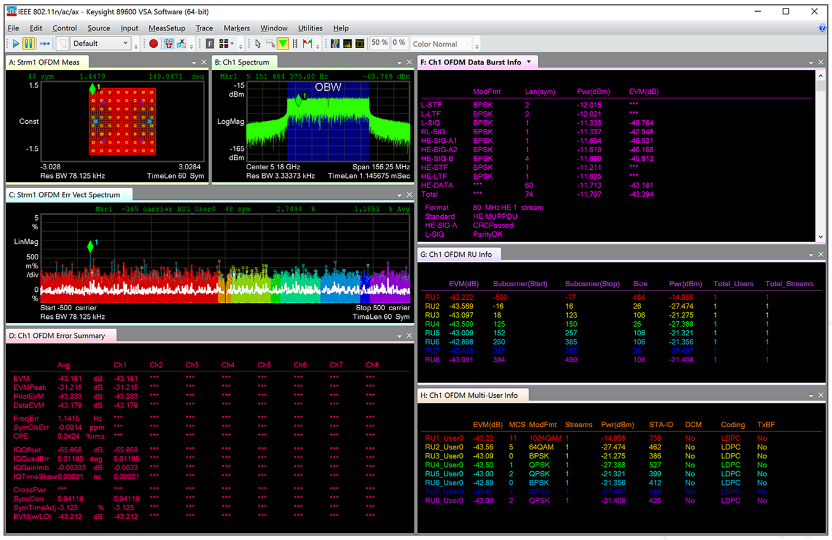
TECHNICAL OVERVIEW

# Wireless Connectivity and High Throughput WLAN Modulation Analysis 89600 VSA Software

## Option 89601BHXC (Replaced the 89601B/BN/BK-BHJ and BHX)
## Option 89601B7RC (Replaced the 89601B/BN/BK-B7R and B7Y)



- Perform measurements on the latest IEEE 802.11be, 802.11ax, 802.11ac and 802.11n formats ( Option 89601BHXC), and legacy IEEE 802.11a/b/g/j/p formats (Option 89601B7RC)
- Demodulate all operating modes of 802.11ax: High efficiency (HE) single user, HE multi-user, HE extended range, HE trigger-based, HE NDP and Non-HT
- Analyze OFDMA, multi-user MIMO (MU-MIMO), up to 8 spatial streams, and up to 1024 QAM 802.11ax signals
- Analyze 802.11be signals with EHT compressed mode, up to 320 MHz bandwidth, and modulation format up to 4096 QAM
- Verify and troubleshoot PHY layer performance and errors down to the bit level

KEYSIGHT TECHNOLOGIES

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# 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.

The current 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.

While in the early research and development stage,  the next generation 802.11 standard, 802.11be or Extremely High Throughput (EHT) WLAN holds great promises. A lot of new features are being proposed that will significantly increase throughput and provide support for real-time applications. These features include 320 MHz transmission bandwidth, use of 4096-QAM modulation, and enhancements to MIMO with more spatial streams. Similar to 802.11ax, 802.11be will also operate in 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, ac, ax, and be.

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 |
| Resource unit (RU) size (# of subcarriers, 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

Designers can now gain greater insight into the latest wireless LAN signals with the 89600 VSA software for 802.11n/ac/ax, and 802.11be modulation analysis. 89600 VSA software provides spectrum, time and modulation quality measurements for WLAN 802.11n/ac/ax/be with option 89601BHXC and for WLAN 802.11a/b/g/j signals with option 89601B7RC.

WLAN options provide an advanced troubleshooting and evaluation toolset specifically designed to handle the challenge of analyzing legacy and new WLAN signals, covering technologies such as MU-MIMO and OFDMA used in the latest standards.

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 even the most advanced designs. Just as critically, the software helps you cut through the complexity as you assess your design tradeoffs.

# Analysis and Troubleshooting

## Analyze a wide range of WLAN formats

89600 VSA software option 89601BHXC provides the tools necessary to measure and troubleshoot IEEE 802.11n/ac/ax/be signals, and option 89601B7RC provides the tools to measure and troubleshoot IEEE 802.11a/b/g/j/p signals.

