TECHNICAL OVERVIEW

5G New Radio Modulation Analysis PathWave Vector Signal Analysis (89600 VSA)

Option 89601BHNC

- See through the complexity of 3GPP 5G New Radio (NR) signals with a comprehensive and forward compatible set of tools for demodulation and vector signal analysis
- Address the wide range of design and measurement challenges arising from the use of mmWave frequency, multiple numerologies, and CP-OFDM waveforms
- Analyze downlink and uplink signals and derive signal quality: Overall EVM, EVM across symbols and subcarriers, constellations, IQ error plots and more
- Use the color coding and marker coupling features to identify and isolate specific signal and channel effects and impairments
- Analyze LTE and 5G NR simultaneously for NR and LTE coexistence through dynamic spectrum sharing (DSS)

3GPP 5G NR Physical Layer Overview

3GPP Release 15 delivers the first set of 5G standards with the focus on urgent market needs for enhanced mobile broadband (eMBB) and ultra-reliable low latency communication (URLLC). To achieve higher data rates, improve connectivity, and reach higher capacity required for eMBB, in addition to using FR1 below 7.125 GHz frequencies, 5G also operates in millimeter wave (mmWave) frequency bands, which has significantly wider contiguous bandwidths.

Waveform, numerology and frame structure

Waveform

Like LTE, 5G NR downlink transmission waveform is conventional OFDM using a cyclic prefix (CP-OFDM). Unlike LTE, the main uplink waveform is CP-OFDM. Transmit precoding, or DFT-S-OFDM, based waveform can also be used for uplink; however it is limited to single stream transmissions targeting devices with limited link budget.

Numerology

Multiple OFDM numerologies (μ), as shown in Table 1, are defined to handle wide range of frequencies, bandwidths and deployment scenarios. The numerology is based on exponentially scalable subcarrier spacing $\Delta f = 2^{\mu} \times 15$ kHz, where the LTE numerology of 15 kHz subcarrier spacing is the baseline numerology.

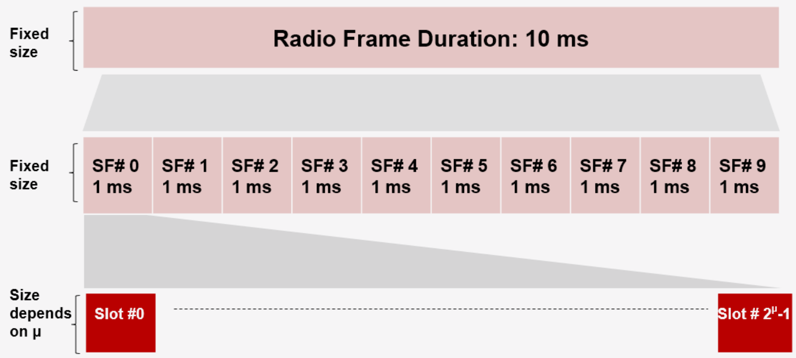
Table 1. 5G NR numerologies.

<table>
<tr><th>μ</th><th>$\Delta f = 2^{\mu} \cdot 15$ kHz</th><th>Cyclic prefix</th><th>Notes</th></tr>
<tr><td>0</td><td>15 kHz</td><td>Normal</td><td>Sub-7.125 GHz</td></tr>
<tr><td>1</td><td>30 kHz</td><td>Normal</td><td>Sub-7.125 GHz</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">60 kHz</td><td rowspan="2">Normal, Extended</td><td>Sub-7.125 GHz and mmWave</td></tr>
<tr><td>Not used for sync (SS/PBCH)</td></tr>
<tr><td>3</td><td>120 kHz</td><td>Normal</td><td>mmWave</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">240 kHz</td><td rowspan="2">Normal</td><td>mmWave</td></tr>
<tr><td>Not used for data</td></tr>
</table>

Frame structure

Downlink (DL) and uplink (UL) transmissions are organized into frames with 10 ms duration, consisting of ten 1 ms subframes. The number of slots within a subframe or a frame depends on the numerology, as shown in Figure 1.

A slot is a scheduling unit and it can contain all DL, all UL or a mix of UL and DL data. There are 14 consecutive OFDM symbols in a slot with normal CP, and 12 OFDM symbols with extended CP.



