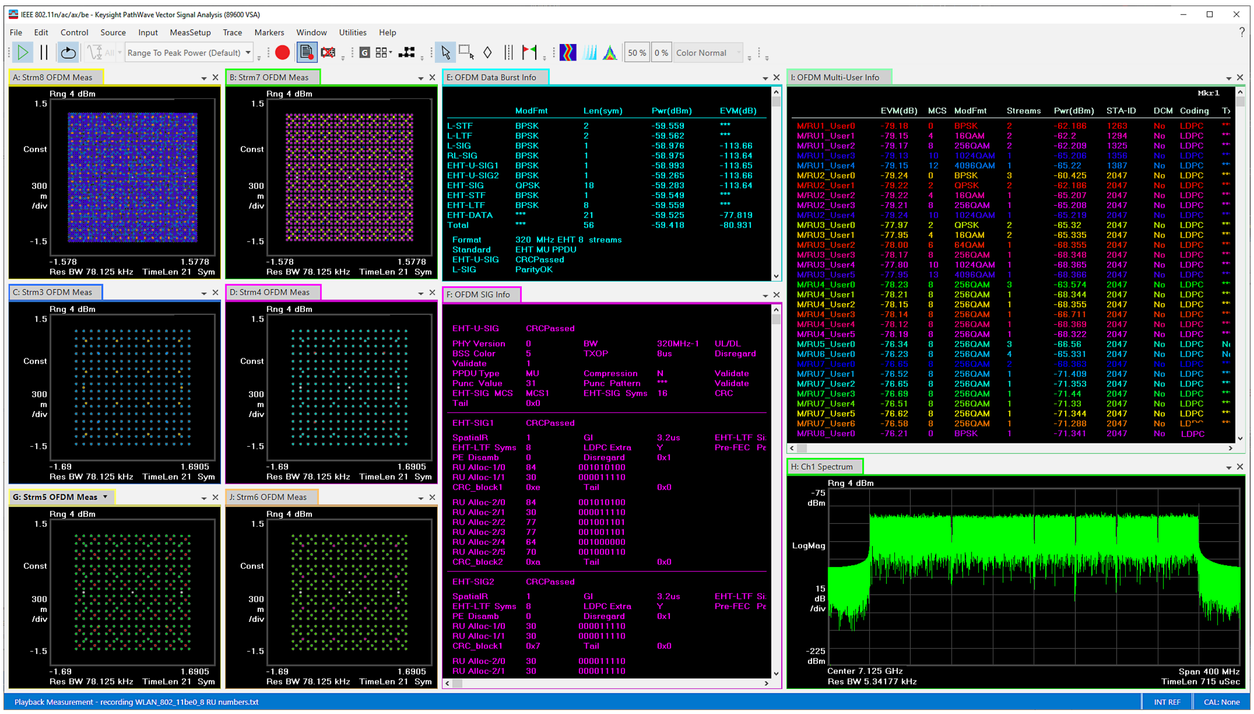

Figure 6. Evaluate signal quality and perform error vector measurements of 802.11be signal with up to 320MHz bandwidth, with or without punctured channel, 4096QAM modulation, multiple streams and multiple user configurations

As WLAN technologies continue to evolve, designers need powerful tools to analyze and optimize their designs effectively. The 89600 VSA software, with its extensive support for legacy and cutting-edge WLAN standards, empowers engineers to stay ahead of the curve in this dynamic landscape. By providing comprehensive modulation analysis capabilities across a wide range of formats, the software enables designers to make informed decisions, troubleshoot issues, and push the boundaries of wireless performance.

Get basics right, find major problems

Spectrum and time domain measurements provide the basic signal parameters of the signal in the frequency and time domains enabling correct demodulation. Use measurements such as occupied bandwidth (OBW) to quickly and accurately report the occupied bandwidth, band power and power ratio of the transmitted signal.

Time-gated spectrum measurements are useful for burst signals, especially those with complex preambles. Use gated spectrum to examine the various elements of the preamble.

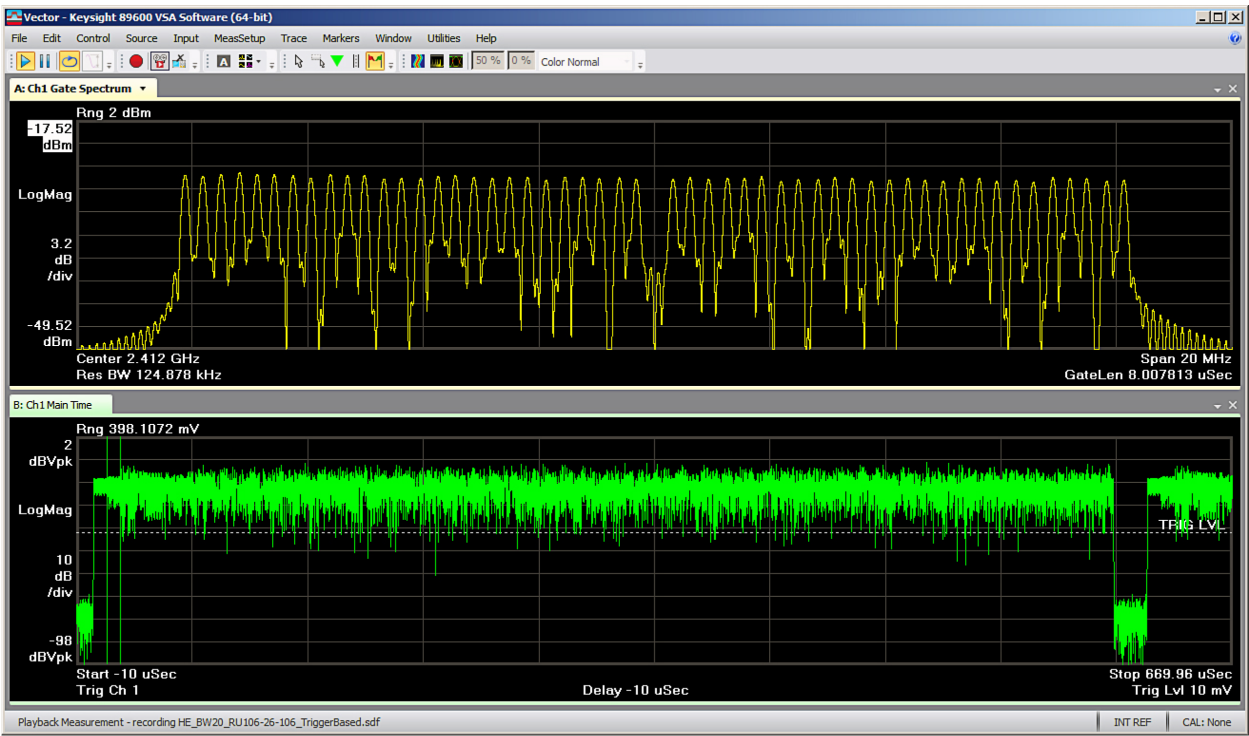

Figure 7. Gated spectrum measurement over the L-LTF portion of the SU-PPDU burst. The spectrum of the L-LTF symbol is displayed on the top trace showing flat amplitude across the 52 subcarriers.

