

5G NR/5G-Advanced Modulation Analysis - 89600 VSA

Option 89601BHNC

- See through the complexity of 3GPP 5G and 5G-Advanced signals with a comprehensive and forward compatible set of demodulation and vector signal analysis tools.
- Examine per-user and per-channel performance with up to 8x8 spatial multiplexing single user MIMO and up to 64 channels massive MIMO (mMIMO) and beamforming.
- Analyze downlink and uplink signals to assess signal quality through decoding (CRC and BLER), overall EVM, EVM across symbols and subcarriers, constellations, IQ error plots, and more.
- Integral part of Keysight's Open RAN solution for O-RU uplink and downlink conformance testing, (O-RAN WG4 compliant), including receiver sensitivity testing under low-SNR conditions.
- Use the color coding and marker coupling features to identify and isolate specific signal and channel effects and impairments.
- Analyze LTE and NR simultaneously for coexistence through dynamic spectrum sharing (DSS).
- 89600 VSA introduces three tiered models from VSA2025 U1 release with three different tiered options as 89601201C (Advanced), 89601202C (Standard), and 89601203C (Essential) to cover the capabilities with different Center Frequency (CF), Intermediate Frequency (IF) bandwidth, baseband IQ (BBIQ) bandwidth, and measurement channel limitation (See [5992-4210EN](#) for more details)
- The legacy Option 89601200C as basic core and hardware connectivity can continue to work as advanced tier model which have the same capabilities as 89601201C advanced tier

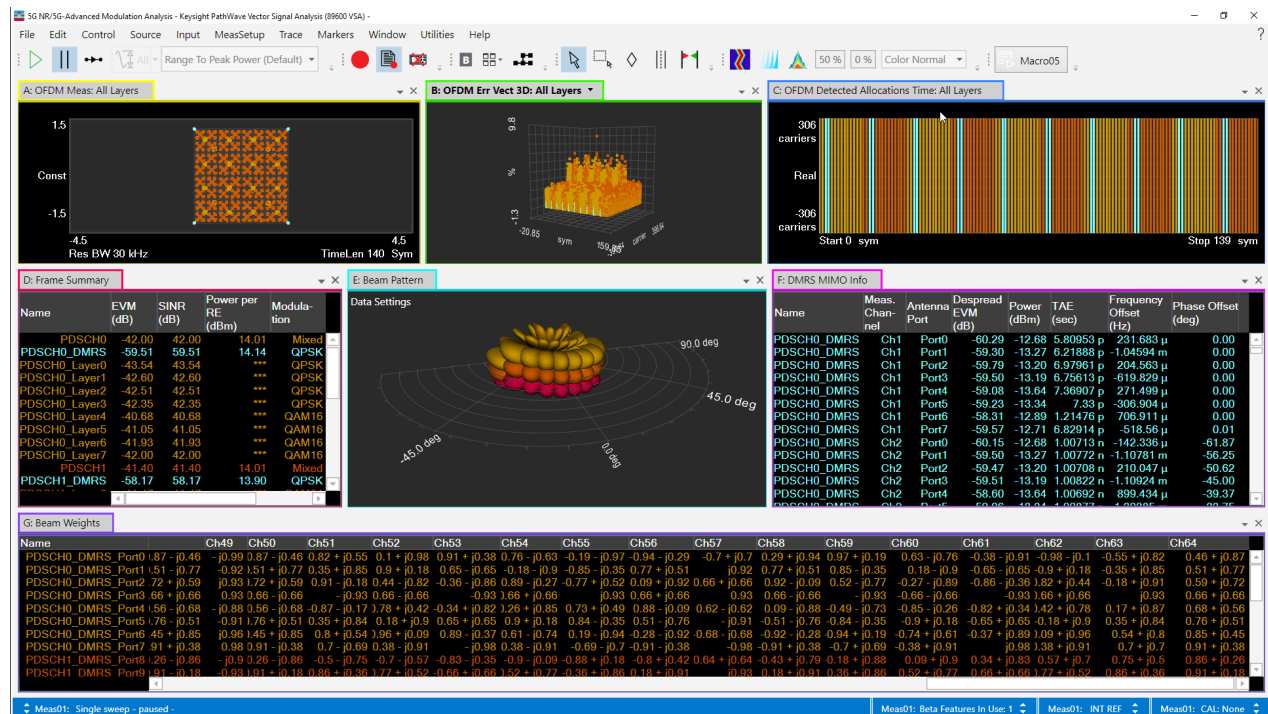


Table of Contents

5G NR/5G-Advanced Modulation Analysis	3
Analysis and Troubleshooting	3
Easy Setup With Complete Parameter Control.....	6
Software Features	20
Ordering Information	26
Additional Resources	27

5G NR/5G-Advanced Modulation Analysis

The 89600 VSA software's 5G NR/5G-Advanced application (89601BHNC) offers comprehensive analysis capabilities across frequency, time, and modulation domains for signals adhering to 3GPP's 5G NR and 5G-Advanced specifications (www.3gpp.org).

The software provides frequency-, time-, and modulation-domain analysis results within a single measurement. By configuring result traces - such as spectrum, acquisition time, and NR specific modulation quality traces and tables - engineers can effectively discern overall signal characteristics and troubleshoot issues like intermittent error peaks or repeated synchronization failures.

To expedite design workflows, the software provides .NET API and SCPI remote interfaces for automated testing, enabling a smooth transition to design verification and manufacturing phases.

Supporting over 75 signal standards and modulation types, including 5G NR and 5G-Advanced, the 89600 VSA is a comprehensive toolkit for demodulation and vector signal analysis. Engineers can explore every aspect of a signal and optimize even the most advanced designs. As you evaluate design tradeoffs, the 89600 VSA helps you cut through complexity.

Analysis and Troubleshooting

Perform 5G NR/5G-Advanced Measurements

The 89601BHNC application supports 5G NR and 5G-Advanced modulation analysis in accordance with 3GPP TS38 specifications (Releases 15, 16, 17, and 18). Key supported features include:

1. Waveform, numerology, and frame structure

- CP-OFDM waveform for downlink (DL) and uplink (UL)
- Transform precoding (DFT-S-OFDM) waveform for UL
- All numerologies ($\mu = 0-6$ representing 15, 30, 60, 120, 240, 480, 960 kHz subcarrier spacing)
- Mixed numerologies within a single or multiple bandwidth parts (BWPs)
- Flexible slot structure for FDD and TDD: All UL, all DL, mixed UL and DL
- All signal bandwidths for frequency range 1 (FR1) and frequency range 2 (FR2-1, FR2-2)
 - FR1 (sub-7.125 GHz): 3, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100 MHz
 - FR2-1 (24.25 - 52.6 GHz): 50, 100, 200, 400 MHz
 - FR2-2 (52.6 - 71 GHz): 400, 800, 1600, 2000 MHz

2. UL and DL channels and signals with modulation formats and power boosting

- Initial access channels and signals: PSS, SSS, PBCH
- DL reference signals: DMRS, PTRS, CSI-RS, RIM-RS, PRS
- DL control and shared channels: PDSCH, PDCCH
- UL reference signals: DMRS, PTRS, SRS
- UL control and shared channels: PUSCH, PUCCH, PRACH

3. Channel decoding

- LDPC decoding for PDSCH and PUSCH
- Polar decoding for PBCH, PDCCH and PUCCH

4. MIMO and beamforming

- Up to 8x8 single user MIMO for DL and UL,
- Up to 24 DMRS ports for Multi-User MIMO (MU-MIMO)
- Up to 64 channels massive MIMO and beamforming

5. Test models

- Test models for FDD and TDD per 3GPP TS 38.141-1 and TS 38.141-2 specifications
- Test models for Satellite Access Node (SAN) per 3GPP TS 38.181 specification

6. O-RAN transmitter and receiver test

- Transmitter conformance test for uplink and downlink
- Uplink performance improvement (ULPI) analysis
- Receiver sensitivity test under low-SNR conditions

7. Dynamic Spectrum Sharing (DSS)

- Simultaneous demodulation of LTE and 5G NR signals

8. 3GPP releases

- 3GPP Release 16: NR unlicensed spectrum (NR-U), enhanced MIMO (eMIMO), enhanced DSS (eDSS), SRS for positioning
- 3GPP Release 17: 1024QAM modulation for PDSCH, new numerology (480 and 960 kHz sub carrier spacing) resulting up to 2 GHz signal bandwidth, non-terrestrial networks (NTN), reduced capability (RedCap) NR devices
- 3GPP Release 18 (5G-Advanced): 3 MHz bandwidth, 8x8 MIMO in UL, up to 24 orthogonal DMRS ports for MU-MIMO