μ	N_{sym}^{slot}	$N_{slot}^{subframe,\mu}$	$N_{slot}^{frame,\mu}$	Slot duration
0 *15 kHz*	14	1	10	1 ms
1 *30 kHz*	14	2	20	500 µs
2 *60 kHz (normal CP)*	14	4	40	250 µs
2 *60 kHz (extended CP)*	12	4	40	250 µs
3 *120 kHz*	14	8	80	125 µs
4 *240 kHz*	14	16	160	62.5 µs

Figure 1. 5G NR frame structure.

Carrier bandwidth part (BWP)

Carrier bandwidth part is a contiguous subset of the physical resource blocks (PRBs) defined for a given numerology on a given component carrier.

One or multiple BWP configuration for each component carrier can be signaled to a user equipment (UE); however, only one BWP is active at a given time instant. This means, the UE cannot transmit and cannot receive outside an active BWP. Configuration parameters for each BWP includes numerology, frequency location, bandwidth size, and control resource set (CORESET).

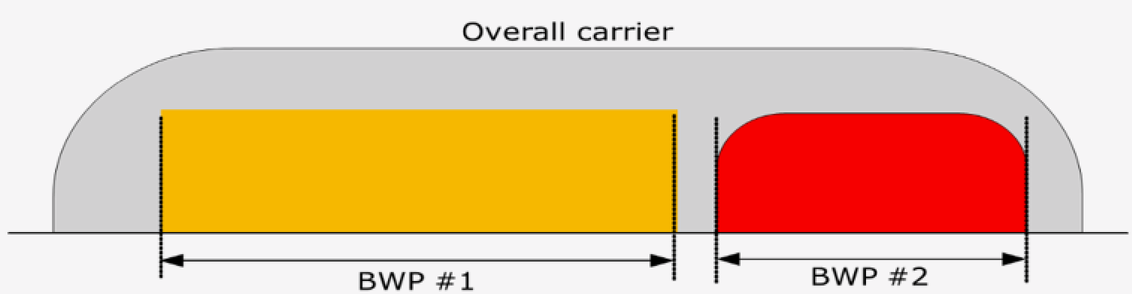


Figure 2. Example of a downlink component carrier with multiple BWPs.

5G NR Modulation Analysis

The 89600 VSA software's 5G NR application (89601BHNC) provides comprehensive analysis capabilities in the frequency, time, and modulation domains for signals based on both 3GPP's 5G NR specification (www.3gpp.org) and Verizon's 5G open trial specification (http://5gtf.org/).

Note: This technical overview focuses on 3GPP 5G NR. See pre-5G technical overview for information about Verizon pre-5G analysis.

The software provides frequency-, time-, and modulation-domain analysis results in a single measurement. By configuring result traces of spectrum, acquisition time, and NR specific modulation quality traces and tables, engineers can identify overall signal characteristics and troubleshoot intermittent error peaks or repeated synchronization failures.

For automated testing, .NET API and SCPI remote interfaces are available to accelerate design, which enables quicker transition to the design verification and manufacturing phases.

5G NR is among over 75 signal standards and modulation types supported by the 89600 VSA software. The 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. As you assess your design tradeoffs, the 89600 VSA helps you cut through the complexity.