IEEE 802.11a/b/g/j/p
- Support 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 bandwidth 10 MHz, 20 MHz, and 40 MHz
- Modulation format of BPSK to 64 QAM

IEEE 802.11b/g DSSS/CCK/PBCC
- Support standard defined DSSS, CCK or PBCC
- Support modulation format of Barker1/Barker2CCK5.5/CCK11PBCC5.5/PBCC11/PBCC22/PBCC33

IEEE 802.11n:
- All operating modes: legacy, mixed and greenfield
- Channel bandwidth of 20 MHz and 40 MHz
- Up to four spatial streams

IEEE 802.11ac:
- VHT operating mode
- Channel bandwidth of 20 MHz, 40 MHz, 80 MHz, 80 + 80 MHz and 160 MHz
- Modulation format of BPSK up to 256QAM
- Up to eight spatial streams
- Downlink MU-MIMO with up to four simultaneous users

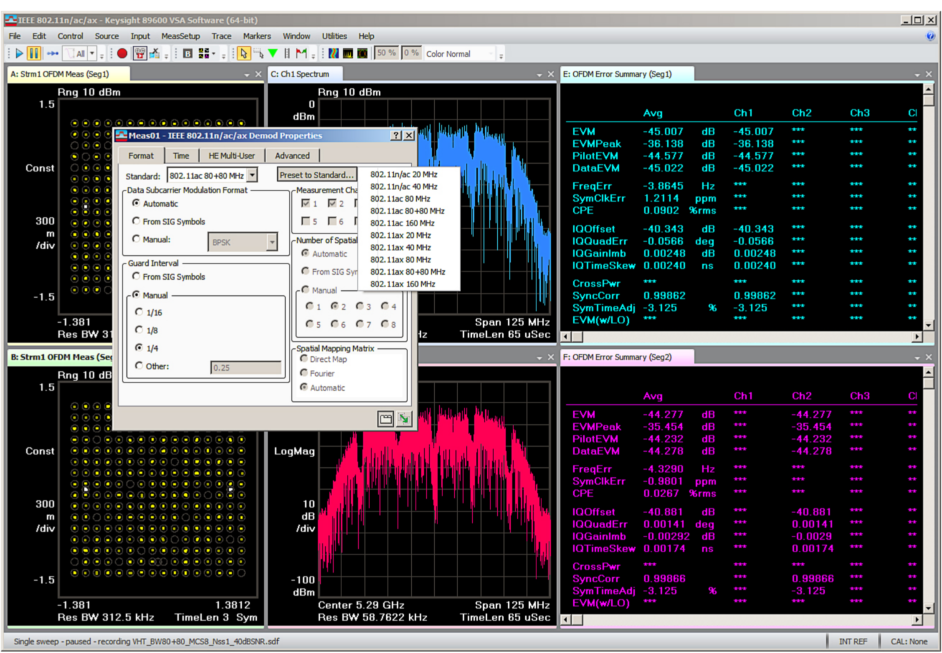


Figure 4. Troubleshoot and analyze 802.11ac signals with 80 + 80 MHz bandwidth and 256QAM

## IEEE 802.11ax

- All operating modes: HE SU, HE extended range, HE MU, and HE trigger-based
- Channel bandwidth of 20 MHz, 40 MHz, 80 MHz, 80 + 80 MHz and 160 MHz
- Modulation formats of BPSK up to 1024QAM
- 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