Flexible configuration and dynamic help

Quickly set up measurements with standard presets for 802.11n, 802.11ac, 802.11ax, and 802.11be, while maintaining the ability to adjust a wide range of signal parameters for troubleshooting. For example, the measured IQ impairments can be removed from the EVM results by enabling "Compensate IQ Mismatch" which is useful when testing transmitters that have not been fully calibrated for IQ mismatch. Additionally, you can modify sub-carrier spacing, symbol timing offset, FFT length, pilot tracking, equalizer training sequence and more.

Use Dynamic Help to access the Help text and learn about WLAN formats and presets available in the 89600 VSA software option 89601BVXC. Detach the Dynamic Help window and move it to the side for easier viewing as it follows your menu choices and activities. You can also lock it to stay focused on important Help data topics.

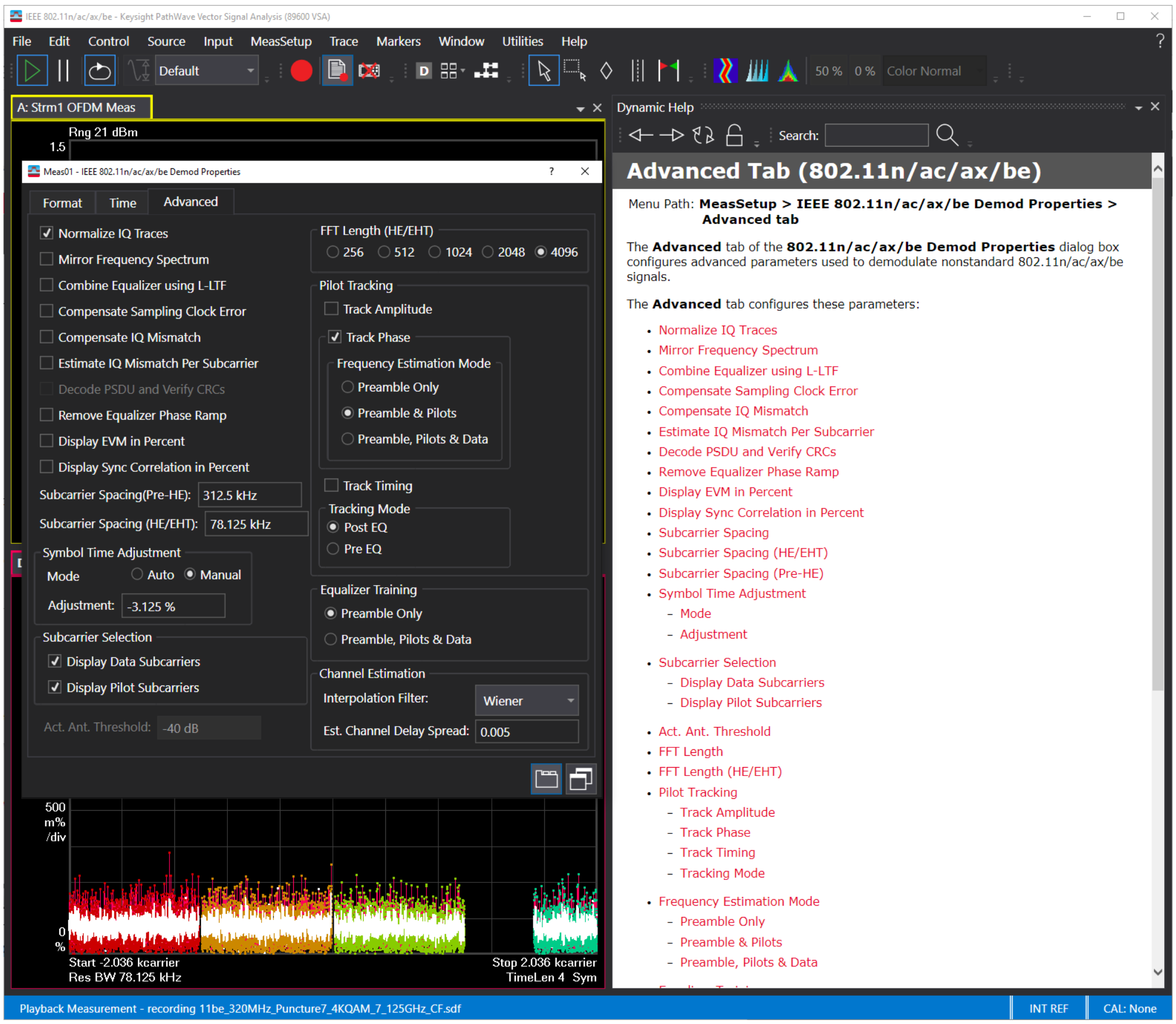

Figure 8. Easy setup to configure the WLAN demodulator to lock on to and demodulate the test signal. Dynamic Help provides useful information to explain the demod properties and other important WLAN and 89600 VSA software operations.

Comprehensive signal quality and error vector analysis

Evaluate signal quality and error vector measurements of transmitted WLAN signals with a comprehensive set of tools. Error vector spectrum, error vector time, common pilot error, channel frequency response and more, are available for all WLAN formats. Composite constellation displays let you determine and display the various modulation formats present within the burst.