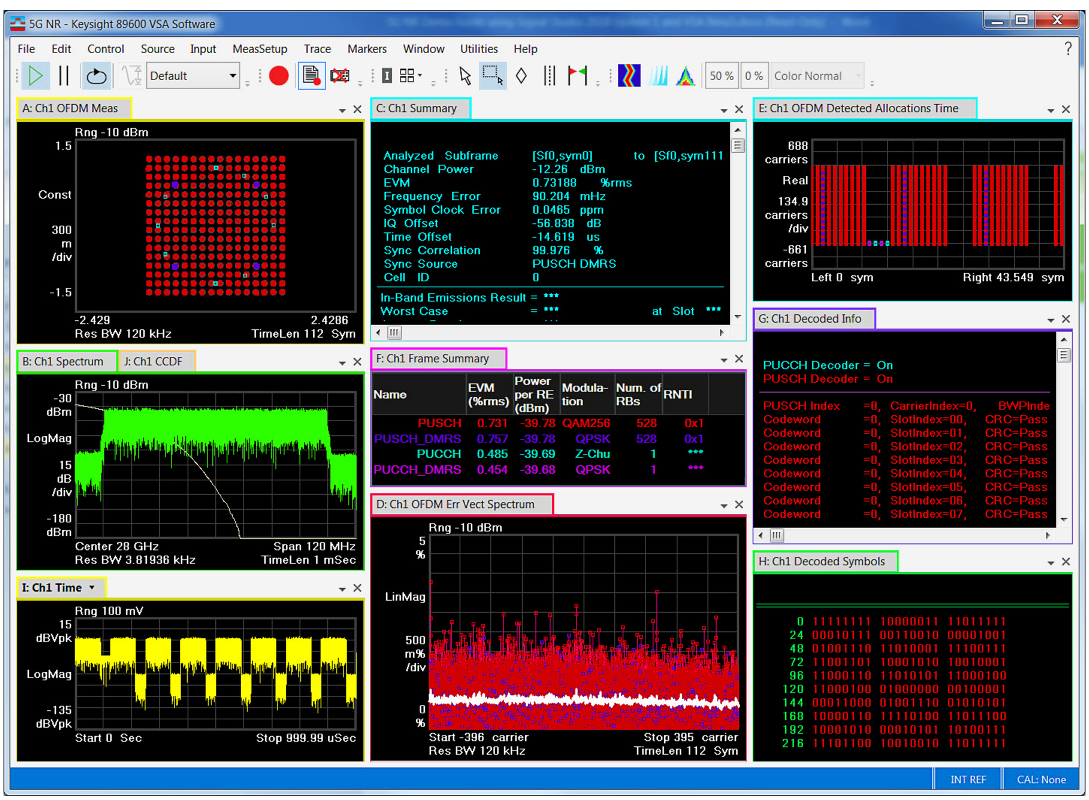
Analysis and Troubleshooting

Perform 5G NR transmitter measurements

89601BHNC supports 5G NR modulation analysis measurements according to Release 15 and Release 16 of 3GPP's TS38 specification. Supported features include:

1. Waveform, numerology and frame structure
    - CP-OFDM waveform for DL and UL
    - Transform precoding (DFT-S-OFDM) waveform for UL
    - All numerologies (μ = 0-4 representing 15, 30, 60, 120, 240 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)
        - FR1 (sub-7.125 GHz): 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100 MHz
        - FR2 (mmWave): 50, 100, 200, 400 MHz

2. UL and DL channels and signals with corresponding modulation formats and individual power boosting
   - Initial access channels and signals: PSS, SSS, PBCH
   - DL reference signals: DMRS (for PDSCH, PDCCH, PBCH), PTRS (for PDSCH), CSI-RS
   - DL control and shared channels: PDSCH, PDCCH
   - UL reference signals: DMRS (for PUCCH and PUSCH), PTRS (for PUSCH), SRS
   - UL control and shared channels: PUSCH, PUCCH, PRACH
3. LDPC decoding for PDSCH and PUSCH Polar decoding for PBCH, PDCCH and PUCCH
4. Beamforming and up to 8x8 MIMO for DL and 4x4 MIMO for UL
5. Test models for FDD and TDD per 3GPP TS 38.141-1 and TS 38.141-2 specifications
6. Dynamic Spectrum Sharing (DSS) with simultaneous demodulation of LTE and 5G NR signals
7. 3GPP Release 16: NR unlicensed spectrum (NR-U), enhanced MIMO (eMIMO), enhanced DSS (eDSS), SRS for positioning
8. 3GPP Release 17: 1024QAM modulation for PDSCH