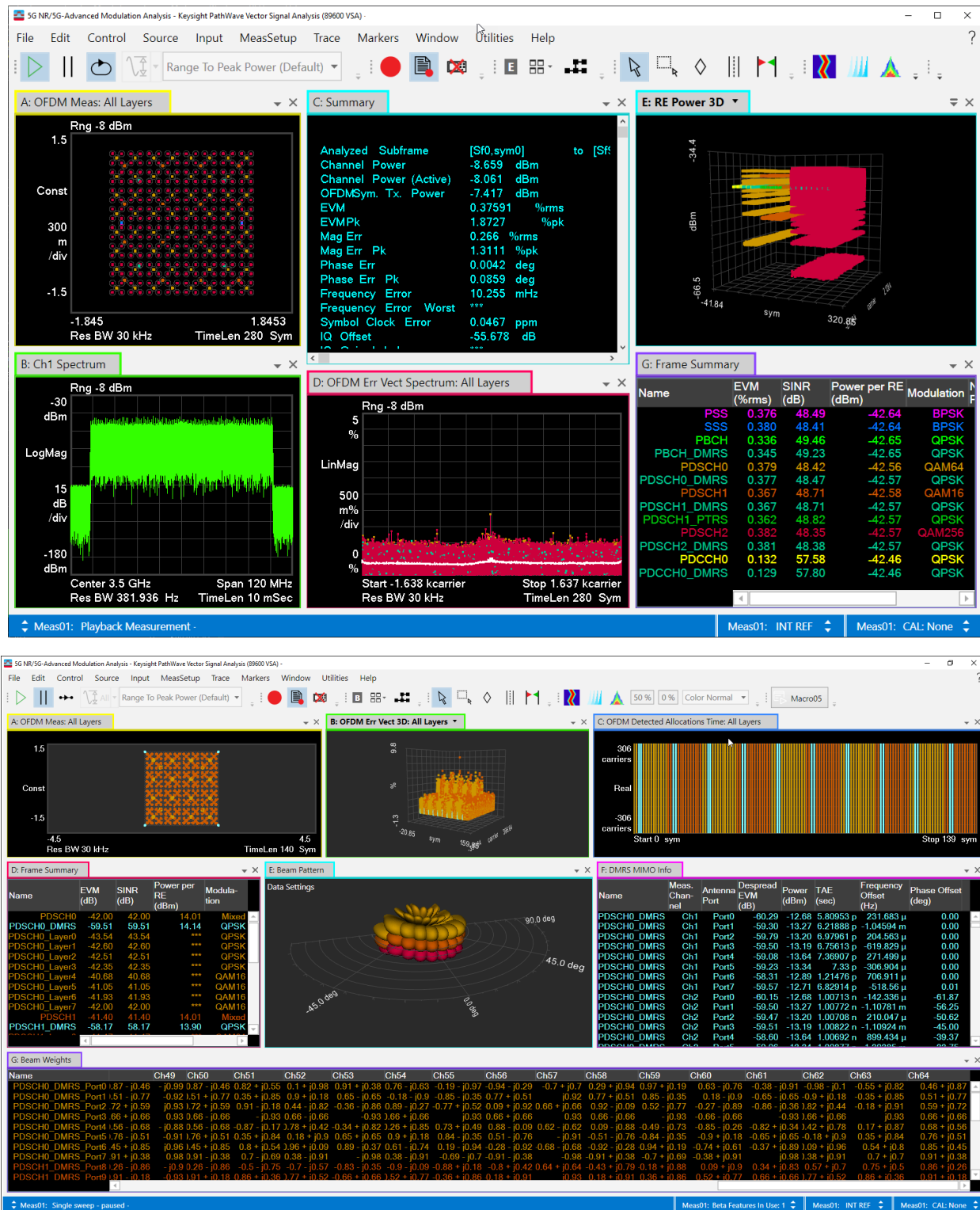


Figure 1. With the 89600 VSA software, you can analyze 5G and 5G-Advanced MIMO and Massive MIMO signals with up to 24 orthogonal DMRS ports and up to 64 input channels. Signal quality metrics such as EVM, Timing Alignment Error (TAE), phase error, frequency error, and more can be measured per DMRS port and channel.

Easy Setup with Complete Parameter Control

For successful demodulation and troubleshooting, configure your VSA using the easy-to-follow Graphical User Interface (GUI). The Block Diagram window provides a left-to-right flowing visual representation of the VSA measurement setup. Each block corresponds to a set of related parameters in the Menu Bar. You can click any block to open a dialog that contains the full set of related parameters (also accessible from the Menu Bar). In addition, you can use one of the quick setups to load one of the commonly used configurations and modify it for your specific measurement.

Dynamic Help allows you to access the help text and learn about the 5G/5G-Advanced format and the features available for option BHN. Detaching the Dynamic Help window and moving it to the side of the screen, as shown in Figure 2, enables easier viewing as it follows your menu choices. You can even lock it to stay fixed on important Help data topics.

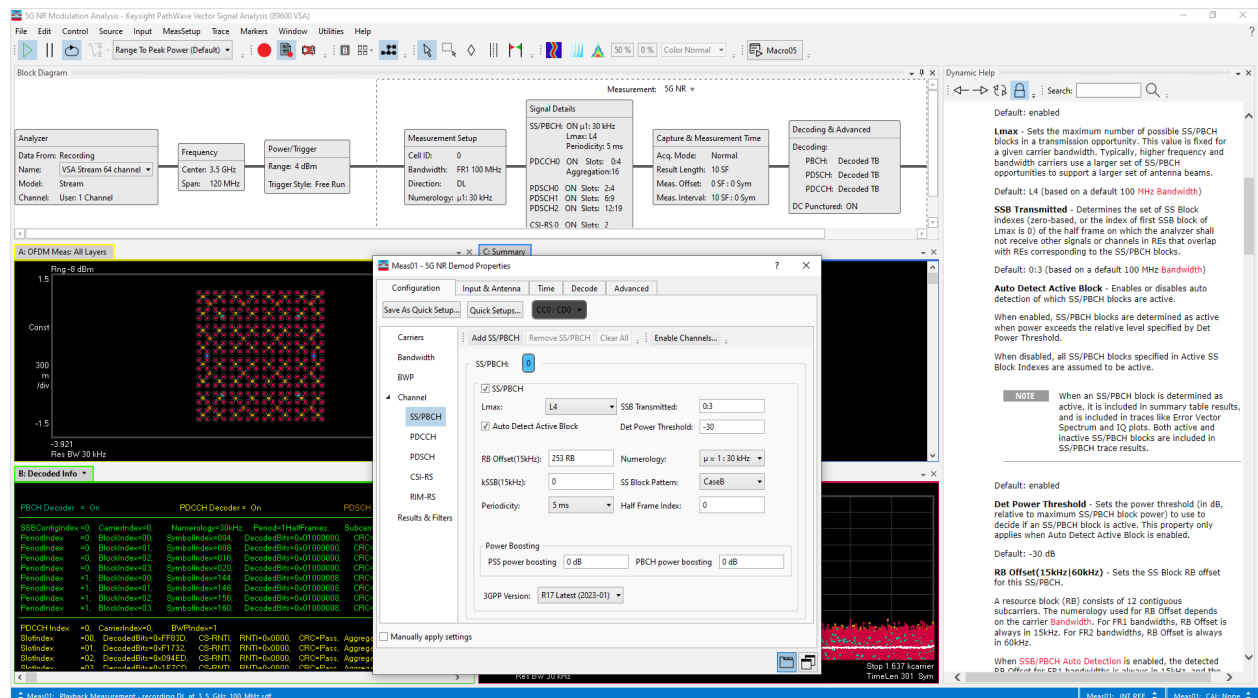


Figure 2. Setup is easy with complete parameter control. Dynamic Help provides useful information to explain measurements and other important 5G/5G-Advanced and 89600 VSA software operations.

Understand the Structure and Quality of 5G NR and 5G-Advanced Signals

The 89600 VSA software provides powerful demodulation, decoding, and analysis tools that enable users to assess the structure and quality of transmitted NR signals. Users have full flexibility to select the trace format and the number of simultaneous traces displayed.

Figure 3 illustrates a downlink NR signal, with each trace offering a unique, orthogonal perspective of the signal. Additional trace views are available depending on the analysis objective.

Description of some of the digital demodulation traces:

- **Trace A (top, left):** Composite IQ constellation of the demodulated signal, showing modulation formats ranging from 256QAM on PDSCH to BPSK for PSS and SSS.
- **Trace B (top, center):** Frame summary table using color coding to indicate the modulation format and channel allocation within the radio frame. Measurement results include EVM, SINR, power, modulation format, number of resource blocks, RNTI, and the BWP ID associated with each channel or signal.
- **Trace C (top, right):** Color-coded view of the transmitted signal structure. This two-dimensional grid plots frequency (subcarriers) on the vertical axis and time (symbols) on the horizontal axis, showing SS/PBCH blocks, PDCCH, and multiple PDSCH allocations.
- **Trace D (middle, left):** Slot summary table organized by BWP, subframe, and slot. Each entry reports RNTI, EVM, power, modulation format, number of resource blocks, CRC status, peak EVM value, and the corresponding symbol and subcarrier indices.
- **Trace E (middle, center):** Error summary table providing composite-signal quality statistics, including EVM, frequency and phase error, symbol-clock error, IQ offset, IQ gain imbalance, IQ quadrature error, and time offset. When channel decoding is enabled, the table also reports total transport block (TB) count, error TB count, BLER, and throughput results.
- **Trace F and G (middle, right):** 3D power plot and 3D EVM plot, showing magnitude and error variation across time and frequency.
- **Trace H (bottom, left):** RF spectrum of the transmitted signal at a 39 GHz center frequency, used to verify bandwidth usage and spectral performance.
- **Traces I and J (bottom center and right):** EVM as a function of OFDM symbols and subcarriers, respectively, helping identify localized impairments or interference patterns.

Note: Users have full control over each channel's color assignment, trace visibility, and inclusion in EVM computations, allowing for tailored visualization and deeper signal-quality insights.

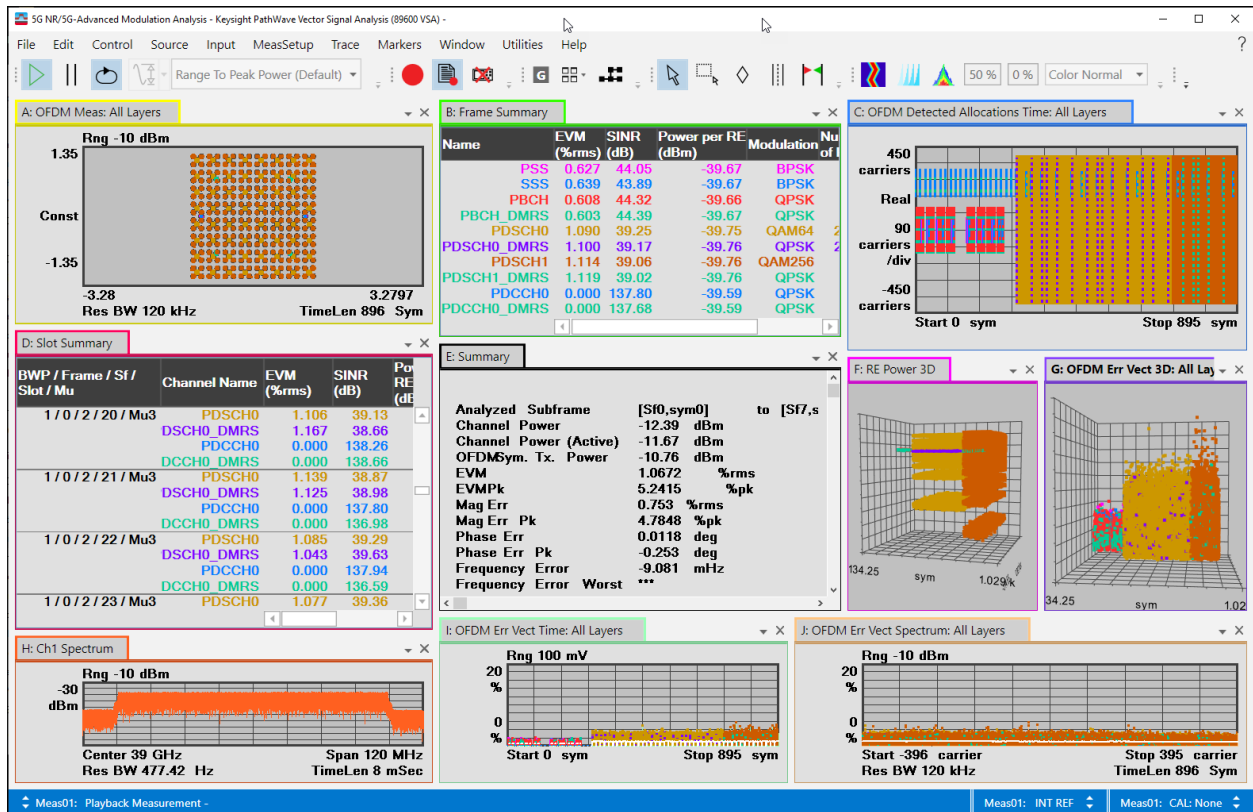


Figure 3. Example analysis of a downlink 5G NR signal at a 39 GHz center frequency, showing SS/PBCH, PDCCH, and multiple PDSCH allocations.