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

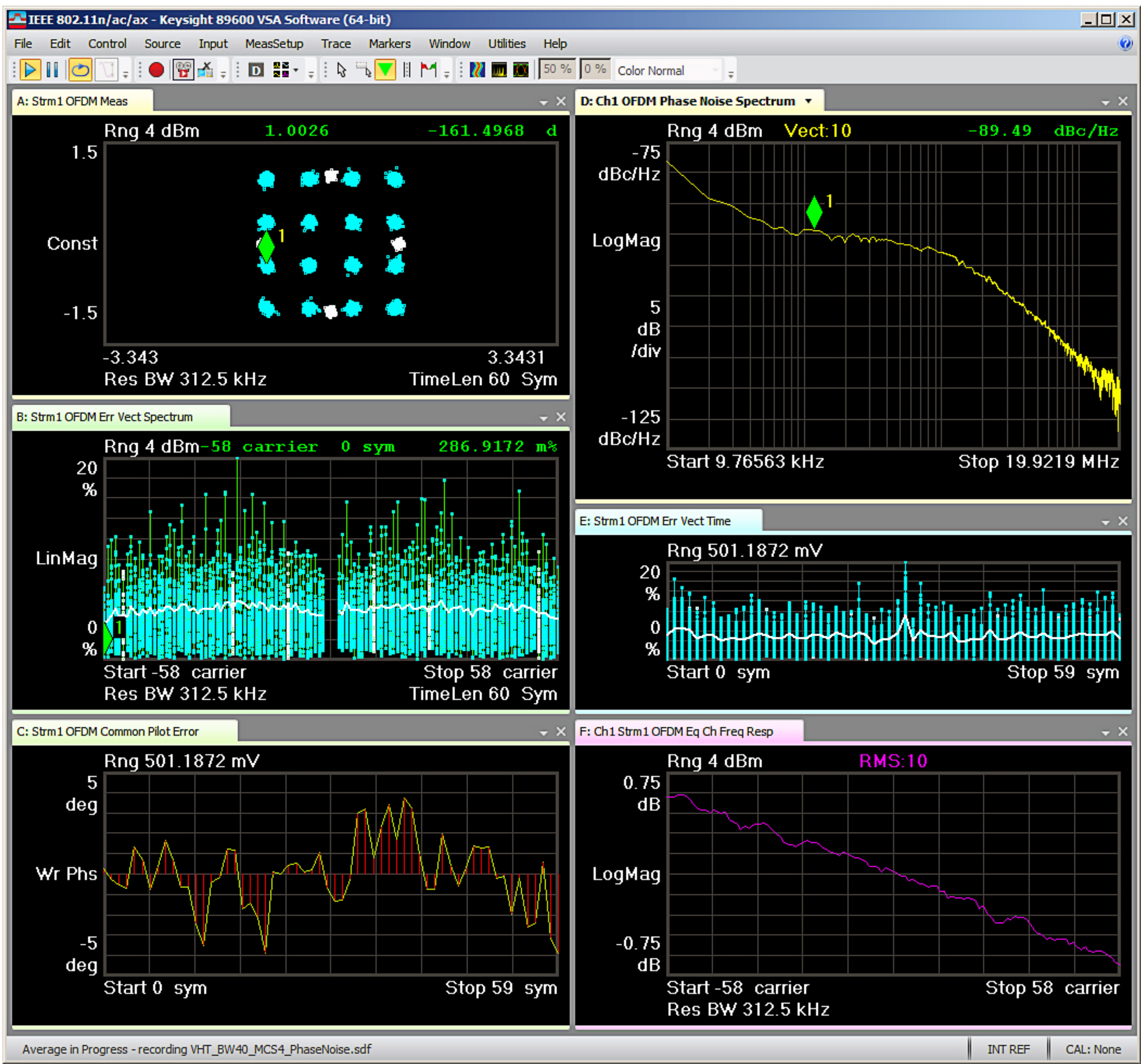

Figure 9. The 89600 VSA software lets you view an unlimited number of simultaneous traces, showing results such as EVM vs. frequency or time, equalizer channel frequency response, common pilot error, phase noise spectrum and more.

Comprehensive EVM analysis and burst decoding

The VSA provides a comprehensive set of error vector magnitude (EVM) measurements and burst decoding tools to thoroughly evaluate and troubleshoot WLAN signals. The EVM measurements are available at various levels of granularity: overall burst, per symbol, and per subcarrier within a symbol. The "Ch1 OFDM Error Summary Trace" displays key metrics like average EVM, peak EVM, pilot EVM, and data EVM, offering insights into overall signal quality and modulation accuracy. It also reports common pilot error, IQ impairments, synchronization correlation, and symbol timing adjustment – crucial for identifying potential issues.

The "Strm1 OFDM Syms/Errs" trace focuses on EVM measurements for specific spatial streams, including average stream EVM, peak stream EVM, pilot EVM, and data EVM. This granular view of stream-specific quality metrics is invaluable for troubleshooting multi-stream WLAN configurations.

Complementing the EVM analysis, the "Ch1 OFDM SIG Info" and "Ch1 OFDM Data Burst Info" traces provide detailed decoding of the signal's preamble and data burst structure. The SIG Info trace reveals critical parameters like bandwidth, spatial configuration, compression mode, and puncturing pattern, ensuring compliance with the latest WLAN standards. The Data Burst Info trace breaks down the modulation format, length, power, and EVM for individual fields like L-STF, L-SIG, EHT-SIG, and EHT-Data, enabling in-depth analysis of the burst composition.

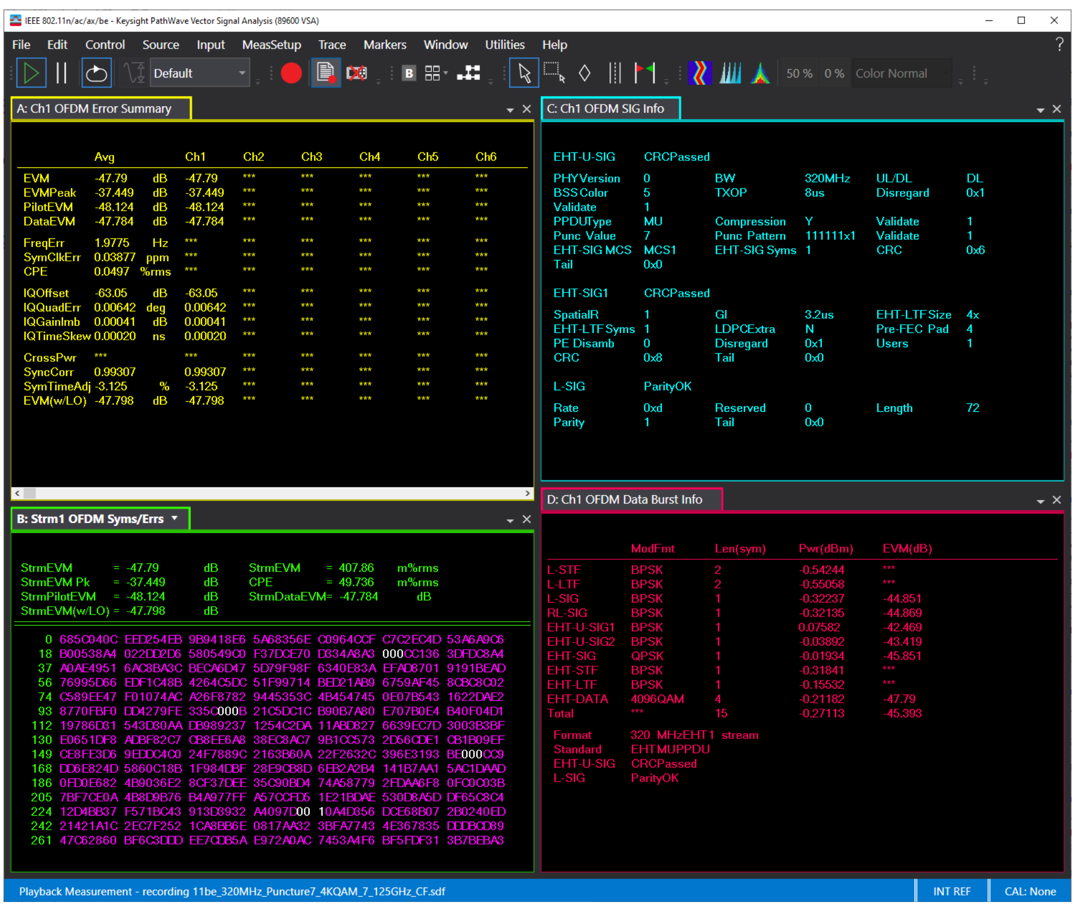

Figure 10. Example of 802.11be signal, showing in-depth, bit-level analysis with error summary tables, detected burst info and decoded SIG info.