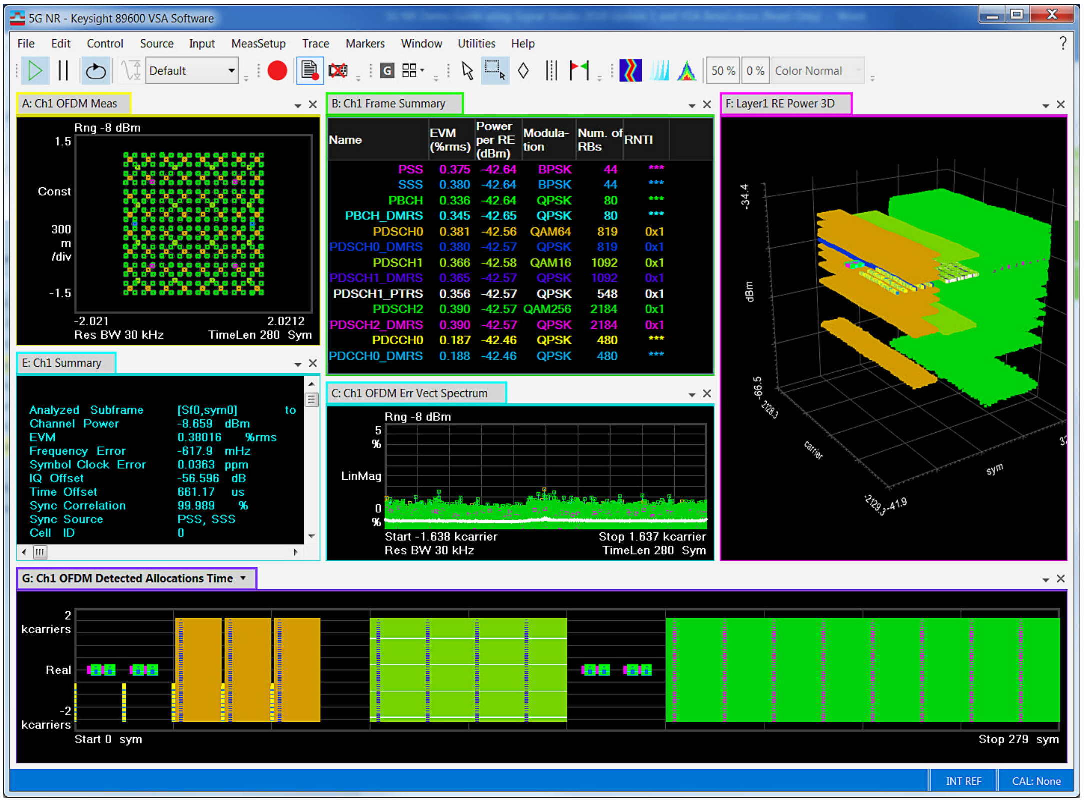


Figure 3. With the 89600 VSA software, you can analyze 5G NR UL and DL signals and derive signal quality parameters for each.

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 NR 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 4, enables easier viewing as it follows your menu choices. You can even lock it to stay fixed on important Help data topics.