Test Beyond the Physical Layer

The 89600 VSA software extends analysis beyond the physical layer with powerful channel decoding for both downlink and uplink signals. It supports LDPC decoding for PDSCH and PUSCH, and polar decoding for PBCH, PDCCH, and PUCCH—providing detailed insight into transmitted and received data content.

For each channel, the software reports Code Block (CB) and Transport Block (TB) CRC Pass/Fail status.

- **PBCH:** Decodes all parameters defined in 3GPP TS 38.331 (e.g., SFN, subcarrier spacing, SSB offset).
- **PDCCH:** When auto detection is enabled, reports aggregation level, candidate index, payload size, and DCI format.
- **PDSCH/PUSCH:** Displays allocated slots, Redundancy Version (RV) index, effective code rate, CRC status, and number of code blocks.

BLER and throughput results appear in the Summary table—key metrics for O-RAN receiver testing. The decoded bitstream is also displayed for each channel, an essential feature for O-RAN conformance verification, where the decoded payload must match the original transmission.

Users can choose how much of the coding process to reverse before displaying bits: Descrambled, Deratematched, Decoded Code Block (CB) and Decoded Transport Block (TB)

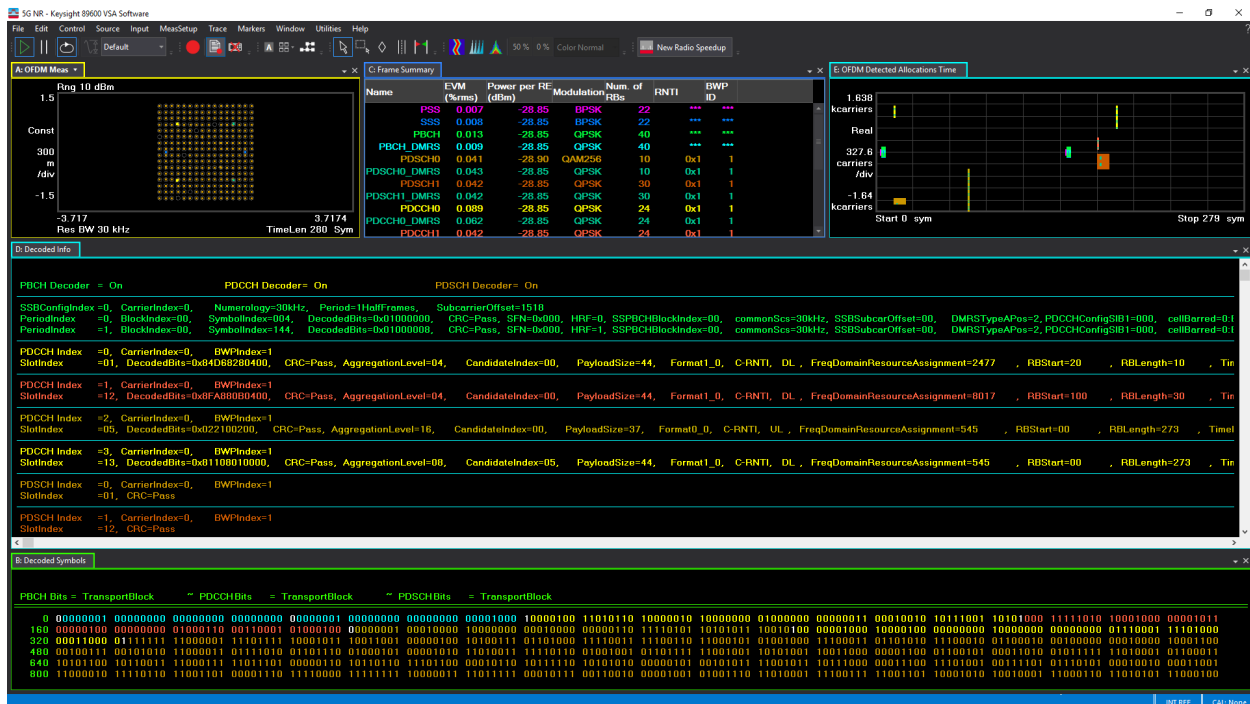


Figure 4. Example of downlink decoded information and decoded symbols for PBCH, PDCCH, and PDSCH

In-depth Analysis and Troubleshooting with Coupling Measurements Across Domains

The 89600 VSA software enables deeper troubleshooting of 5G and 5G-Advanced signals through multiple color-coded traces combined with marker coupling across time, frequency, and error domains. This approach is particularly valuable when analyzing signals with many elements—such as channels, reference signals, and OFDM subcarriers—where visual correlation simplifies problem identification.

Using coupled markers, engineers can instantly correlate events across traces. Figure 5, as an example, shows an uplink signal with multiple color-coded traces and coupled markers. A peak search in the Error Vector Spectrum (Trace C) or Error Vector Time (Trace D) identifies the same symbol across all other domains. The corresponding time-domain OFDM symbol index, frequency-domain subcarrier number, channel type, and IQ magnitude or phase can then be examined simultaneously.

This synchronized view makes it easy to isolate the root cause of impairments such as distortion, phase noise, or symbol-timing error—improving both analysis accuracy and debug efficiency.

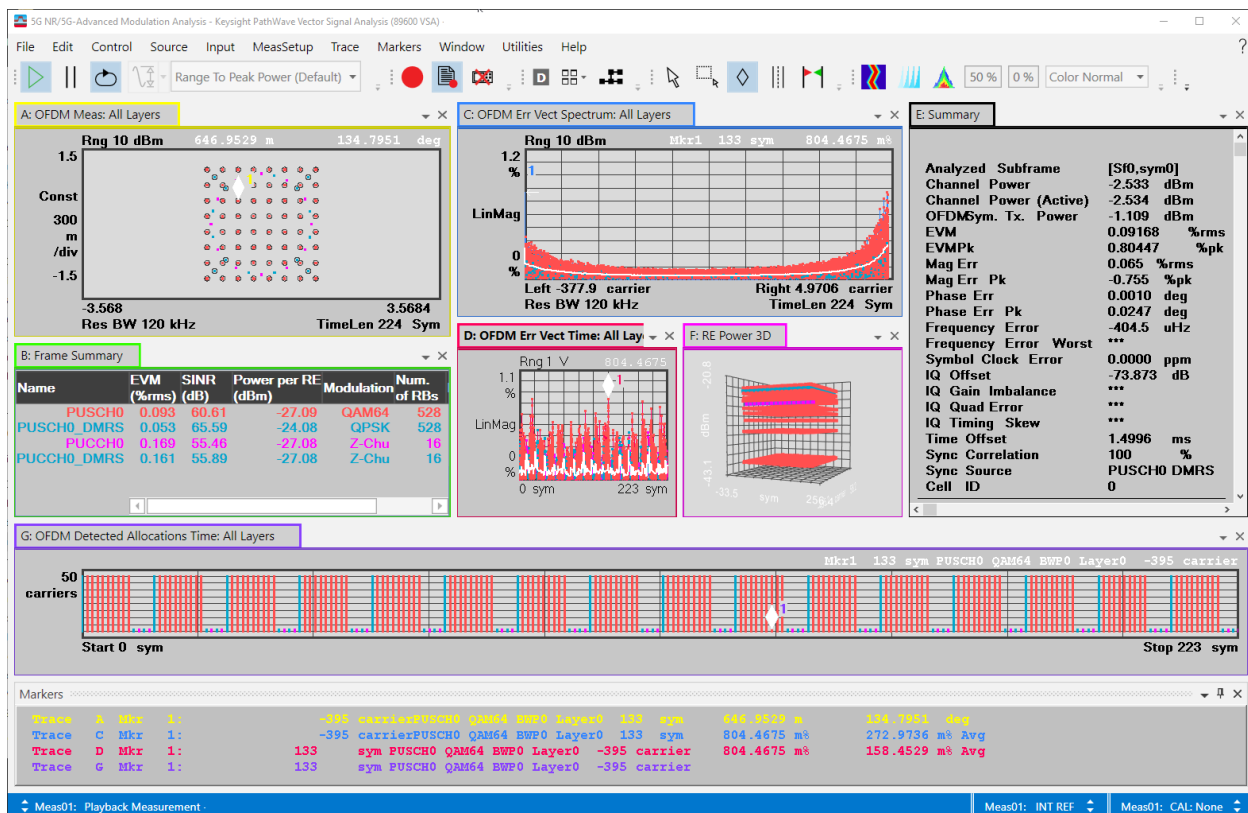


Figure 5. Example of an uplink signal with multiple color-coded traces and coupled markers. A peak search in the Error Vector Spectrum or Time trace highlights the associated symbol across all measurement domains, revealing its exact position and characteristics.

Analyze Beam-Sweeping with SS/PBCH Phase and Power Traces

To establish reliable connections and sufficient coverage, an NR base station (gNB) performs beam-sweeping, transmitting synchronization and system information through the initial access signals (SS/PBCH). At mmWave frequencies, up to 64 SS/PBCH blocks may be transmitted in different beam directions, making it essential to measure both power and phase across all beams to confirm uniform coverage and alignment.

The 89600 VSA software provides dedicated SS/PBCH measurements to evaluate beam-sweeping performance.

As shown in Figure 6, the SS/PBCH Power trace (Trace D) displays the absolute power of each active SS/PBCH block, while the SS/PBCH Survey traces (Traces E and F) present the relative power and phase differences across all beams.

These synchronized traces enable quick identification of beam imbalance, phase drift, or mis-aligned SS blocks that may impact link establishment and handover reliability.