Comprehensive MIMO analysis in WLAN systems

The 89600 VSA offers comprehensive MIMO analysis for WLAN systems, accommodating up to 8x8 SU-MIMO and MU-MIMO configurations. Well-designed traces provide a quick system overview and detailed analysis of the signal, including important channel, stream, and data information. These options can be applied from baseband to receiver, from simulation to antenna, enabling thorough evaluation and optimization of MIMO designs.

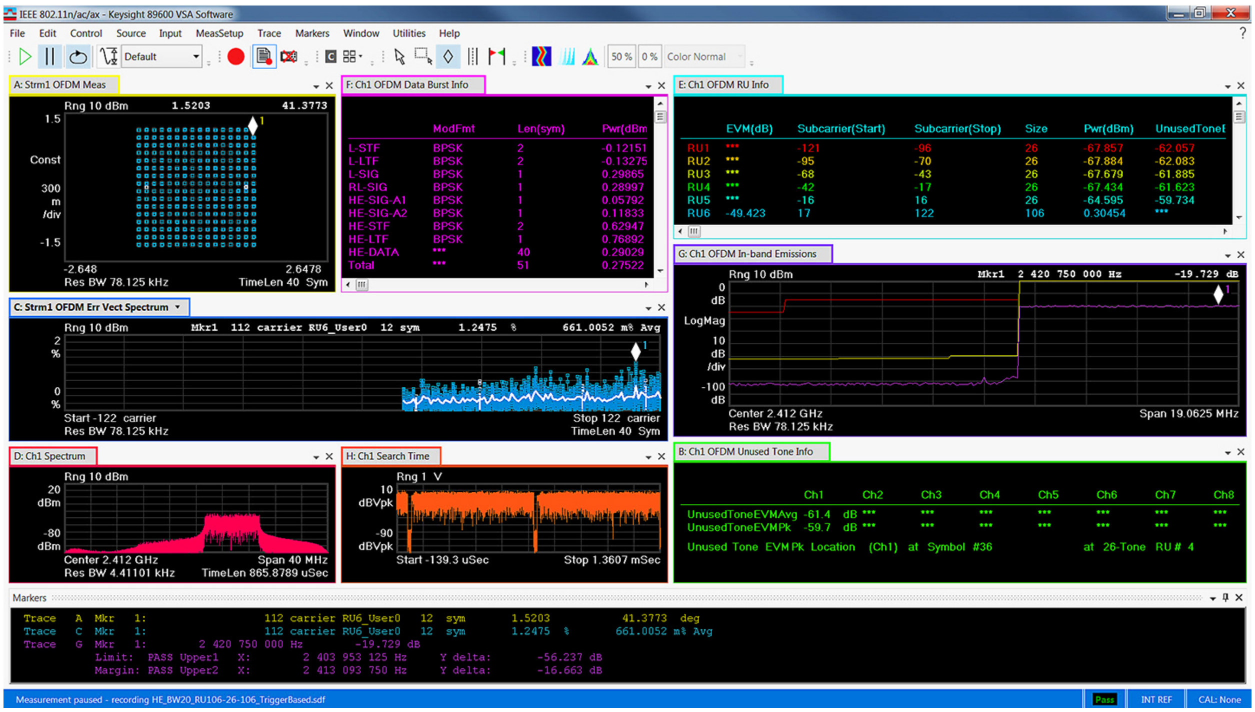

Figure 11. View key WLAN MIMO parameters simultaneously such as multiple constellations, error summary and channel matrix for each combination of Stream and Channel.

- The "Strm1 OFDM Meas" trace (Trace A) displays the constellation diagram for a specific spatial stream, providing a visual representation of the modulation accuracy.
- The "Strm1 OFDM Err Vect Spectrum" trace (Trace C) shows the Error Vector Magnitude (EVM) across tone frequencies for the same spatial stream.
- The “Ch1 Spectrum” trace (Trace D) displays the spectrum of the entire signal, enabling users to analyze the frequency characteristics and identify any potential interference or out-of-band emissions.
- The “Ch1 OFDM Data Burst Info” trace (Trace F) and “Ch1 OFDM RU Info” trace (Trace E) provide detailed information about the modulation format, length, power, and EVM for various fields and symbols within the analyzed burst, as well as information about the detected resource units (RUs). These traces are invaluable for understanding the burst structure, resource allocation, and signal quality.

Advanced Multi-user analysis and OFDMA for 802.11ax and 802.11be

For OFDMA and MU-MIMO in 802.11ax and 802.11be, the VSA software offers advanced analysis tools to evaluate the performance of these cutting-edge technologies. In addition to composite EVM, the computes and displays the EVM of individual resource units (RUs) and individual users within each RU, providing visibility into multiuser transmissions.

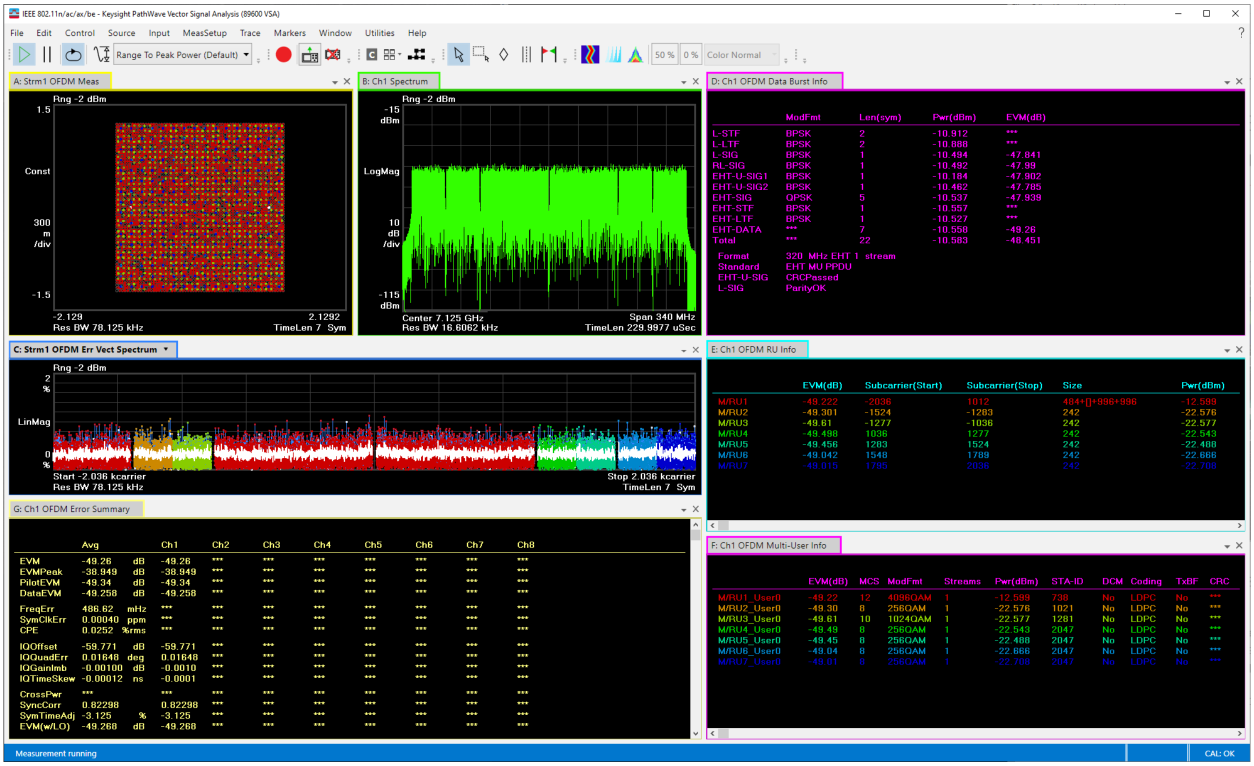

Figure 11. The 89600 VSA software lets you view an unlimited number of simultaneous traces color-coded by RU and user, showing results such as constellation diagram, IQ errors, and in the case of 802.11ax and 802.11be MU-PPDU, EVM of individual RUs and individual users are also provided.