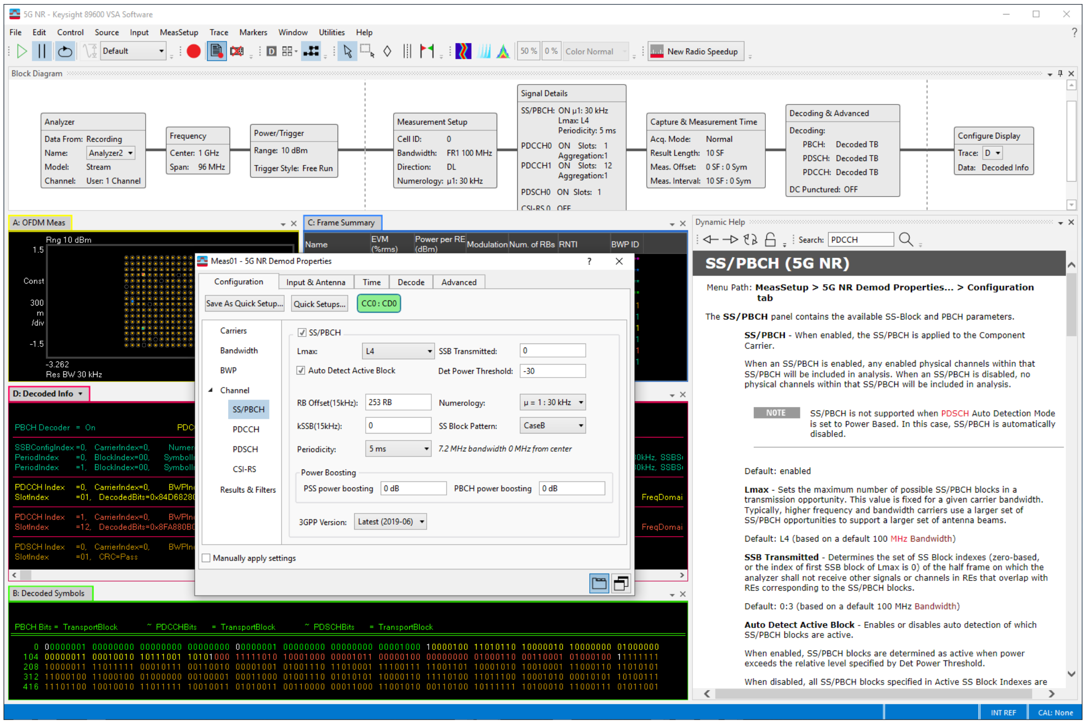


Figure 4. Setup is easy with complete parameter control. Dynamic Help provides useful information to explain measurements and other important 5G NR and 89600 VSA software operations.

Understand the structure and quality of 5G NR signal

Use the powerful demodulation, decoding and analysis tools to understand the structure and quality of the transmitted NR signal. A user has complete flexibility to choose the trace format and the number of simultaneous traces. Figure 5 shows an example of a downlink NR signal. The different traces show an orthogonal view of the signal, and many more views are possible depending on the purpose of the analysis.

Description of some of the digital demodulation traces

- Trace A (top, left), shows a composite IQ constellation of the demodulated signal containing 256QAM allocated to PDSCH down to BPSK allocated to PSS, and SSS.
- Trace B (top, center), shows frame summary table, which is the key to the color coding and the modulation format used by each channel/signal within the radio frame. For each entry, there is an assigned color, and measurement results are displayed: EVM, power, modulation format, number of resource blocks occupied, RNTI and the ID number of the BWP that is associated with the channel.

- Trace C (top, right), shows a color-coded view of the transmitted signal structure. This two-dimensional grid with frequency (subcarriers) on the vertical axis and time (symbols) on the horizontal axis shows the transmitted signal, in this example SS/PBCH blocks followed by PDCCH and multiple PDSCHs.
- Trace D (middle, left), shows a slot summary table, organized into BWP/subframe/slot groupings. For each entry, RNTI, EVM, Power, modulation format, number of resource blocks occupied, and CRC for each channel within each slot are displayed.
- Trace E (middle, center), shows the error summary table providing quality statistics for the composite signal including EVM, frequency and phase error, symbol clock error, IQ offset, IQ gain imbalance, IQ quadrature error, and time offset.
- Trace F and G (middle, right), shows a 3D power plot and a 3D EVM plot respectively.
- Trace H (bottom, left), show the RF spectrum of the transmitted signal at 39 GHz center frequency.
- Traces I (bottom, center) and J (bottom, right), shows EVM as a function of OFDM symbols and subcarriers respectively.

Note: A user has full control of each channel's color and display in traces, and whether they are included in EVM calculations.

Figure 5. Example analysis of a downlink signal, at 39 GHz center frequency, with SS/PBCH, PDCCH and multiple PDSCHs.

Test beyond the physical layer

Use the channel decoding capability of the 89600 to perform LDPC (for PDSCH, PUSCH) and polar (for PBCH, PDCCH, PUCCH) decoding of the transmitted signal. Code block and transport block CRC Pass/Fail for each channel is reported. For the PBCH, all the information carried within the PBCH, as defined in 3GPP 38.331, is decoded and reported. Similarly, for PDCCH when auto detection is enabled, aggregation level, candidate index, payload size and DCI format are returned for formats 0_0, 1_1, 1_0 and 1_1. In addition, for DCI formats 0_0 and 1_0, it also returns decoded information contained within the DCI such as RB start and RB length for active PDSCHs.

In addition, decoded bitstream is reported for the different uplink and downlink channels. User specifies how much coding to undo before showing the bits: descrambled, deratematched, decoded CB (code block) or decoded TB (transport block). The data is color coded to match the color of the corresponding channel in the Frame Summary trace.