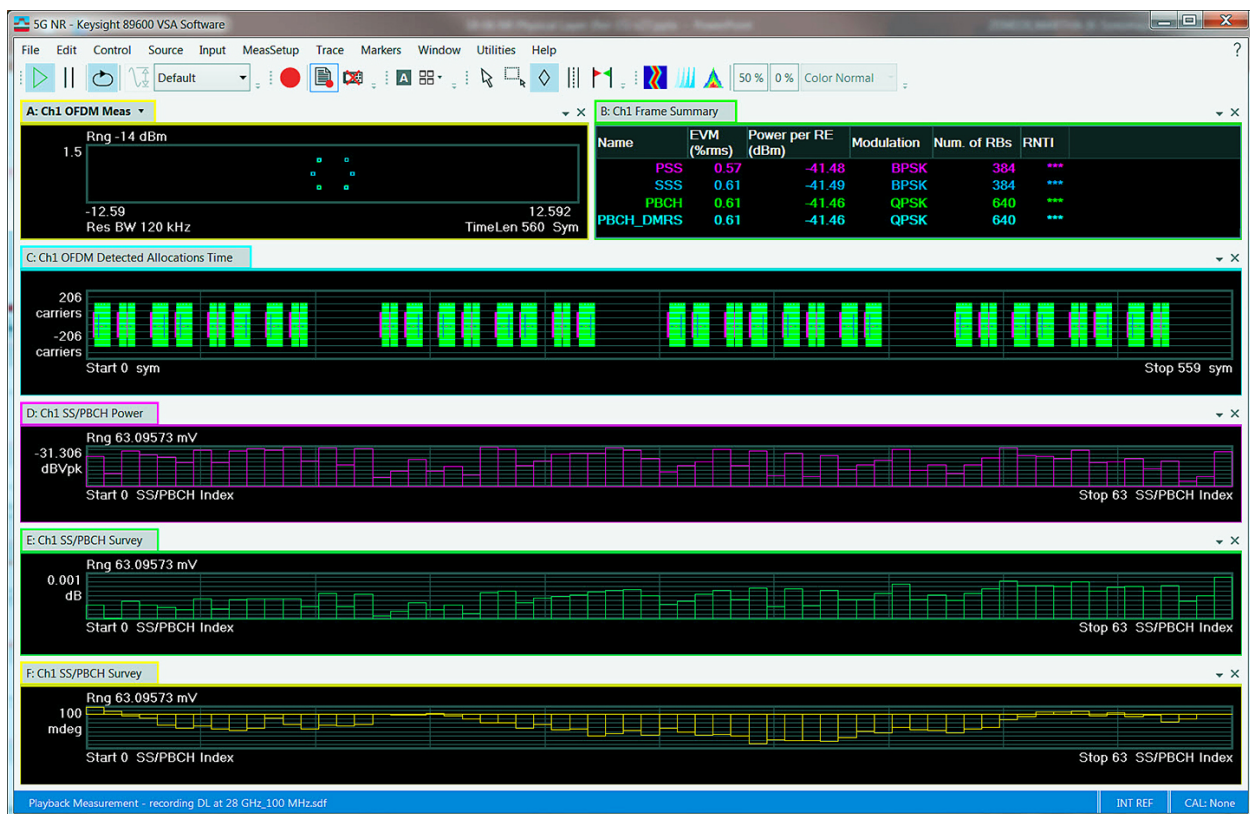


Figure 6. Example of SS/PBCH-specific measurements showing power (Trace D) and relative power/phase (Traces E and F) across active SS/PBCH indices for beam-sweeping analysis.

Faster Validation with Design and Test Integration

When moving from design to test, engineers can streamline their workflow and avoid measurement inconsistencies by leveraging the tight linkage between Keysight EDA SystemVue ESL software and the 89600 VSA software.

SystemVue, when used with the W1906EP 5G Baseband Verification Library, can simulate 5G and 5G-Advanced signals. These simulated signals can then be analyzed directly in the 89600 VSA software using the same demodulation and visualization tools applied during hardware testing.

In this configuration, connection to physical hardware isn't required. Engineers can instead use the 89600 VSA Sink within SystemVue to verify and troubleshoot 5G designs in simulation. The VSA Sink provides the same measurement algorithms, interface, and graphical displays used in real test set-up, enabling rapid debugging during design, prototype, and validation phases.

The VSA Sink can also record a waveform at virtually any point in the simulation flow for playback on test hardware or use as a reference against measured data from a Device Under Test (DUT). Because the same algorithms and displays are used for both simulated and measured data, any discrepancies observed on prototypes can be confidently attributed to the device — not the measurement tools.

Using a consistent GUI across design and test further eliminates the learning curve as projects transition through the development lifecycle.

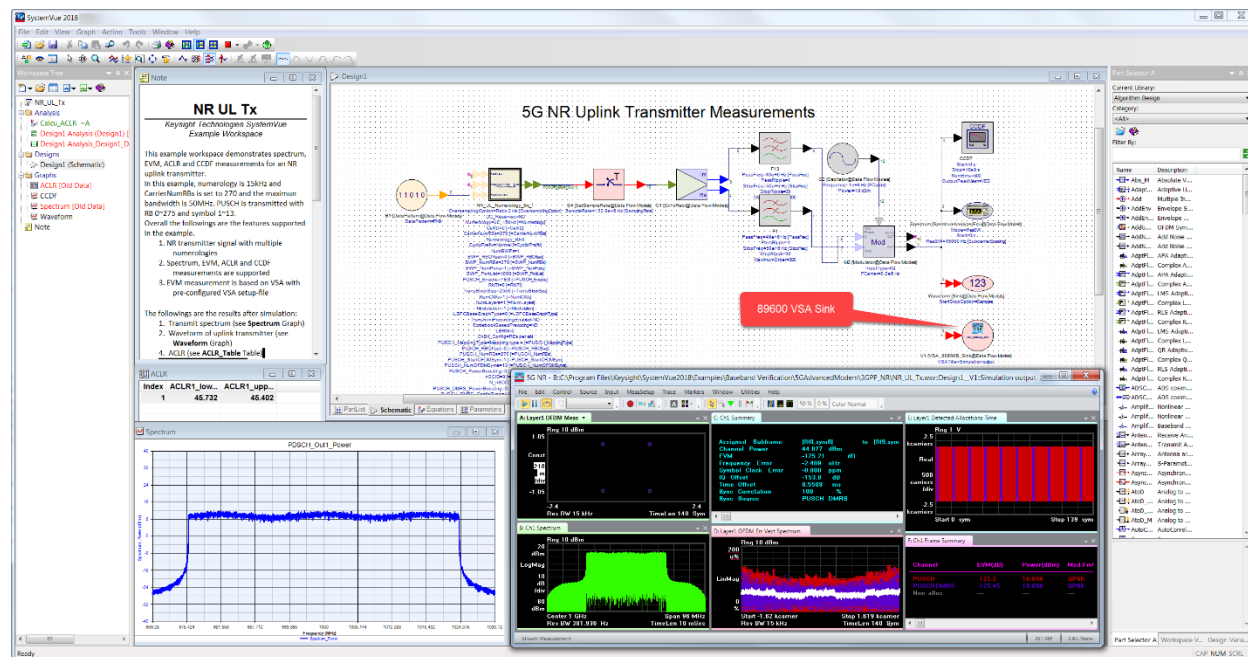


Figure 7. Example showing linkage between Keysight EDA SystemVue ESL software and 89600 VSA software for unified design and test validation.

MIMO and Beamforming Analysis

Use the 5G/5G-Advanced application for analysis and troubleshooting of MIMO and beamforming configurations for both uplink and downlink, supporting up to 8×8 single-user MIMO (SU-MIMO), up to 24 DMRS ports for multi-user MIMO (MU-MIMO), and massive MIMO (mMIMO) or beamforming setups with as many as 64 channels.

Various traces are available to evaluate per-user, per-layer, per-port, and per-channel modulation quality, as well as power, time, frequency, and phase characteristics.

The MIMO Information Table (Figure 8, Trace C) lists per-user details such as measurement channel and antenna port, along with de-spread EVM, power per RE, Timing Alignment Error (TAE), frequency offset, and phase offset for each user and antenna port.

In addition, the Channel Summary trace (Figure 8, Trace D) provides measurements for each RF input channel. For example, in a 32-channel beamforming measurement, the Channel Summary trace reports results for each of the 32 RF input channels.

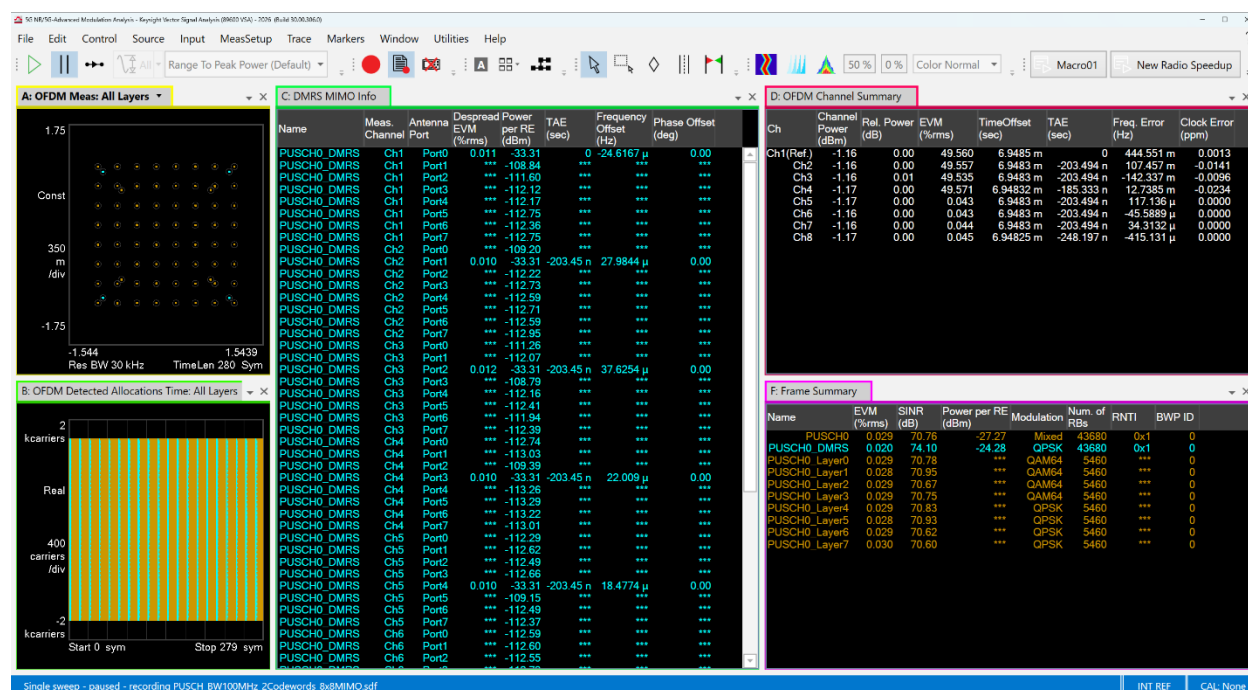


Figure 8. Example of an 8×8 MIMO measurement showing per-user and per-port results in the DMRS MIMO Info table (Trace C), per-user and per-layer results in the Frame Summary (Trace E), and per-channel metrics in the Channel Summary table (Trace D).