The "Ch1 OFDM RU Info" trace (Trace E) provides detailed information about each detected RU, including EVM, subcarrier indices, size, and power. This more granular view allows users to identify and troubleshoot issues specific to individual RUs or users within a multi-user transmission.

For trigger based PPDUs used in uplink OFDMA and/or MU-MIMO transmissions, the VSA provides detailed analysis of the transmitted RU and the unoccupied tones outside of the RU.

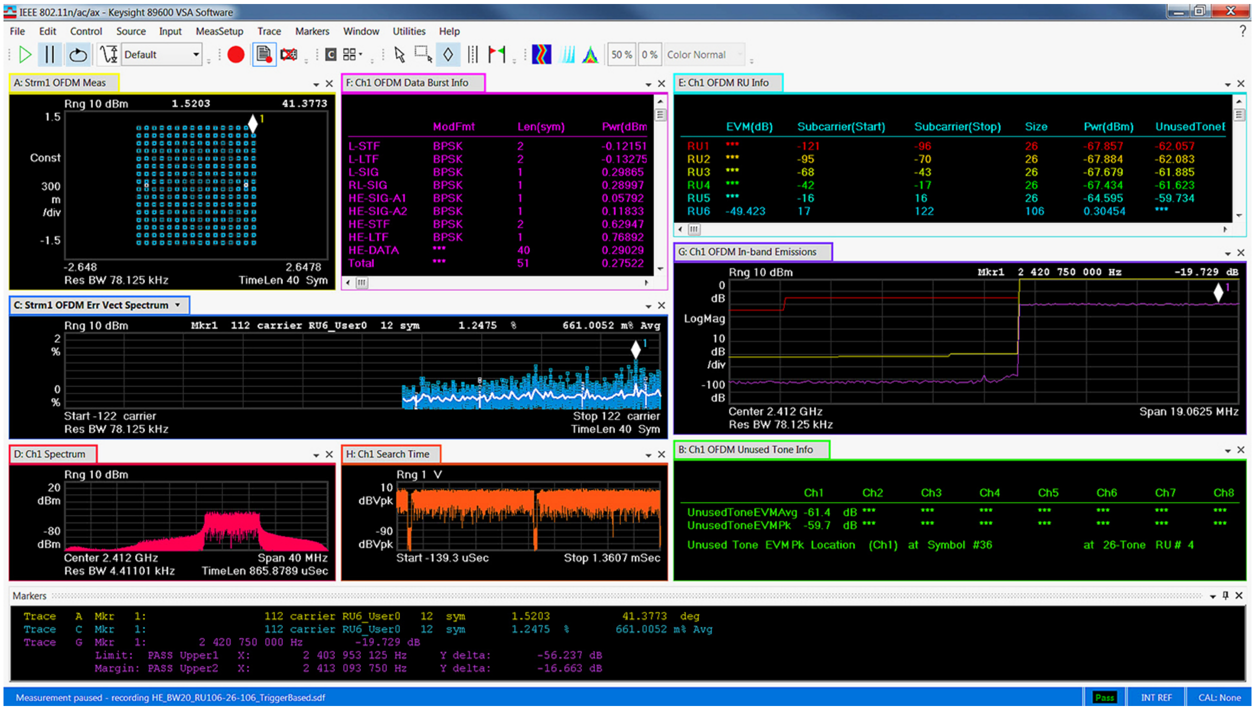

Figure 12. EVM measurement of trigger-based PPDU showing EVM of transmitted RU and “Unused Tone EVM” trace displaying average and peak EVM of unoccupied tones outside of the RU and “In-band Emissions” providing average power over each subcarrier, limit over each unoccupied RU and unused tone EVM over each RU.

The "Ch1 OFDM Unused Tone Info" trace (Trace B) displays the averaged and peak unused tone EVM values for each measurement channel, as well as the position of the peak unused tone EVM for the first measurement channel.

By leveraging these advanced analysis tools, wireless LAN signal analysis customers can thoroughly evaluate the performance of their 802.11ax and 802.11be designs, identify and mitigate issues related to OFDMA and MU-MIMO transmissions, and optimize the system for improved efficiency and user experience.

Spectrum Emissions Mask (SEM)

The IEEE 802.11 specification incudes a spectral emission mask (SEM) requirement that defines the acceptable power levels across different frequency bands relative to the transmission frequency. It outlines the maximum allowed emissions at various offsets from the center frequency, effectively controlling the bandwidth of the signal and reducing the likelihood of adjacent-channel interference. The 89600 VSA features the 89601PSMC option for Power Suite measurements providing standards compliant SEM measurement with a quick setups for 802.11be 40 MHz, 160 MHz and 320 MHz bandwidths.