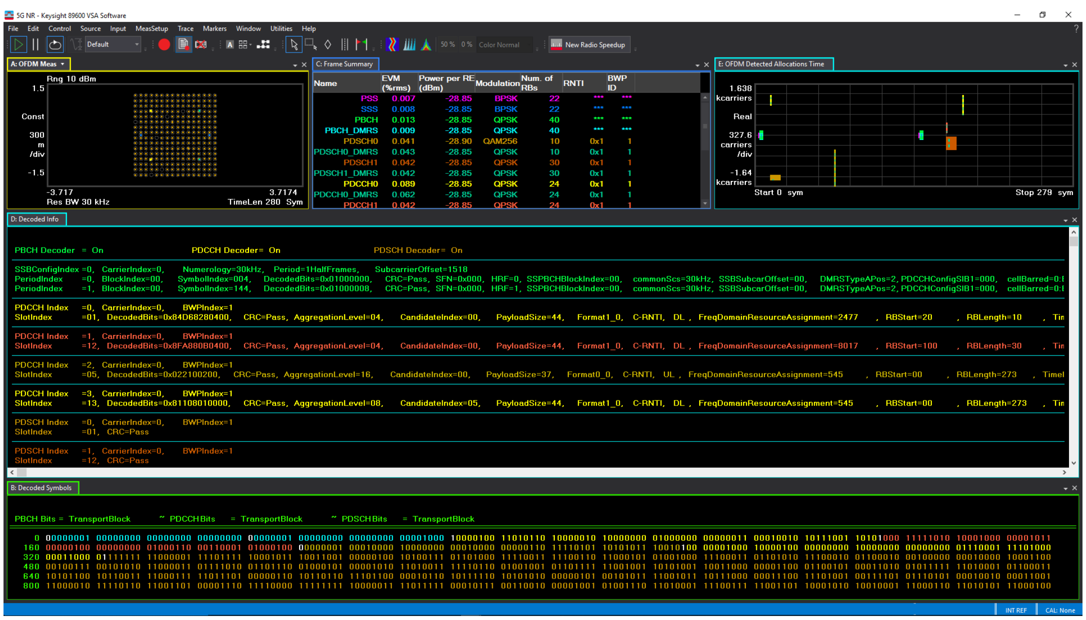


Figure 6. Example of a downlink decoded information and decoded symbols for PBCH, PDCCH and PDSCH.

In-depth analysis and troubleshooting with coupling measurements across domains

Use the multiple color-coded traces along with marker coupling across different measurements, traces and domains for ease of troubleshooting. This is particularly effective for analyzing 5G NR signals, because of high symbol content and a large number of different signal elements (channels, reference signals, OFDM subcarriers, etc.). Coupled markers allow the user to understand the identity and characteristics of a symbol simultaneously in time, frequency, and error.

Figure 7 shows an example of the simultaneous multiple color-coded traces and a complete marker table. With markers coupled, a peak search in either the error vector spectrum (Trace C) or error vector time (Trace D) trace indicates the largest error during the measurement interval. The exact symbol associated with this error can now be understood in terms of time domain OFDM symbol index, frequency domain subcarrier number, physical channel type, IQ magnitude and phase value.

Figure 7. Example of coupled markers across multiple color-coded traces in different measurement domains.

Analyze beam-sweeping with SS/PBCH phase and power traces

To establish a successful connection and sufficient coverage, NR basestation (gNB) uses beam-sweeping to transmit synchronization and system information via the initial access channel and signals (SS/PBCH). Multiple SS/PBCH blocks, up to 64 at mmWave, are potentially transmitted on different beam directions so it is important to measure power and phase across these different SS/PBCH blocks or beams.

89600 VSA, as shown in Figure 8, provides SS/PBCH power trace (Trace D) to measure absolute power of each SS/PBCH and SS/PBCH survey trace (Traces E and F) to measure relative power or phase of the different SS/PBCH blocks or beams.