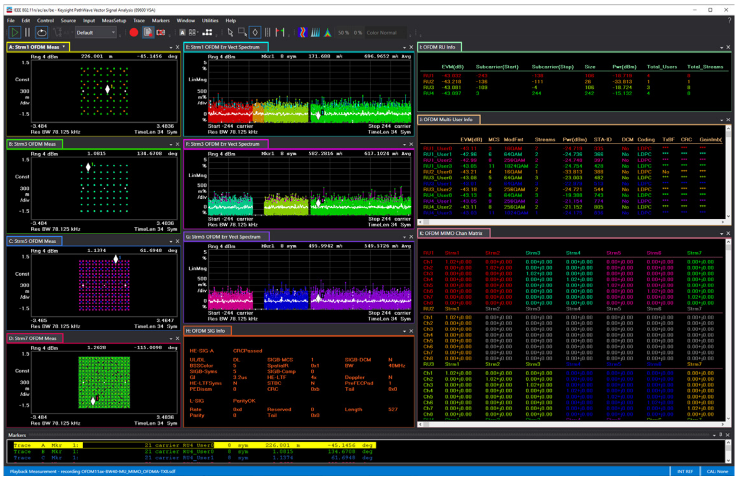

Figure 5. Evaluate signal quality and perform error vector measurements of 802.11ax signal with up to 160 MHz BW, 1024QAM and multi-user technologies such as OFDMA and MU-MIMO

## IEEE 802.11be

- EHT Multi User (MU) PPDU, compressed mode with resource unit (RU) puncturing
- Channel bandwidth of 20 MHz, 40 MHz, 80 MHz, 160 MHz and 320 MHz
- Modulation formats of BPSK up to 4096QAM
- Color coded measurement results by RU

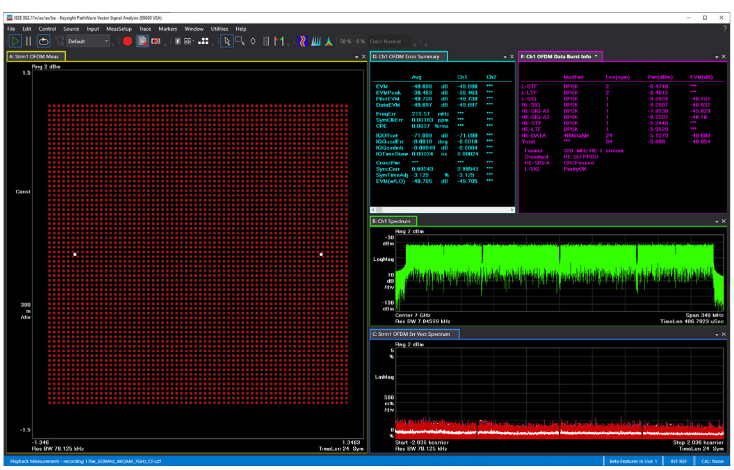

Figure 6. Evaluate signal quality and perform error vector measurements of 802.11be signal with up to 320MHz bandwidth and 4096QAM modulation.

## Get basics right, find major problems

Spectrum and time domain measurements give the basic parameters of the signal in frequency and time domain so that correct demodulation can take place. Use measurements such as occupied bandwidth (OBW) to quickly and accurately report the occupied bandwidth, band power and power ratio of the transmitted signal.

In addition, 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.

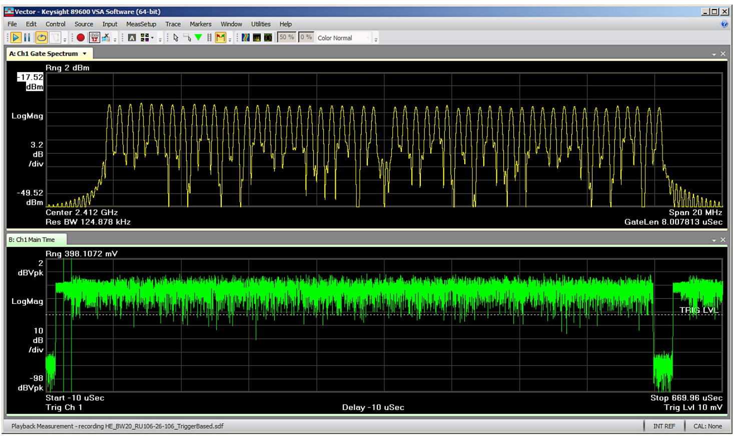


Figure 7. Gated spectrum measurement over the L-LTF portion of the SU-PPDU burst. The spectrum of the L-LTF symbol is displayed on the top trace showing flat amplitude across the 52 subcarriers.

## Easy digital demodulation setup with complete parameter control

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.  In addition, 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 for 89600 VSA software option 89601BHXC. 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.