For massive MIMO and beamforming measurements, results include beam weights, beam picks, and beam patterns for channels such as SSB, CSI-RS, PDSCH, PDCCH, PUSCH, and SRS.

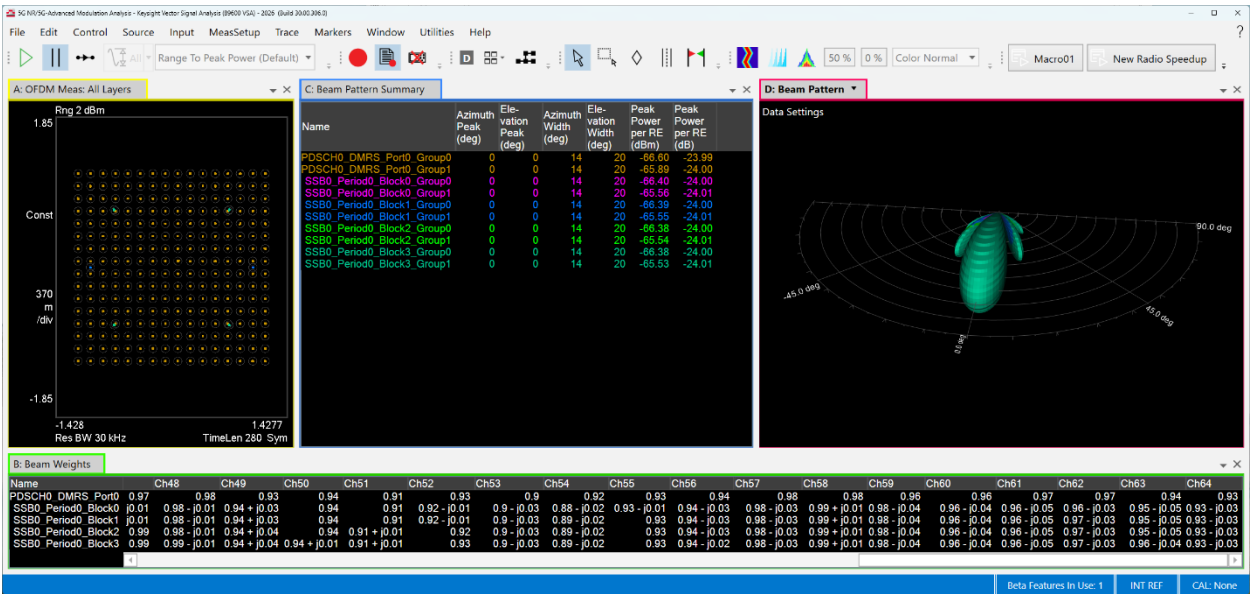


Figure 9. Example of a 64-channel downlink beamforming measurement, showing magnitude and phase weightings and the corresponding beam patterns.

The 89600 VSA supports O-RAN channel-information-based beamforming by using user-provided channel estimates (H-Matrix) to process beamformed signals and perform per-user measurements.

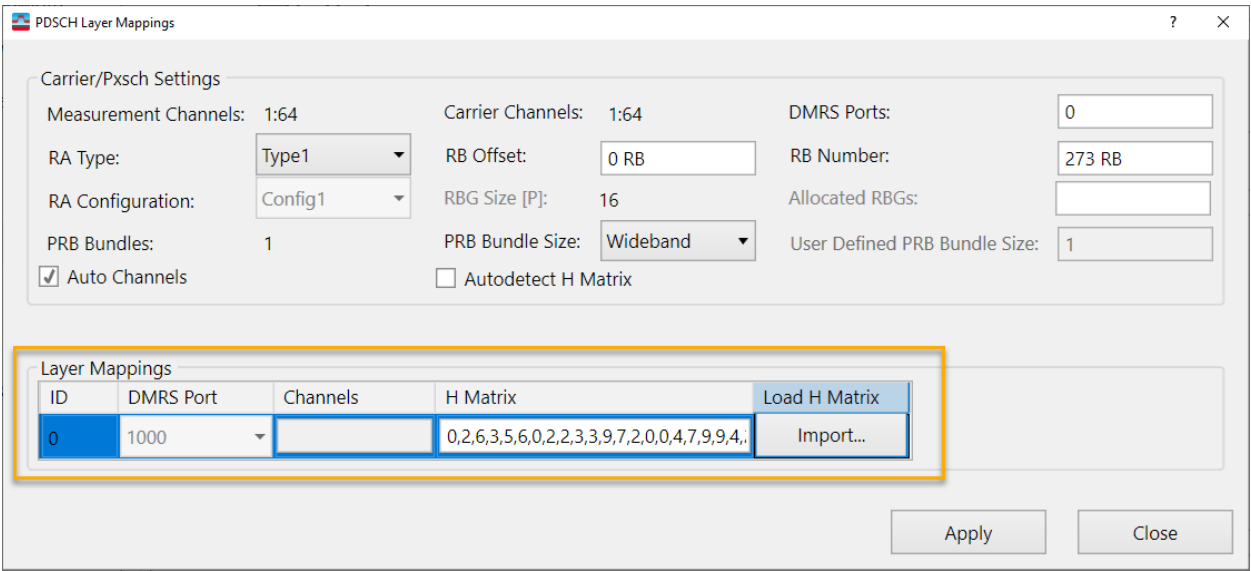


Figure 10. Measurement setup for loading a user-provided H-matrix as channel information.

O-RAN Uplink Performance Improvement (ULPI)

In O-RAN systems, the 7-2x functional split is well-suited for configurations with a low number of transmit and receive antennas. However, in uplink massive MIMO (mMIMO) scenarios, it can result in performance degradation and increased fronthaul bandwidth due to the transmission of more streams than layers from the O-RU to the O-DU. O-RAN Uplink Performance Improvement (ULPI) addresses these challenges by enhancing the capabilities of the O-RU.

With ULPI, the O-RU can operate in one of two modes for DMRS-based beamforming: DMRS beamforming with equalization (DMRS-BF-EQ) or DMRS beamforming without equalization (DMRS-BF-NEQ). In both modes, the O-RU uses the DMRS for channel estimation to compute beamforming weights, effectively reducing the uplink fronthaul bandwidth by transmitting the number of layers instead of the number of streams. The key difference between the two modes is whether equalization is performed at the O-RU.

When the O-RU performs equalization (DMRS-BF-EQ), it introduces specific challenges. Since the IQ data output from the O-RU is already equalized, the signal must be demodulated without any additional equalization. In this case, the VSA allows users to disable equalization. Furthermore, because the IQ data from the O-RU is equalized, the DMRS transfer from the O-RU to the O-DU can be muted to further reduce the fronthaul bandwidth. This requires the VSA to synchronize and demodulate the PUSCH without the DMRS, which differs from the standard 3GPP 5G NR operations.

The 89601ULPC application enables synchronization and demodulation of PUSCH without DMRS. For accurate measurement, the VSA requires the IQ data to be aligned with the 5G frame boundary.

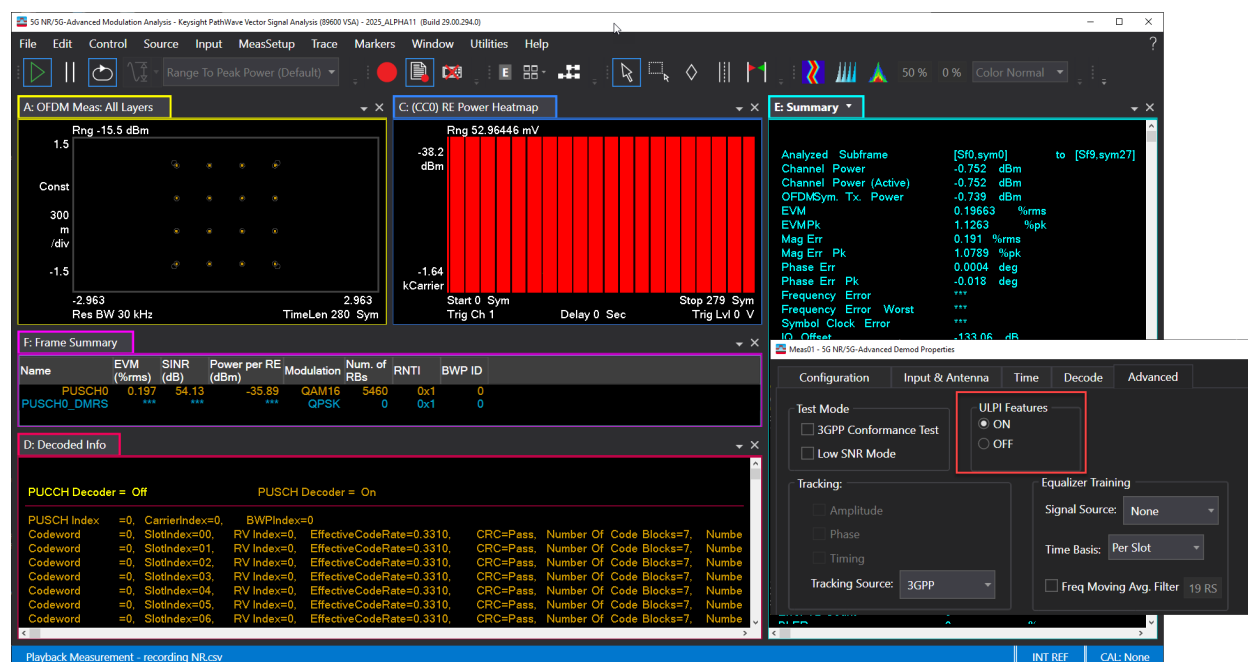


Figure 11. ULPI analysis for the DMRS-BF-EQ use case, where no DMRS is transmitted in the uplink as indicated by the Frame Summary table (Trace F).

Analyze 5G NR and LTE Carriers Simultaneously for NR and LTE Coexistence through Dynamic Spectrum Sharing

Dynamic Spectrum Sharing (DSS) — also known as NR and LTE coexistence — enables 5G networks to operate within the same spectrum currently used by LTE. This capability allows network operators to efficiently deploy 5G services without dedicating separate frequency bands, providing a smooth transition from LTE to 5G.