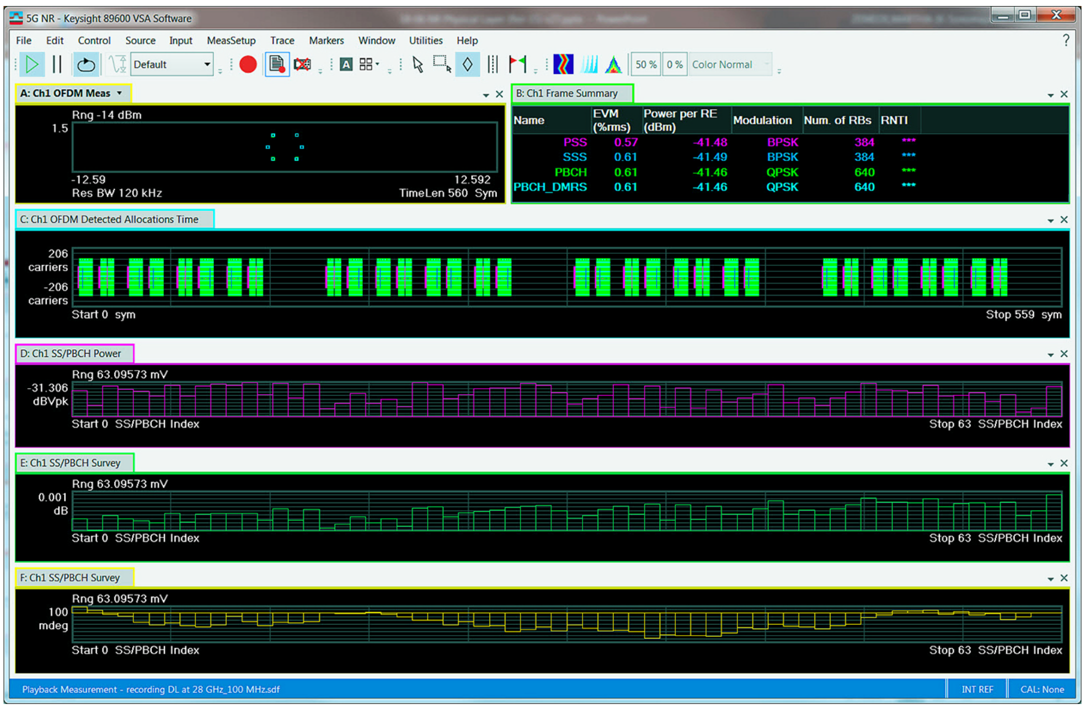


Figure 8. Example of SS/PBCH dedicated measurements to measure power and phase of each SS/PBCH active indices.

Faster validation with design and test integration

When transitioning from design to test, you can avoid surprises by taking advantage of the tight linkage between Keysight EDA SystemVue ESL software and 89600 VSA software. SystemVue ESL software can be used with the W1906EP SystemVue 5G baseband verification library to simulate 5G signals, while the 89600 VSA software can be used to analyze and display the simulated signals.

In this configuration, you don't necessarily have to connect to hardware. Instead, you can use the Sink in simulation to verify and troubleshoot your 5G design with the graphical user interface (GUI) provided by the 89600 VSA software. This capability gives you the same interface, measurement and demodulation algorithms for both design and test, which enables faster troubleshooting of issues during the design and prototype phases. You can also use the VSA Sink to record a waveform at virtually any point in your design, play it back in hardware, or use it as a reference versus a real measurement on your device under test.

Since you're using the same measurement algorithms and displays used by the test equipment, you can be assured that any differences measured on prototypes are not due to differences between measurement hardware and simulation tools. Moreover, using the same GUI in simulation and test eliminates the learning curve for any new tools introduced as the design transitions through its development lifecycle.