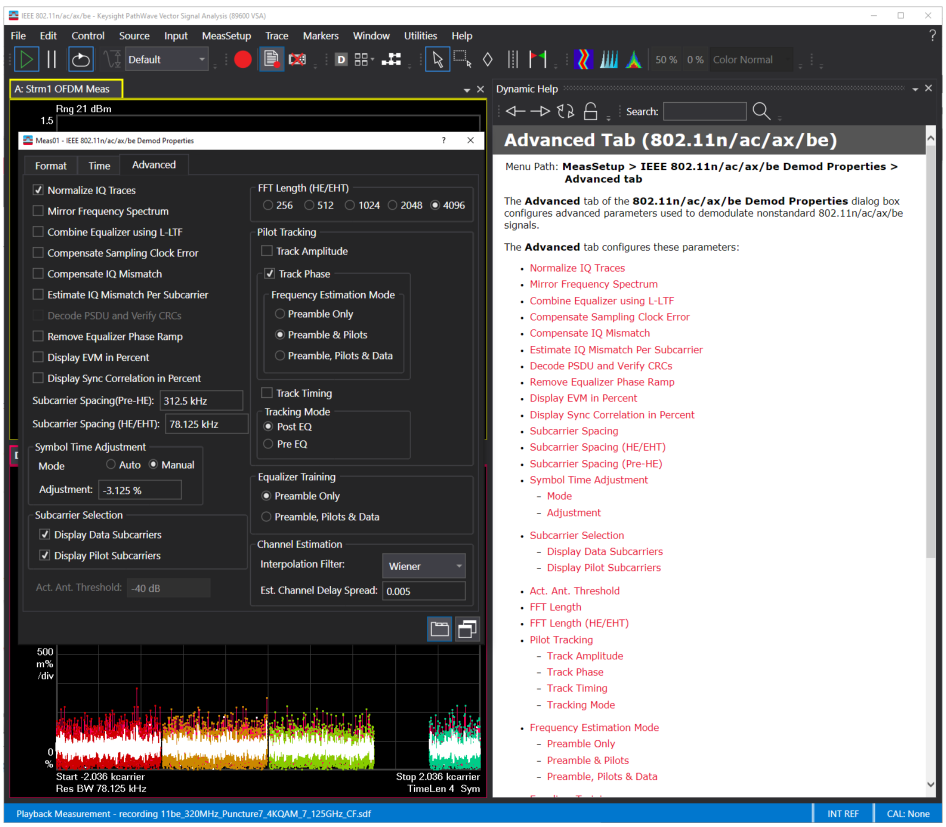


Figure 8. Easy setup to configure the WLAN demodulator to lock on to, and demodulate the test signal. Dynamic Help provides useful information to explain the demod properties and other important WLAN and 89600 VSA software operations.

## Powerful measurements to let you look at signal performance and investigate causes of errors in detail

Evaluate signal quality and error vector measurements of transmitted WLAN signals. 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 all modulation formats in the burst.