The 89600 VSA software allows engineers to analyze DSS signals as defined in 3GPP specifications, with the option to perform simultaneous demodulation of both 5G NR and LTE carriers or to analyze each carrier sequentially. In either case, measurement results are displayed side-by-side, enabling direct comparison of key metrics such as EVM, power and frequency error between the two systems.

This dual-view presentation, as shown in Figure 12, provides visibility into subtle interactions and interference effects between NR and LTE transmissions that may otherwise go unnoticed—helping engineers verify coexistence performance and optimize DSS network operation.

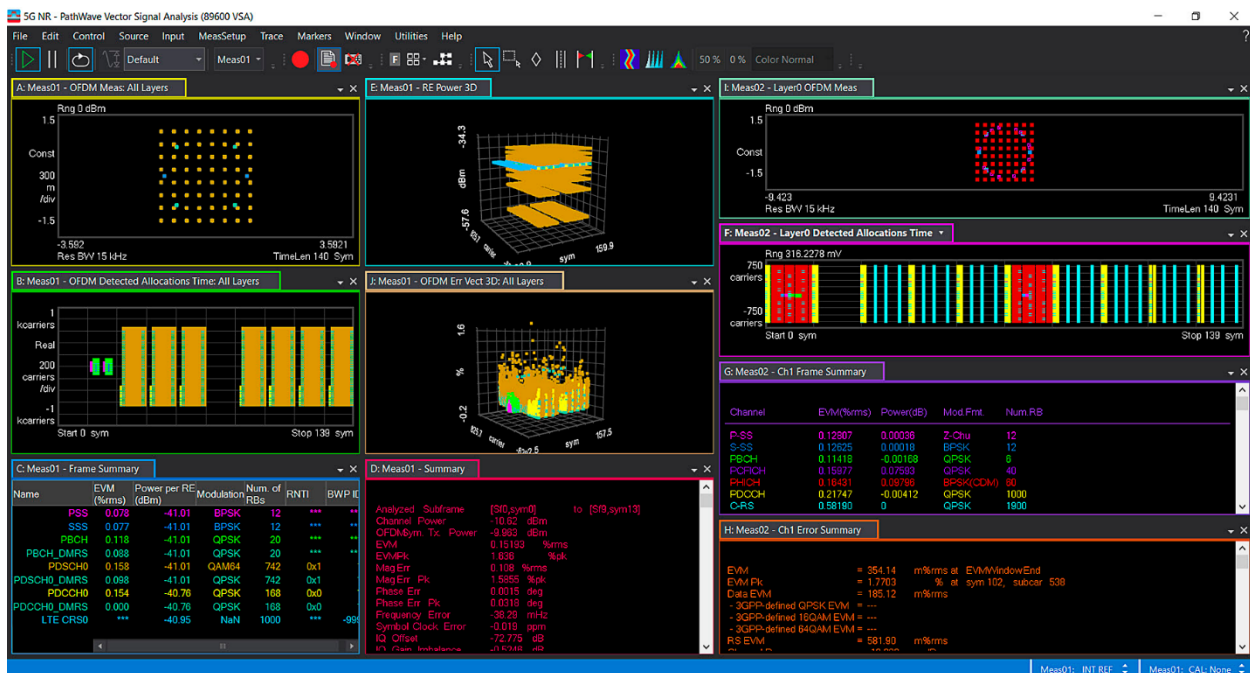


Figure 12. VSA's DSS analysis capability showing simultaneous demodulation of 5G NR and LTE carriers with side-by-side presentation of measurement results.

Enhanced EVM Analysis with ccEVM and IQ-NC

Technologies such as 5G and 5G-Advanced, with bandwidths up to 2 GHz and modulation rates as high as 1024QAM, make accurate EVM measurements increasingly challenging—especially when signal power is low. Noise from the measurement hardware can obscure the true performance of the Device Under Test (DUT). To overcome this, the 89600 VSA software with the 89601EVMC option provides two powerful noise-cancellation techniques: Cross-Correlated EVM (ccEVM) and IQ Noise Correction (IQ-NC). These methods significantly reduce the contribution of analyzer noise, ensuring that measured EVM primarily reflects DUT's performance.

In ccEVM, multiple time-synchronous signal analyzers (for example, two for SISO or four for 2×2 MIMO) simultaneously capture and demodulate the same signal. By cross-correlating the resulting error vectors, uncorrelated noise introduced by the measurement hardware is canceled out, lowering the overall EVM floor. This enables the ccEVM value to represent primarily the noise originating from the DUT—or, in amplifier tests, the combined noise of the signal source and DUT.

As shown in Figure 13, the Cross-Correlated EVM trace (Trace E) demonstrates clear improvement compared with the individual receiver EVM traces (Traces B and D). In this loopback example using a signal generator and two receivers, ccEVM achieves a 5.5 dB EVM improvement for a 100 MHz, 1024QAM test model NR signal.

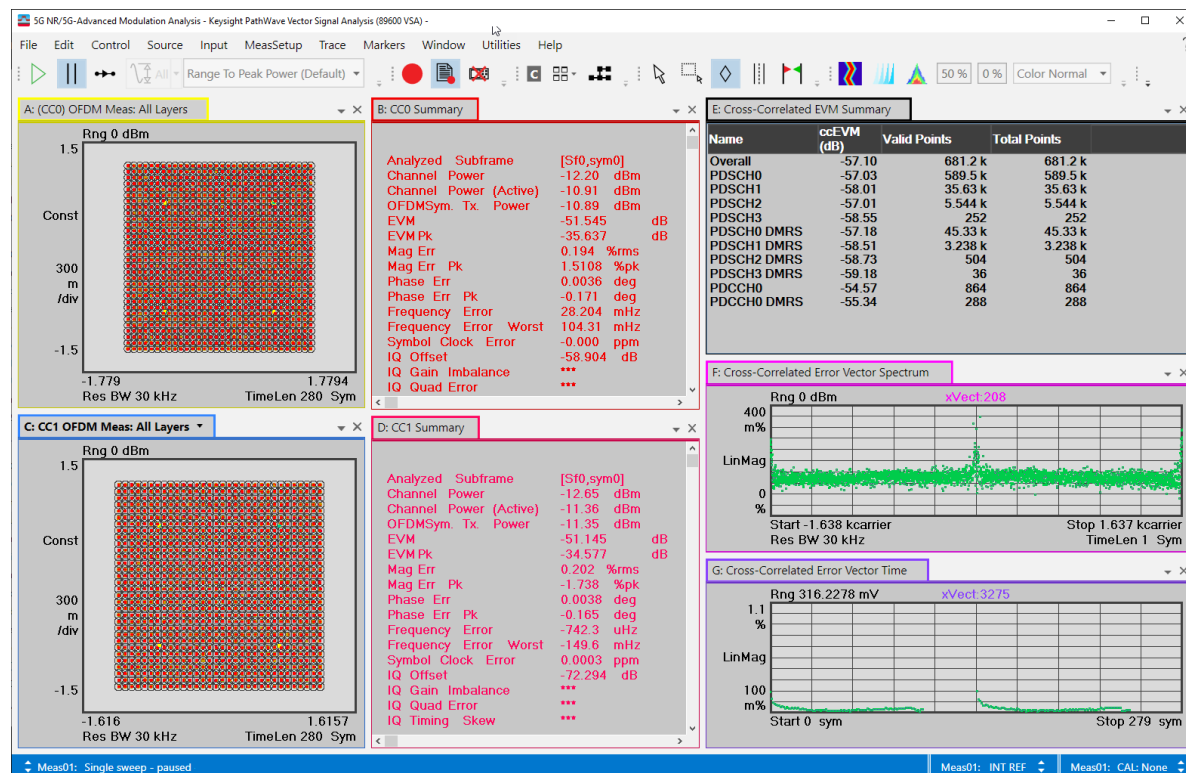


Figure 13. Cross-correlated EVM (Trace E) compared with EVM of individual receivers (Traces B and D), showing a 5.5 dB improvement in a 100 MHz, 1024QAM NR signal measurement.

In IQ-NC, a single receiver is used to compensate the acquired signal so that the measured EVM excludes noise contributions from the analysis hardware. This is accomplished by capturing multiple repetitions of the same signal, averaging to separate the noise from the signal, scaling the noise, and then recombining.

As shown in Figure 14, the IQ-NC EVM trace (Trace B) demonstrates improved accuracy compared with EVM measured without IQ-NC (Trace D). In this example, IQ-NC provides a 4 dB improvement in EVM.

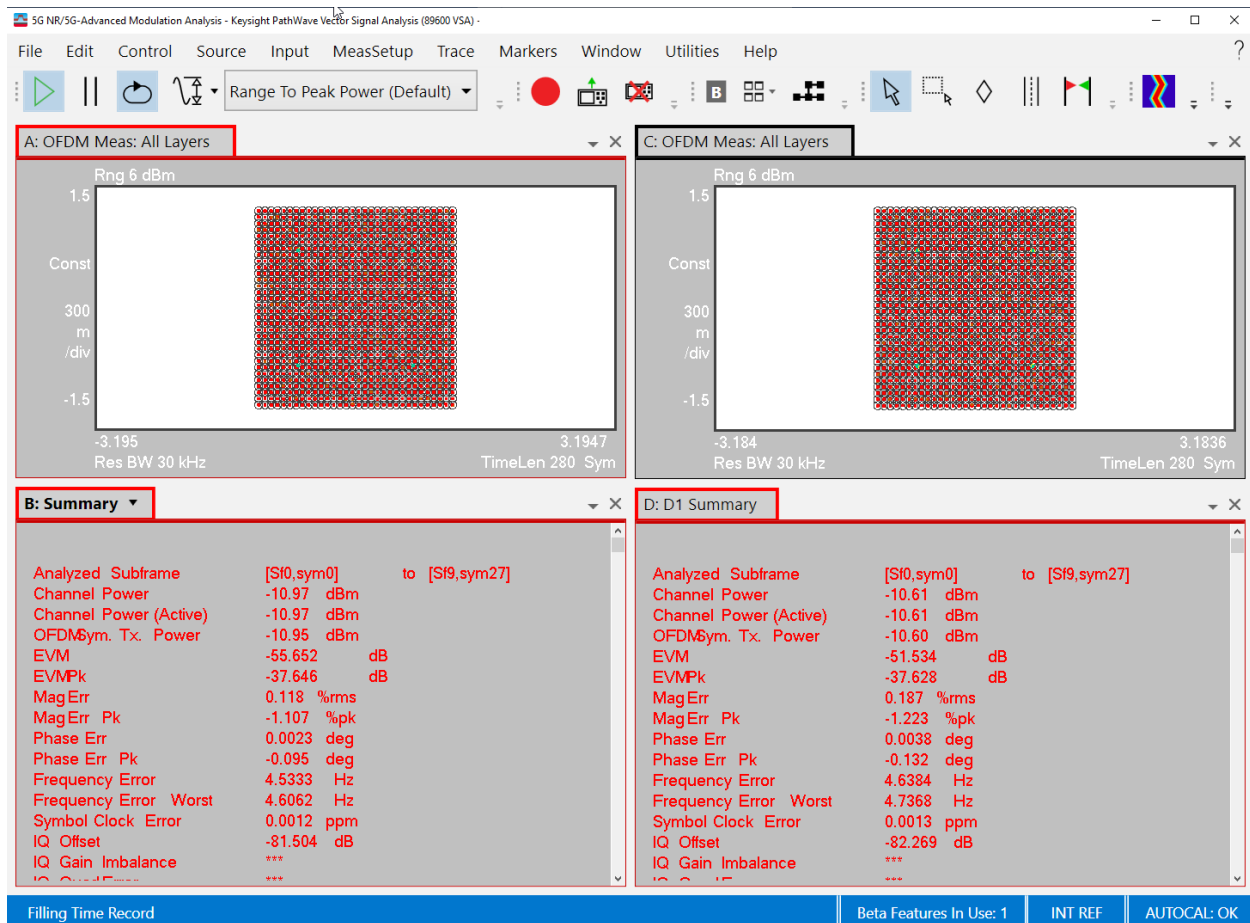


Figure 14. IQ-NC EVM (Trace B) compared with EVM without IQ-NC (Trace D), showing a 4 dB improvement in EVM accuracy.