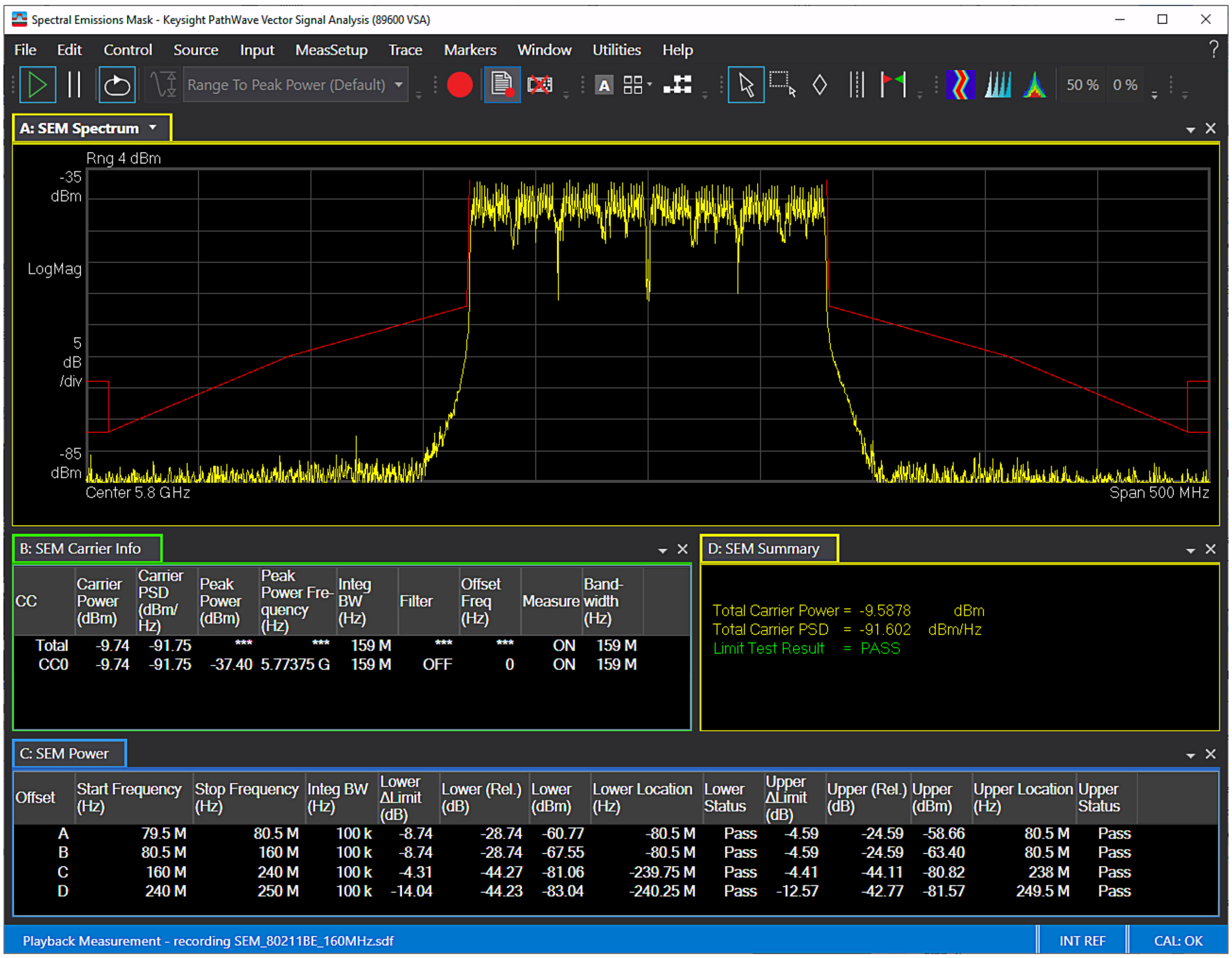

Figure 14. shows an SEM measurement with the 802.11be limit mask.

Figure 14 shows an SEM measurement with the 802.11be limit mask. The yellow trace represents the measured power spectral density of the signal, while the red lines indicate the specified limits. The Carrier Info table provides carrier power and power spectral density results. For each offset, the SEM Power table displays the measured absolute and relative power, the delta from IEEE-defined limits, and a pass/fail result based on those limits.

Extending EVM dynamic range with Cross-Correlated EVM (ccEVM)

Cross-Correlated EVM (ccEVM) is a technique that extends the receiver's dynamic range for optimal EVM performance. Two receivers independently capture and demodulate the same signal, then perform cross-correlation on the error vectors to cancel out uncorrelated noise added by the receivers. This results in a much lower EVM that primarily contains just the noise coming from the device under test (DUT), or in the case of an amplifier, noise from signal source plus the DUT. The 89601EVMC option is required for this measurement.

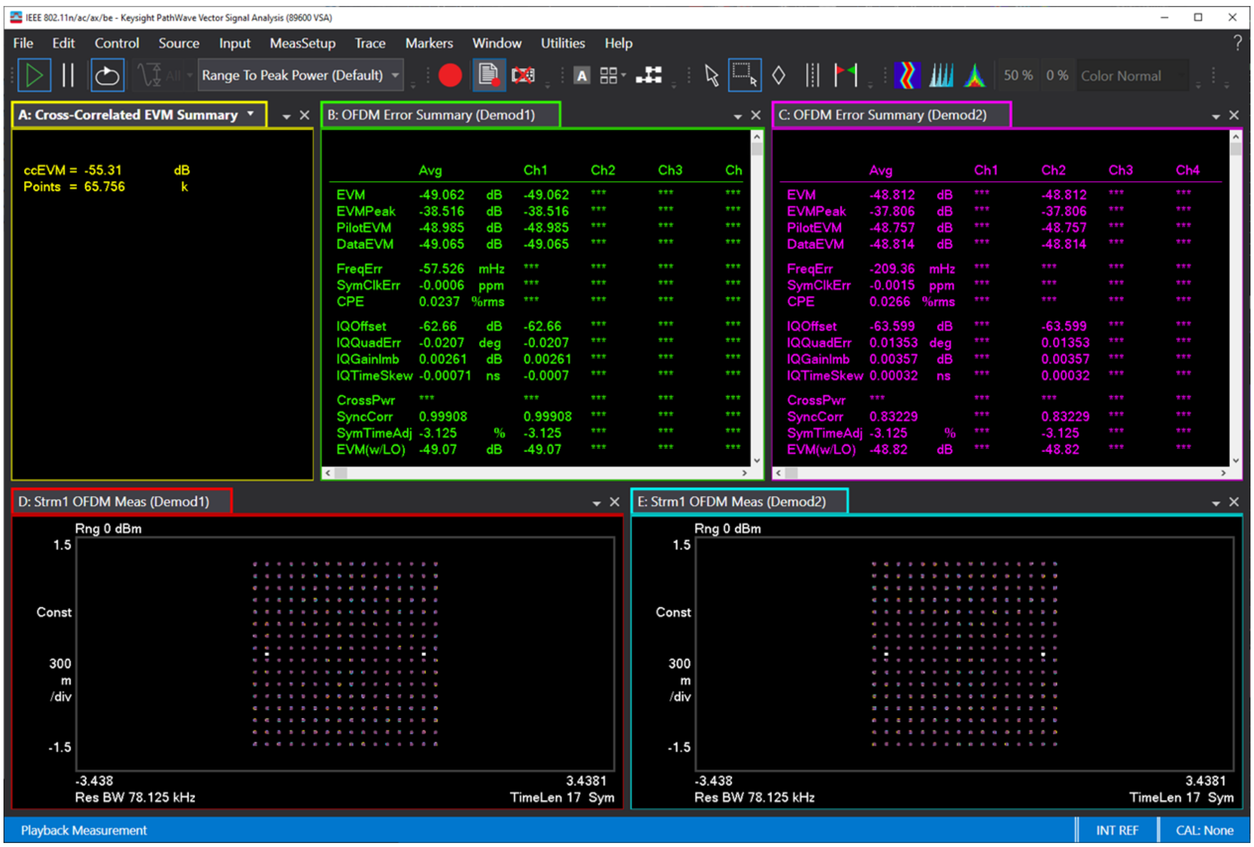

Figure 15. Cross-correlated EVM measurement demonstration

Figure 15 shows a side-by-side comparison of the EVM from combined receiver data (Trace A) against the EVM of each individual receiver (Traces B and C). For this test, we connected a Keysight Vector Signal Transceiver in a loopback setup. We split the output of the signal generator to feed two analyzer channels. We noted that with 2 receivers, we achieved a notable 6 dB improvement in EVM for an 802.11be WLAN signal. This underscores the benefit of cross-correlation in enhancing EVM measurement fidelity, even if at the cost of an additional receiver channel.