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

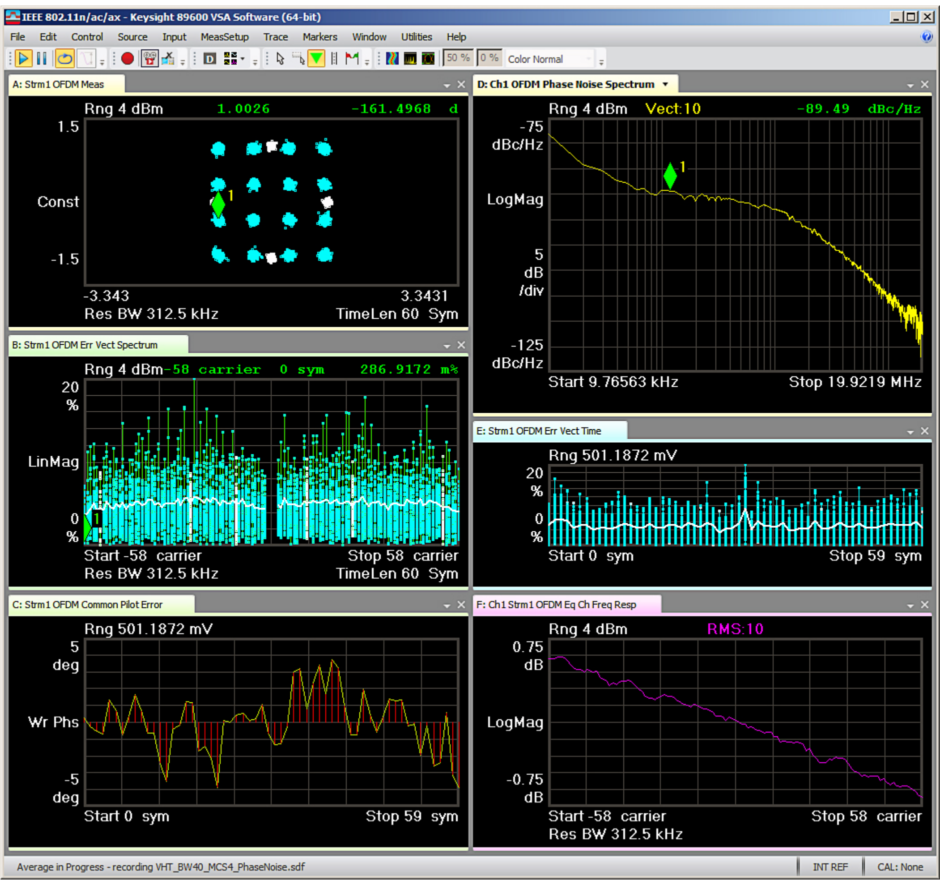


Figure 9. The 89600 VSA software lets you view an unlimited number of simultaneous traces, showing results such as EVM vs. frequency or time, equalizer channel frequency response, common pilot error, phase noise spectrum and more.

# 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.
The Data Burst Info trace provides decoded information of legacy and non-legacy preamble as well as data.

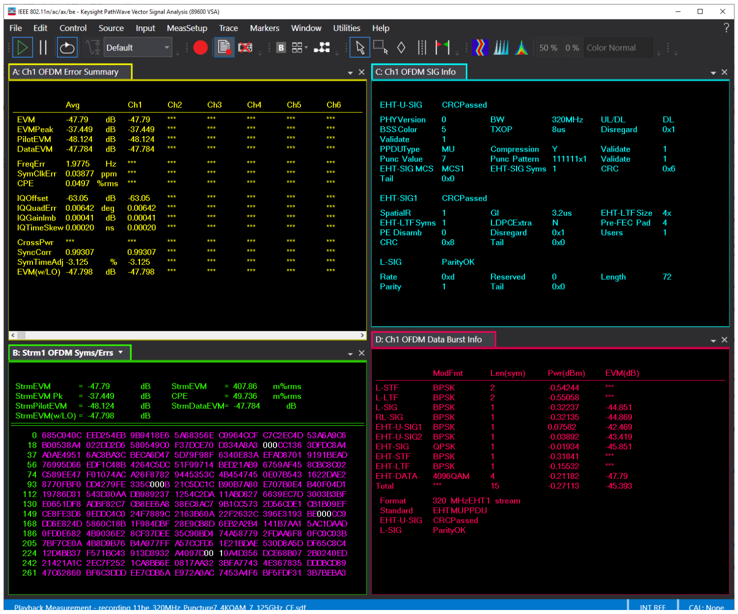

Figure 10. Example of 802.11be signal, showing in-depth, bit-level analysis with error summary tables, detected burst info and decoded SIG info.

# Multi-user analysis for 802.11ax: OFDMA and MU-MIMO

For OFDMA and MU-MIMO used in 802.11ax, in addition to composite EVM, EVM of individual RUs and individual users within each RU are computed and displayed.
For MU-MIMO, enabling SIG-B compression field enables full bandwidth MU-MIMO, instead of OFDMA MU-MIMO.