Power Suite Measurements

The 89601PSMC power suite measurement application provides Adjacent Channel Power (ACP) and Spectral Emissions Mask (SEM) measurements with presets to 3GPP's RF conformance test. Pass/Fail results per the limits set by 3GPP are returned.

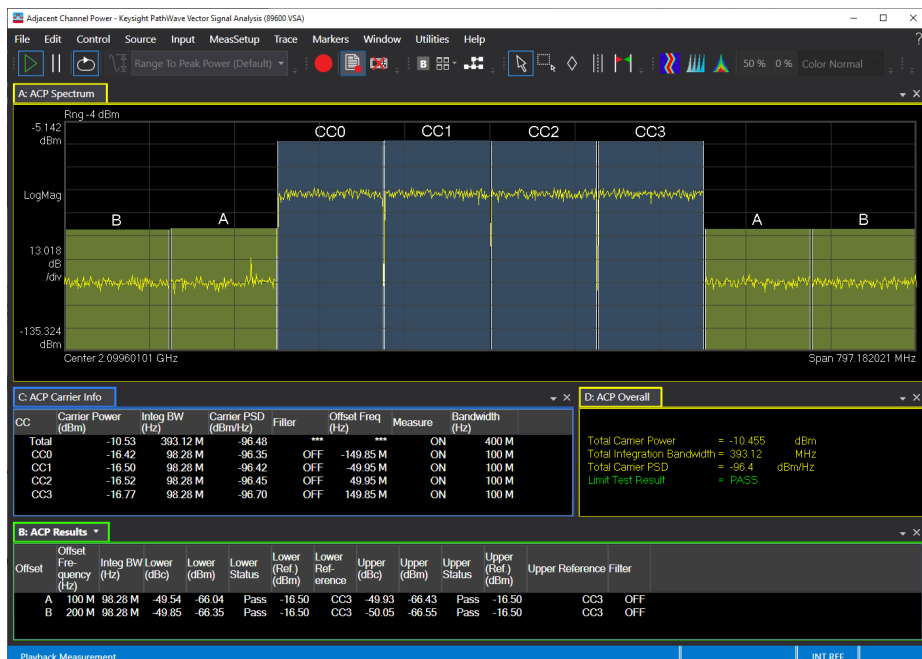


Figure 15. 5G NR multi-carrier ACP measurement with four contiguous component carriers



Figure 16. SEM measurement of a single carrier 5G NR signal

Software Features

Core Supported Features

Feature	Description
Standard	3GPP TS 38 series Release 18, Release 17, Release 16, and Release 15
Open-RAN	Part of Keysight's Open RAN Studio solution for O-RU uplink and downlink conformance test compliant with O-RAN WG4 Fronthaul standard
Numerology, Waveform, Signal Structure	
Numerology (μ)	μ 0 – 6: 15 kHz, 30 kHz, 60 kHz normal CP, 60 kHz extended CP, 120 kHz, 240 kHz, 480 kHz, 960 kHz Note: Mixed numerology within a BWP or multiple BWPs is supported
Waveform	CP-OFDM for DL and UL. Transform precoding (DFT-S-OFDM) for UL
Frame structure	Frame, subframe, slot
Slot structure	All DL, all UL, mixed DL and UL Note: All DL and all UL used for FDD deployment. Mixed DL and UL used for TDD
Signal direction	DL and UL
Maximum bandwidth for different Frequency Ranges (FR)	FR1 (sub-7.125 GHz): 3, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100MHz FR2-1 (24.25 - 52.6 GHz): 50, 100, 200, 400 MHz FR2-2 (52.6 - 71 GHz): 400, 800, 1600, 2000 MHz
Number of Component Carriers (CC)	Up to 32 Note: Simultaneous capture of all CCs or sequential capture of each carrier is supported.
Number of Bandwidth Part (BWP)	Up to 5 BWPs per component carrier Note: DL Initial BWP with CORESET0 configuration is supported
Multiple antenna technologies	Up to 8x8 spatial multiplexing MIMO in DL and UL. Codebook and non-codebook based precoding support in UL
Massive MIMO and beamforming	Up to 24 orthogonal DMRS ports for MU-MIMO; Up to 64 channels beamforming
Physical Signals and Channels	
Initial access	PSS, SSS, PBCH, PBCH-DMRS Periodicity: 5, 10, 20, 40, 80, 160 ms Lmax: L=4, L=8, L=64
Downlink	PDSCH (multiple users), PDSCH-DMRS, PDSCH-PTRS, PDCCH (multiple CORESETs and Search Spaces), PDCCH-DMRS, CSI-RS, RIM-RS, PRS CSI-RS: Up to 32 antenna ports and periodicity from 4 to 640 slots
Uplink	PUCCH (Format 0/1/2/3/4), PUCCH-DMRS, PUSCH (multiple users), PUSCH-DMRS, PUSCH-PTRS, PRACH with multiple occasions, SRS with up to 4 antenna ports

Modulation and Coding (MCS)	
PDSCH	All MCS formats in MCS index Table 5.1.3.1-1, 5.1.3.1-2, 5.1.3.1-3, and 5.1.3.1-4 (1024QAM in FR1) of 3GPP TS 38.214
PUSCH	All MCS formats in MCS index Table 5.1.3.1-1, 5.1.3.1-2, 5.1.3.1-3, 6.1.4.1-1 and 6.1.4.1-2 of 3GPP TS 38.214 Note: For PDSCH, 1024QAM per MCS Table 5.1.3.1-4 is supported as defined in 3GPP Rel-17. General purpose such as 8PSK, 1024QAM, and user-defined modulation formats are supported for PUSCH and PDSCH special use cases. MCS tables are provided in 3GPP TS 38.214 specification.
Channel Decoding	
PDSCH and PUSCH	LDPC decoding for PDSCHs and PUSCHs with a choice of Offset Min Sum or Belief Propagation algorithm. Measurement results include Codeword, slot index, effective code rate, number of code blocks, number of corrected bits, CRC pass/fail and descrambled, deratematched, decoded CB or decoded TB data. Additionally, BLER and throughput results are presented in the Summary table. If uplink control information (UCI) is multiplexed with PUSCH data, decoded information contains HARQ-ACK, CSI1, CSI2 and CG-UCI.
PDCCH	Polar decoding for PDCCH. Measurement results include CRC pass/fail and decoded bits. For DCI Format 0_0, measurement results include: format identifier, UL/SUL, freq and time domain allocations, freq hopping, VRB-PRB mapping, MCS, new data indicator (NDI), RV, HARQ process number and PUSCH power control. For DCI Format 1_0, measurement results include: format identifier, freq and time domain allocations, VRB-PRB mapping, MCS, new data indicator (NDI), RV, HARQ process number, DAI, PDSCH-to-HARQ feedback, PTC for PUCCH, PUCCH resource indicator, PUCCH power control Descrambled, deratematched, decoded CB or decoded TB data also available. Note: When PDCCH auto detection is used the decoded information also includes: aggregation level, candidate index, payload size and DCI format. This covers DCI formats 0_0, 1_1, 1_0 and 0_1
PUCCH	Polar decoding for PUCCH Formats 0, 2, 3 and 4. Measurement results include CRC pass/fail and decoded bits plus descrambled, deratematched, decoded CB or decoded TB data Note: For PUCCH Format 0, only decoded bits is returned. There is no CRC attached to Format 0.
PBCH	Polar decoding for PBCH. Measurement results include period index, block index, symbol index, decoded bits, CRC pass/fail, SFN, HRF, common SCS, SSB subcarrier offset, DMRS Type A position, PDCCH Config SIB1, Cell Barred, Intra frequency reselection. Descrambled, deratematched, decoded CB or decoded TB data also available.