Software Features

Core features (802.11a/b/g/j/p)

Option	89601B7RC	
Technology	**IEEE 802.11a/g/j/p OFDM**	**IEEE 802.11b/g DSSS/CCK/PBCC**
Operating modes		IEEE 802.11b long or short preamble/PBCC IEEE 802.11g PBCC22/ PBCC33
Preset to standard	IEEE 802.11a/g OFDM HiperLAN2 IEEE 802.11g DSSS-OFDM IEEE 802.11a/g turbo mode IEEE 802.11p DSRCIEEE 802.11j 10 MHz	DSSS CCK PBCC
Data modulation format	BPSK QPSK 16QAM 64QAM	Barker1/Barker2 CCK5.5/CCK11 PBCC5.5/PBCC11/PBCC22/PBCC33
Measure 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	•	
Table results		
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	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

Core features (802.11n/ac/ax/be)

Option	89601BHXC or 89601BVXC (working with VSA2024 Update 2.0 release or beyond)			
Technology	**IEEE 802.11n**	**IEEE 802.11ac**	**IEEE 802.11ax**	**IEEE 802.11be**
Operating modes	HT-greenfield HT-mixed Non-HT duplicate HT duplicate	VHT	HE-SU HE-MU HE-extended range HE-trigger-based	EHT-MU (SU and MU) EHT-trigger-based
OFDMA	N/A	N/A	Uplink and downlink	Uplink and downlink
SIG information	HT-SIG	VHT-SIG-A, VHT-SIG-B	HE-SIG-A, HE-SIG-B	EHT-U-SIG, EHT-SIG
MU -MIMO	N/A	Downlink Up to 4 users	Uplink and downlink Up to 8 users	Uplink and downlink Up to 8 users
SU-MIMO	Up to 4 spatial streams	Up to 8 spatial streams	Up to 8 spatial streams	Up to 8 spatial streams
Preset to standard	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	802.11ax 20 MHz 802.11ax 40 MHz 802.11ax 80 MHz 802.11ax 80+80 MHz 802.11ax 160 MHz	802.11be 20 MHz 802.11be 40 MHz 802.11be 80 MHz 802.11be 160 MHz 802.11be 320 MHz
Data modulation format	BPSK QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM 256QAM	BPSK QPSK 16QAM 64QAM 256QAM 1024QAM	BPSK QPSK 16QAM 64QMA 256QAM 1024QAM 4096QAM
Dual-carrier modulation	N/A	N/A	Yes	Yes
HE-LTF duration	N/A	N/A	1x, 2x, 4x	1x, 2x, 4x
Guard interval length	1/16, 1/8, 1/4			
FFT length	64, 128, 256, 512	64, 128, 256, 512	256, 512, 1024, 2048	256, 128, 1024, 2048, 4096
Pilot tracking	Amplitude, phase and timing			
Pilot tracking mode	Post Eq; Pre Eq			
Frequency estimation mode	Preamble only; preamble & pilots; Preamble, pilots & data			
Equalizer training	Preamble only; preamble, pilots & data			
Channel Estimation Interpolation Filter	None/Linear; Triangular (with subcarrier length); Wiener (with channel delay spread)			
Compensate IQ mismatch	Yes			
Symbol time adjustment	Auto or manual			
Subcarrier spacing manual adjustment	Yes	Yes	Yes	Yes
Subcarrier selection (for display)	Data subcarriers; pilot subcarriers	Data subcarriers; pilot subcarriers	Data subcarriers; pilot subcarriers	Data subcarriers; pilot subcarriers
Active antenna threshold (for improving MIMO EVM)	Yes	Yes	Yes	Yes
Subcarrier reference points (user specified constellation points)	Yes	Yes	Yes	Yes

Measurement results

	89601BHXC or 89601BVXC (working with VSA2024 Update 2.0 release or beyond)			
Pre-demodulation	**IEEE 802.11n**	**IEEE 802.11ac**	**IEEE 802.11ax**	**IEEE 802.11be**
Time	•	•	•	•
Spectrum	•	•	•	•
Search time	•	•	•	•
Raw main time	•	•	•	•
CCDF	•	•	•	•
CDF	•	•	•	•
PDF	•	•	•	•
Correction	•	•	•	•
OBW	•	•	•	•
Demodulation – non-tabular results				
Channel frequency response	•	•	•	•
Common pilot error (CPE)	•	•	•	•
Equalizer impulse response	•	•	•	•
Error vector spectrum	•	•	•	•
Error vector time	•	•	•	•
IQ measured and IQ reference	•	•	•	•
IQ gain imbalance per subcarrier	•	•	•	•
IQ quad error per subcarrier	•	•	•	•
Preamble frequency error	•	•	•	•
Phase noise spectrum	•	•	•	•
Equalizer MIMO condition number	•	•	•	•
MIMO channel frequency response	•	•	•	•
Demodulation - tabular results for IEEE 802.11n, IEEE 802.11ac				
Error summary (for each channel - up to 4 for 802.11n; up to 8 for 802.11ac)	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, symbol clock error			
Burst info	Detected symbols for active burst (L-STF, L-LTF, L-SIG, HT-STF, HT-LTF, HT-SIG, HT-Data, VHT-SIG-A1, VHT-SIG-A2, 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, PSDU, VHT-SIG-A and HT-SIG CRC pass/fail and L-SIG status			
SIG info	Decoded fields of the L-SIG, HT-SIG, and/or VHT-SIG symbols present in the burst, as described in the 802.11n/ac standards			
Multi-user info (for each detected user; valid for 802.11ac)	EVM, MCS, Mod format, number of streams, length, power			
Symbols/errors (for each stream)	Stream EVM, stream peak EVM, stream pilot EVM, stream data EVM, CPE; raw binary bits for data symbols			
MIMO channel matrix	A complex value (displayed in real + j*imag format) of the linear average over all subcarriers of the equalizer channel frequency response for each available channel/stream.			