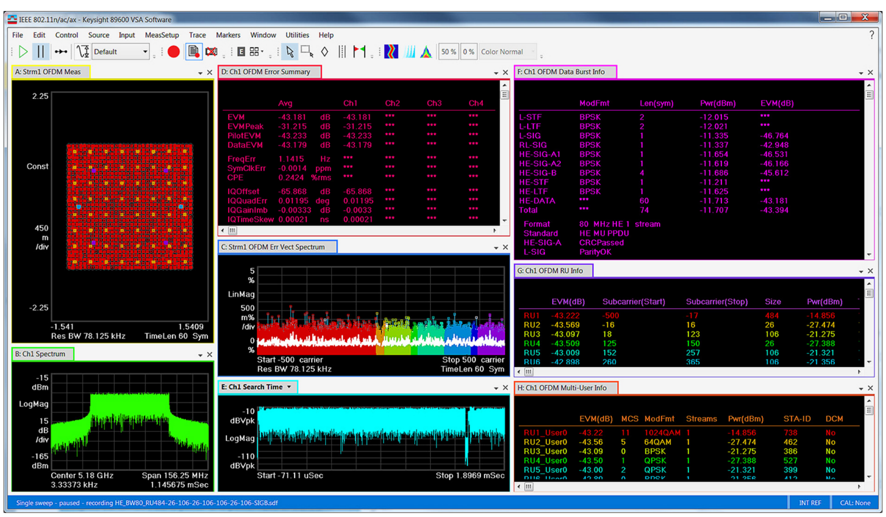

Figure 11. The 89600 VSA software lets you view an unlimited number of simultaneous traces color coded by RU and user, showing results such as constellation diagram, IQ errors, and in the case of 802.11ax MU-PPDU, EVM of individual RUs and individual users are also provided.

For trigger based PPDU of 802.11ax signal, which is used in UL OFDMA and/or MU-MIMO transmission, EVM of the transmitted RU as well as EVM of the unoccupied tones outside of the RU are measured. The averaged and peak unused tone EVM values for each measurement channel as well as the position of the peak unused tone EVM of the first measurement channel are displayed.

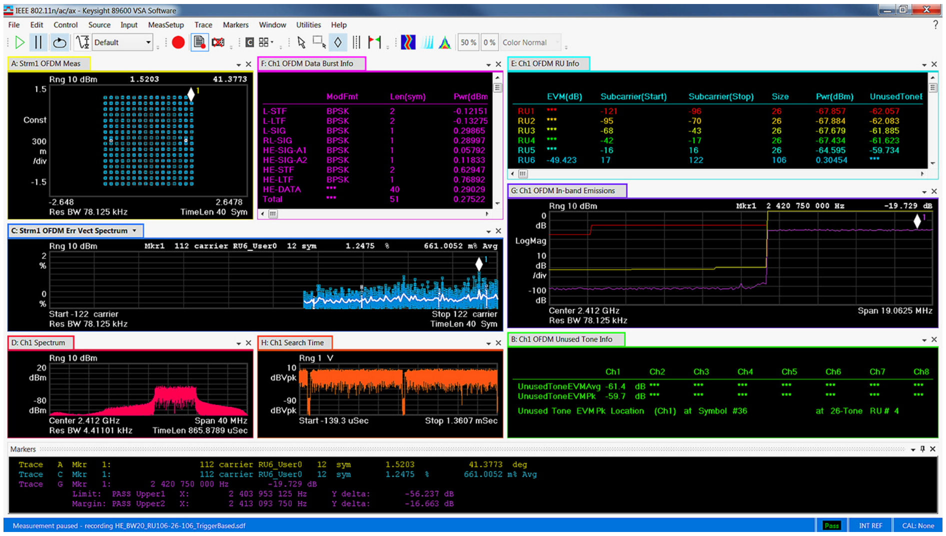

Figure 12. EVM measurement of trigger-based PPDU showing EVM of transmitted RU and new "Unused Tone EVM" trace displaying average and peak EVM of unoccupied tones outside of the RU and "In-band Emissions" providing average power over each subcarrier, limit over each unoccupied RU and unused tone EVM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

## MIMO analysis

Based on the format and use of the appropriate multi-channel front end, the 89600 software easily accommodates up to 8x8 SU-MIMO and MU-MIMO analysis with well-designed traces which provide data for both quick system overview as well as detailed analysis of the signal. Important channel, stream, and data information is available to you in user-selectable traces. Use these options anywhere from baseband to receiver, from simulation to antenna.