Measurement Parameters	
Cell ID	In downlink, Cell ID can be auto detected if SS/PBCH is present
SS/PBCH auto detection	SS/PBCH parameters can be auto-detected and the detected parameters can be returned in the Summary table
PDCCH auto detection (Beta)	Auto detection based on DCI for formats 0_0, 0_1, 1_0 and 1_1. The detected parameters are returned in the Decoded Info table
PDSCH auto detection (Beta)	Auto detection based on signal power. Does not return detected signal parameters
PUSCH auto detection (Beta)	Auto detection based on signal power for CP-OFDM based waveform. Does not return detected signal parameters
PRACH auto detection	Auto detection based on signal power. Auto detected parameters include preamble ID (PID) and timing advanced (TA)
Test model for BS	Predefined FDD and TDD test models for base station. FR1 TM1.1, 1.2, 2.0, 2.0a, 2.0b, 3.1, 3.1a, 3.1b, 3.2, 3.3. FR2 TM1.1, 2.0, 2.0a, 3.1, 3.1a
Test model for SAN	Predefined NTN test models for satellite access node (SAN). FR1 TM1.1, 1.2, 2, 3.1, 3.2, 3.3. FR2 TM1.1, 2, 3.1
Quick setups	Provides a list of presets, commonly used configurations, for convenient saving and loading of common configurations
Analysis region	Result length and measurement interval in subframes, slots and symbols Note: Multiple subframes, multiple symbols, or a combination of subframes and symbols can be used as a measurement interval
Time scale factor	Sets the value by which to scale the bandwidth and time lengths of the measured signal. Example: For a 2 GHz BW signal, the Time Scale Factor would be 20 based on a 100 MHz 5G NR transmission
Analysis start boundary	The time alignment boundary of the analysis region can be frame, half-frame, subframe, or slot
Acquisition mode	determines the amount of data acquired in the measurement. If hardware trigger is used, less data is acquired improving measurement speed
Equalizer and Tracking	
Signal source	Equalization source can be RS or RS + Data. Equalizer can also be turned OFF.
Time basis	The frequency of the equalizer training can be per slot, subframe, frame, result length, contiguous slots
Tracking	Tracking is done in amplitude, phase, and timing
Sync Source and Sync Mode	
CP auto correlation	Faster way to calculate symbol boundary to find sync symbol in the frequency domain. Applies to single numerology use case
Time cross correlation	Used for symbol boundary calculation to find sync symbol in the time domain. Applies to all use cases.
Sync source	Synchronize to any of the downlink or uplink signals. For ULPI, if DMRS is not transmitted, the sync source is set to "Not Provided". In Uplink, when user-specified ideal constellation points are used, the sync source can be set to "All Signals".
Ignore MIB data	Ignores MIB data present in SS/PBCH indexes of an analyzed signal. Fixes synchronization problem due to invalid MIB data

Additional Setup Parameters	
Low SNR mode	Triggers specific synchronization algorithm and demodulation processing for use when the input signal is very noisy, such as during O-RAN receiver testing. It is also used for troubleshooting when EVM is unexpectedly high and the PDSCH/PUSCH RB allocation is small (e.g. 2 or 3 RBs)
IQ impairments	IQ imbalance estimation mode: sets the IQ imbalance calculation mode to per carrier or per subcarrier
	Compensate IQ imbalance: applies IQ imbalance compensation per the selected estimation mode
	Compensate IQ Offset: applies IQ offset compensation to the carrier
	DC punctured: removes DC subcarrier from equalization and EVM computation
UL spectrum flatness	Sets the control for UL spectrum flatness testing. The test results are summarized in the Summary table
Error vector unit	Sets the units used to measure and display EVM results in the Error Vector Spectrum and Error Vector Time traces.
	Time domain: per symbol, per slot, per subframe
	Freq domain: per subcarrier, per RB, All REs
Compensate symbol clock offset	Removes the EVM effect of the reported symbol clock error
Multicarrier filter	Additional filtering can be used to reject adjacent carriers to reduce EVM
Independent SSB/BWP measurement (Downlink)	Timing/frequency/clock error estimations and compensation are independent for SSB and BWP
Extend frequency lock range	Extended frequency lock range to increase the demodulator lock range. It supports up to 1 MHz frequency lock range for Non-Terrestrial Networks (NTN) testing.
Report EVM in dB	Reports the EVM results in dB
Per slot channel frequency response	Changes the channel frequency response trace to be per slot instead of per the equalizer training time-basis (default). The time-basis can be per slot, per subframe, per frame or per result length
Phase contiguous across slots	Specifies whether the phase across slots is contiguous or not on the carrier. This affects the phase tracking algorithm
Tracking and channel estimation strategy (PDSCH and PUSCH only)	Controls the tracking and channel estimation across PDSCH and PUSCH physical channels. The parameter is used to improve the TAE/PAE performance when estimation results are not stable.
Subcarrier Reference Points	Selects whether the reference constellation points are auto detected or manually configured with the internal reference values saved by the Copy to User-Specified button.
PRACH TA relative to trigger (Uplink)	Specifies whether the PRACH Time Advance results are relative to the trigger or the frame boundary

Supported Measurements

Feature	Description
Pre-Demodulation Measurements (Uplink and Downlink)	
CCDF	Displays the complementary cumulative distribution function (CCDF) for the selected input channel. CCDF measurement can be performed for burst signals, excluding the OFF power.
CCDF summary	Summary data include average and peak power, power level at different percentages of the power, and total number of points accumulated.
CDF	Cumulative density function for the data in the measurement interval
Correction	Correction curve used to correct for the frequency response of the input hardware and input digital filtering
Instantaneous spectrum	Spectrum computed before data is averaged
PDF	Probability density function (PDF) of the signal
Raw main time	Raw time data read from the input hardware or playback file for the selected channel, prior to correction or resampling
Search time	Time record data after resampling and time adjustment, used to search for the pulse (or burst)
Spectrum	Frequency spectrum of the pre-demodulated Time trace data
Time	Time data of the signal that is to be demodulated
Demodulation Data (Uplink and Downlink)	
	Provides demodulation results for uplink and downlink channels/signals
Beam Pattern	A three-dimensional representation of all available beam patterns in the system
Beam peaks (beam pattern summary)	Summary of beam peaks of all users on all layers in all antenna groups per physical channel
Beam weights	Transformed representation of the power and phase data in the MIMO Info table. The data is provided for the first user listed in the MIMO Info table.
CC summary	Shows measurement results for each component carrier such as power, EVM, TAE, center freq, freq error, clock error, Cell ID
Ch frequency response	Shows a per-slot channel frequency response calculated from the reference signal
Channel summary	Shows the per-channel summary data for channels under the Input & Antenna tab.
Decoded info	Contains decoded information from PDSCHs, PDCCHs, PBCH, PUSCHs, PUCCH Formats 0, 2, 3 and 4
Decoded symbol	Contains decoded bits from PDSCHs, PDCCHs, PBCH, PUSCHs, PUCCH Formats 0, 2, 3 and 4
Detected allocation time	Color-coded display showing a two-dimensional grid with frequency on the vertical axis and time on the horizontal axis. Each point on the grid represents a single resource element (1 subcarrier x 1 symbol)
Error vector 3D	A three-dimensional representation of error vector spectrum and error vector time trace data
Error vector spectrum	EVM as a function of subcarrier or resource block (RB) in the frequency domain
Error vector time	EVM as a function of OFDM symbol or slot or subframe in the time domain
Frame summary	Table showing EVM, SINR, power (dBm), modulation format, number of RBs, RNTI and BWP ID for each channel present within the measurement interval, color-coded by channel type
Frequency error summary	Table providing frequency error per subframe
Inst Ch frequency response	Shows the channel frequency response of the current sweep

Feature	Description
IQ imbalance spectrum	Shows the IQ gain imbalance and IQ quad error across the subcarriers before the IQ impairment compensation.
IQ measured	IQ constellation of the demodulated signal. Each point represents the amplitude and phase of one subcarrier in the frequency domain and one symbol in the time domain
IQ reference	Reference IQ constellation for computing signal EVM values
MIMO condition number	Displays the MIMO condition number for each subcarrier or resource block or wideband
MIMO Eq Ch Freq Resp	Shows the channel frequency response for all active paths.
MIMO Info	Shows per channel performance such as EVM, power, time/frequency/phase offset plus cross channel power of the transmitted MIMO signal. CSI-RS MIMO Info and DMRS MIMO Info tables are available.
RE Power 3D	Resource element (RE) power per symbol and per subcarrier
RE power heatmap	Two-dimensional representation of RE power, with symbols on the x-axis, carriers on the y-axis, and power (in dBm) represented by color.
RMS error vector spectrum	Root mean square (RMS) average EVM for each subcarrier or resource block (RB)
RMS error vector time	Root mean square (RMS) average EVM for each symbol or slot or subframe
Slot summary	Table showing RNTI, EVM, SINR, power, modulation format, number of RBs and CRC for each channel present within each slot, peak EVM, peak EVM symbol index, peak EVM subcarrier index, color-coded by channel type. For PDSCH with a known reference (NR-TM PN23 or all zeros), Error Bits, Total Bits and BER are shown for each slot
Symbol table	Shows the numerical values of demodulated data for the selected layer
Summary	Table providing signal quality metrics of the demodulated signal within the measurement interval: channel power, channel power (Active) OFDM Sym. Tx. Power (OSTP), EVM, frequency error, magnitude error, phase error, symbol clock error, IQ offset, IQ gain imbalance, IQ quadrature error, IQ time skew, time offset, sync correlation, sync source, Cell ID. When channel decoding is enabled, it also shows the total transport block (TB) count, error TB count, BLER, and throughput results
Demodulation Data (Downlink Only)	
	Provides demodulation results for downlink SS/PBCH block
SSPBCH power	Average power per each SS/PBCH per input channel. Power can be measured in dBm
SSPBCH survey	Relative amplitude or phase across SS/PBCH index per input channel
UE reported metrics summary	UE-reported measurement metrics such as RSRP, RSRQ, RSSI and SINR for SSB and CSI-RS
Demodulation Data (Uplink Only)	
EVM equalizer spectrum flatness	Shows the UL spectrum flatness measurement, one of the conformance test for uplink
Inband emission	Shows the RB power spectrum for the data specified by measurement interval and measurement offset

Ordering Information

Software Licensing and Configuration

Flexible licensing and configuration

- **Perpetual:** License can be used in perpetuity.
- **Subscription:** 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

89600 VSA Base Platform and Hardware Connectivity (One of 89601200C/89601201C/89601202C/89601203C Options is Required)

5G NR/5G-Advanced Modulation Analysis (89601BHNC)

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
USB portable perpetual	SW1000-LIC-01	SW1000-SUP-01
USB portable time-based	SW1000-SUB-01	Included
Floating (single site) perpetual	SW1000-LIC-01	SW1000-SUP-01
Floating (single site) time-based	SW1000-SUB-01	Included
Floating (regional) perpetual	SW1000-LIC-01	SW1000-SUP-01
Floating (regional) time-based	SW1000-SUB-01	Included
Floating (worldwide) perpetual	SW1000-LIC-01	SW1000-SUP-01
Floating (worldwide) time-based	SW1000-SUB-01	Included

One-month KeysightCare Support and Subscription

Software License	Software License Type
SW1000-SUP-01	1-month support subscription renewal for perpetual license

1. z means different time-based license duration. F for 6 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. y 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 Keysight Care 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 including signal analyzers, one-box-testers, and oscilloscopes. For a complete list of currently supported hardware, please visit: www.keysight.com/find/89600_hardware

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

Model-Option	Description
5990-6553EN	89600 VSA Software - Brochure
5990-6386EN	89600 VSA Software - Configuration Guide
5992-4210EN	Tiered Options 89601200C/201C/202C/203C Basic Vector Signal Analysis & Hardware Connectivity, 89600 VSA Software - Technical Overview
3121-1438.EN	Option 89601PSMC PowerSuite Measurement, 89600 VSA Software – Technical Overview

Web

- www.keysight.com/find/89600vsa
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