Demodulation - tabular results for IEEE 802.11ax and IEEE 802.11be	
Error summary (for each channel, up)	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, symbol time adjustment, EVM with LO
Burst info (802.11ax)	Detected symbols for active burst (L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A1, HE-SIG-A2, HE-SIG-B, HE-STF, HE-LTF, HE-DATA) with modulation format, length, power and EVM; total burst length, power, EVM; format, number of streams, standard, PSDU CRC pass/fail, HE-SIG-A CRC pass/fail and L-SIG status
Burst info (802.11be)	Detected symbols for active burst (L-STF, L-LTF, L-SIG, RL-SIG, EHT-U-SIG1, EHT-U-SIG2, EHT-SIG, EHT-STF, EHT-LTF, EHT-DATA) with modulation format, length, power and EVM; total burst length, power, EVM; format, number of streams, standard, PSDU CRC pass/fail, EHT-U-SIG CRC pass/fail, Gamma phase rotation, and L-SIG status
SIG info	For 802.11ax, decoded fields of the HE-SIG-A and L-SIG symbols present in the burst. For 802.11be, decoded fields of the EHT-U-SIG, EHT-SIG1 and L-SIG symbols present in the burst.
RU info (for each detected RU)	EVM, start/stop subcarrier index, size (# of subcarrier) power total users, total streams. For HE trigger based PPDU, it also includes unused tone EVM, limit and margin
Multi-user info (for each detected user)	EVM, MCS, modulation format, number of streams, power, STA-ID, DCM, coding, TxBF
Unused tone EVM (for each channel; only for HE and EHT trigger based PPDU)	Unused tone EVM Avg, unused tone EVM Pk, unused tone EVM Pk location
Symbols/errors (for each stream)	Stream EVM, Stream EVM with LO, stream peak EVM, stream pilot EVM, stream data EVM, CPE; raw binary bits for data symbols
MIMO Chan Matrix for SU and MU-MIMO with result for individual RU	A complex value (displayed in real + j*imag format) of the linear average over all subcarriers of the equalizer channel frequency response for each available channel/stream.

Ordering Information

Software licensing and configuration

Flexible licensing and configuration

- **Perpetual**: License can be used in perpetuity.
- **Subscription (time-based)**: License is time limited to a defined period, such as 12-months.
- **Node-locked**: Allows you to use the license on one specified instrument/computer.
- **Transportable**: Allows you to use the license on one instrument/computer at a time. This license may be transferred to another instrument/computer using Keysight's online tool.
- **Floating**: Allows you to access the license on networked instruments/computers from a server, one at a time. For concurrent access, multiple licenses may be purchased.
- **USB portable**: Allows you to move the license from one instrument/computer to another by end-user only with certified USB dongle, purchased separately.
- **Software support subscription**: Allows the license holder access to Keysight technical support and all software upgrades

Licenses ordering information

Option	Title	Description
89601200C	Basic vector signal analysis and hardware connectivity	(Required) This option provides the foundational vector signal analysis functionality and hardware connectivity necessary for WLAN signal analysis.
89601B7RC	Wireless Connectivity Modulation Analysis	Enables modulation analysis for legacy WLAN standards, including 802.11a/b/g/j/p.
89601BVXC	High Throughput WLAN Modulation Analysis	Adds support for modulation analysis of the latest high-throughput WLAN standards, including 802.11n/ac/ax/be, up to 1024 QAM modulation.
89601QAMC*	WLAN 4096QAM Modulation	For customers requiring support for the highest modulation order of 4096 QAM in 802.11ax and 802.11be, this option enables modulation analysis up to 4096 QAM.
89601EVMC	Cross-correlated EVM	Provides cross-correlated EVM measurement capabilities, which require either the 89601B7RC or 89601BVXC license as a prerequisite.

Note*: Option 89601QAMC is subject to control by the U.S. Department of Commerce under the Export Administration Regulations (EAR) as an Individual Validated License (IVL) for non-US customers.

By selecting the appropriate combination of these options, customers can tailor the 89600 VSA software to meet their specific WLAN signal analysis requirements, ensuring comprehensive support for both legacy and cutting-edge WLAN standards, as well as advanced modulation formats like 4096 QAM.

Software license types and terms

Software license type	Software license	Support subscription
Node-locked perpetual	SW1000-LIC-01	SW1000-SUP-01
Node-locked time-based	SW1000-SUB-01	Included
Transportable perpetual	SW1000-LIC-01	SW1000-SUP-01
Transportable time-based	SW1000-SUB-01	Included
Floating perpetual (single site)	SW1000-LIC-01	SW1000-SUP-01
Floating time-based (single site)	SW1000-SUB-01	Included
Floating perpetual (regional)	SW1000-LIC-01	SW1000-SUP-01
Floating time-based (regional)	SW1000-SUB-01	Included
Floating perpetual (worldwide)	SW1000-LIC-01	SW1000-SUP-01
Floating time-based (worldwide)	SW1000-SUB-01	Included
USB portable perpetual	SW1000-LIC-01	SW1000-SUP-01
USB portable time-based	SW1000-SUB-01	Included

For time-based licenses, KeysightCare support is included. For perpetual licenses, KeysightCare support subscription may be purchased using the following model numbers. For example, a one-month

One month software support subscription extensions

Support subscription	Description
SW1000-SUP-01	Perpetual KeysightCare support (1 month to 60 months)
SW1000-B2S	Back to KeysightCare support fee (Perpetual support only, one time fee) Minimum of 12 months required for a renewal

Hardware configuration

The 89600 VSA software supports more than 45 Keysight hardware platforms. The table below shows the recommended signal analyzer hardware for IEEE 802.11n/ac/ax/be transmitter test. For a complete list of currently supported hardware, please visit: www.keysight.com/find/89600_hardware

Product	Frequency range (option dependent)	Internal analysis bandwidth
X-Series signal analyzers		
N9042B UXA	Up to 110 GHz	Up to 2 GHz
N9041B UXA	Up to 110 GHz	Up to 1 GHz
N9040B UXA	Up to 50 GHz	Up to 1 GHz
N9032B PXA	Up to 55 GHz	Up to 2 GHz
N9030A/B PXA	Up to 50 GHz	Up to 510 MHz
N9021B MXA	Up to 50 GHz	Up to 510 MHz
N9020A/B MXA	Up to 26.5 GHz	Up to 160 MHz
Modular product		
M9415A/16A VXT PXIe Vector Transceiver	Up to 12 GHz per channel	Up to 1.2 GHz per channel
M9410A/11A VXT PXIe Vector Transceiver	Up to 6 GHz per channel	Up to 1.2 GHz per channel
M9421A VXT PXIe Vector Transceiver	Up to 6 GHz per channel	Up to 160 MHz per channel
Wireless test set		
E6680A/E6680E Wireless Test Set	6 GHz or 7.3 GHz per channel	Up to 800 MHz per channel

Keep your 89600 VSA software up-to-date

With rapidly evolving standards and continuous advancements in signal analysis, the 89600 VSA software with valid 89601200C, 89601B7RC, 89601BHXC or 89601BVXC, and 89601QAMC KeysightCare support subscription can offer you the advantage of immediate access to the latest features and enhancements available for the 89600 VSA software. Refer to the 89600 VSA Configuration Guide (5990-6386EN) for more details.

Upgrade

All 89600 VSA options can be added after your initial purchase and are license-key enabled. For more information, please refer to www.keysight.com/find/89600_upgrades

Additional Resources

Literature

- 89600 VSA Software, Brochure, 5990-6553EN
- 89600 VSA Software, Configuration Guide, 5990-6386EN
- 89600 VSA Software Option 89601200C Basic VSA and Hardware Connectivity, Technical Overview, 5992-4210EN

Web

- www.keysight.com/find/89600VSA
- www.keysight.com/find/89601B7RC
- www.keysight.com/find/89601BVXC
- www.keysight.com/find/vsa_trial
- www.keysight.com/find/89600_software
- www.keysight.com/find/89600_hardware