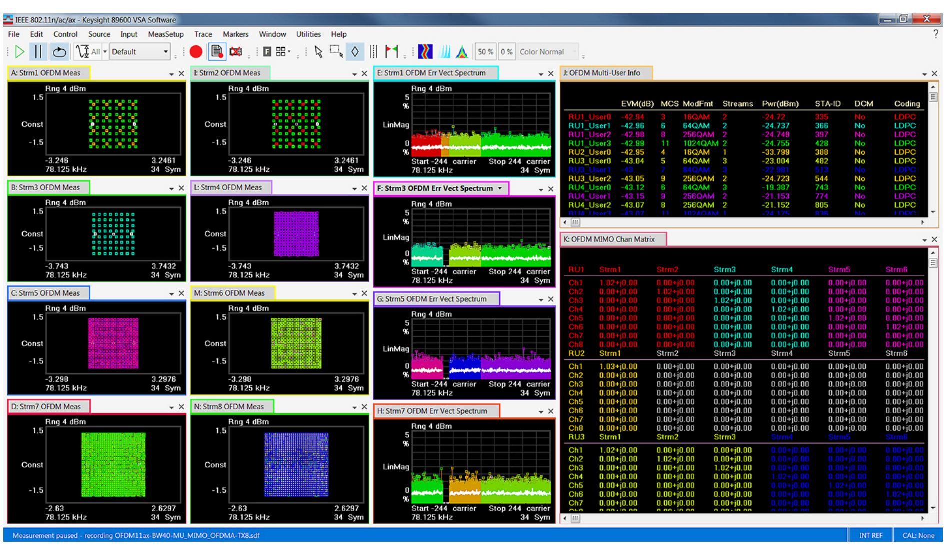

Figure 13. View key WLAN MIMO parameters simultaneously such as multiple constellations, error summary and channel matrix for each combination of Stream and Channel.

# 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** |
| Supported standards | IEEE 802.11-2012 | IEEE 802.11-2012 |
| Operating modes | | IEEE 802.11b long or short preamble/PBCC<br>IEEE 802.11g PBCC22/ PBCC33 |
| Preset to standard | IEEE 802.11a/g OFDM<br>HiperLAN2<br>IEEE 802.11g DSSS-OFDM<br>IEEE 802.11a/g turbo mode<br>IEEE 802.11p DSRCIEEE 802.11j 10 MHz | DSSS<br>CCK<br>PBCC |
| Data modulation format | BPSK<br>QPSK<br>16QAM<br>64QAM | Barker1/Barker2<br>CCK5.5/CCK11<br>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 | | | |
|---|---|---|---|---|
| **Technology** | **IEEE 802.11n** | **IEEE 802.11ac** | **IEEE 802.11ax** | **IEEE 802.11be** |
| Operating modes | HT-greenfield<br>HT-mixed<br>Non-HT duplicate<br>HT duplicate | VHT | HE-SU<br>HE-MU<br>HE-extended range<br>HE-trigger-based | EHT-MU |
| OFDMA | N/A | N/A | Uplink and downlink | Uplink and downlink |
| MU -MIMO | N/A | Downlink<br>Up to 4 users | Uplink and downlink<br>Up to 8 users | Future |
| SIG-B compression | N/A | N/A | Yes | Future |
| SU-MIMO | Up to 4 spatial streams | Up to 8 spatial streams | Up to 8 spatial streams | Future |
| Preset to standard | 802.11n 20 MHz<br>802.11n 40 MHz | 802.11ac 20 MHz<br>802.11ac 40 MHz<br>802.11ac 80 MHz<br>802.11ac 80+80 MHz<br>802.11ac 160 MHz | 802.11ax 20 MHz<br>802.11ax 40 MHz<br>802.11ax 80 MHz<br>802.11ax 80+80 MHz<br>802.11ax 160 MHz | 802.11be 20 MHz<br>802.11be 40 MHz<br>802.11be 80 MHz<br>802.11be 160 MHz<br>802.11be 320 MHz |
| Data modulation format | BPSK<br>QPSK<br>16QAM<br>64QAM | BPSK<br>QPSK<br>16QAM<br>64QAM<br>256QAM | BPSK<br>QPSK<br>16QAM<br>64QAM<br>256QAM<br>1024QAM | BPSK<br>QPSK<br>16QAM<br>64QMA<br>256QAM<br>1024QAM<br>4096QAM |
| Dual-carrier modulation | N/A | N/A | Yes | Future |
| 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 |

## Measurement results

| Pre-demodulation | 89601BHXC<br>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, 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 to 8, for 802.11ax) | 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, 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, EHT-U-SIG CRC pass/fail 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 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 (802.11ax only) | 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. |

## 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. 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 | | | |
| 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.

# 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

## Basic vector signal analysis and hardware connectivity (89601200C) (required) Wireless Connectivity Modulation Analysis (89601B7RC) for 802.11a/b/g/j/p High Throughput WLAN Modulation Analysis (89601BHXC) for 802.11n/ac/ax/be

| Software License Type | Software License | Support Subscription |
|---|---|---|
| Node-locked perpetual | R-Y5A-001-A | R-Y6A-001-z[2] |
| Node-locked time-based | R-Y4A-001-z[1] | Included |
| Transportable perpetual | R-Y5A-004-D | R-Y6A-004- z[2] |
| Transportable time-based | R-Y4A-004-z[1] | Included |
| Floating perpetual (single site) | R-Y5A-002-B | R-Y6A-002-z2 |
| Floating time-based (single site) | R-Y4A-002-z[1] | Included |
| Floating perpetual (regional) | R-Y5A-006-F | R-Y6A-006-z[2] |
| Floating time-based (regional) | R-Y4A-006-z[1] | Included |
| Floating perpetual (worldwide) | R-Y5A-010-J | R-Y6A-010-z[2] |
| Floating time-based (worldwide) | R-Y4A-010-z[1] | Included |
| USB portable perpetual | R-Y5A-005-E | R-Y6A-005- z[2] |
| USB portable time-based | R-Y4A-005-z[1] | Included |

## One month software support subscription extensions[3]

| Support Subscription | Description |
|---|---|
| R-Y6A-501 | 1-month of support subscription for node-locked perpetual license |
| R-Y6A-504 | 1-month of support subscription for transportable perpetual license |
| R-Y6A-505 | 1-month of support subscription for USB portable perpetual license |
| R-Y6A-502 | 1-month of support subscription for floating perpetual license (single site) |
| R-Y6A-506 | 1-month of support subscription for floating perpetual license (single region) |
| R-Y6A-510 | 1-month of support subscription for floating perpetual license (worldwide) |

1. z means different time-based license duration. F for six months, L for 12 months, X for 24 months, and Y for 36 months. All time-based licenses have included the support subscription same as the time-base duration.
2. z means different support subscription duration. L for 12 months (as default), X for 24 months, Y for 36 months, and Z for 60-months. Support subscription must be purchased for all perpetual licenses with 12-months as the default. All software upgrades and KeysightCare support are provided for software licenses with valid support subscription.
3. Support subscription for all perpetual licenses can be extended with monthly extensions.

## 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** | | |
| N9041B UXA | Up to 110 GHz | Up to 1 GHz |
| N9040B UXA | Up to 50 GHz | Up to 1 GHz |
| N9030A/B PXA | Up to 50 GHz | Up to 510 MHz |
| N9021B | Up to 50 GHz | Up to 510 MHz |
| N9020A/B MXA | Up to 26.5 GHz | Up to 160 MHz |
| **Modular product** | | |
| M9415A 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 |

## 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, 89601B7RX, and 89601BHXC 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

## Upgrade your 89601B to 89601C

Keysight now launches the totally new 89600 VSA software as 89601C after September 2019 as version 2019 update 1.0, the existing 89601B customers can continue to use 89601C software with valid 89601B license or can visit the Keysight software upgrade webpage to fill in their current 89601B software license information and get a quote for upgrading from 89601B licenses to 89601C licenses within limited time.
https://upgrade.software.keysight.com/software_upgrade_form.html

# 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

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

## Web

www.keysight.com/find/89600VSA
www.keysight.com/find/vsa_trial
www.keysight.com/find/89600_software
www.keysight.com/find/89600_hardware