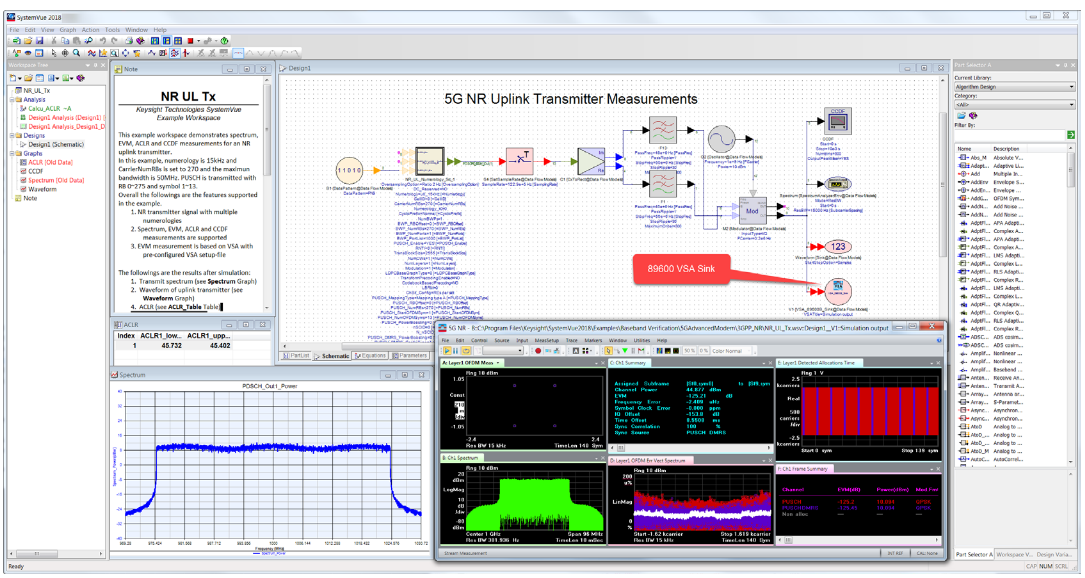


Figure 9. Example showing linkage between Keysight EDA SystemVue ESL software and 89600 VSA software.

MIMO and beamforming analysis

Use the 5G NR option for analysis and troubleshooting of up to 8x8 MIMO in the downlink or 4x4 MIMO in the uplink. Various traces are available to look at per layer and per port modulation quality, as well as power, time, frequency and phase. The MIMO Information table shown in Figure 10 (Trace C) includes per channel performance as well as cross channel performance metrics. EVM for each antenna port is reported. In addition, per path power at each antenna port plus time, frequency and phase offset of the physical channel is reported for each path. Cross-channel performance can be characterized by looking at cross coupling and relative phase, timing and power. A condition number trace (Trace B) is also available to view the impact of the MIMO channel.

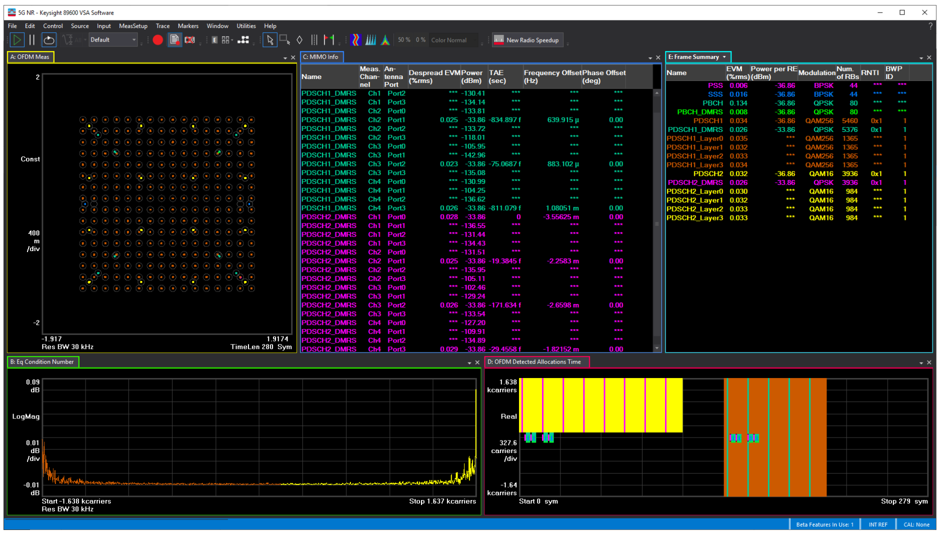


Figure 10. Example of 4 channel 5G NR downlink MIMO measurement.

Digital beamforming with up to 64 antenna elements, with beam weights and beam pattern results, are available for SSB, PDSCH and PUSCH.

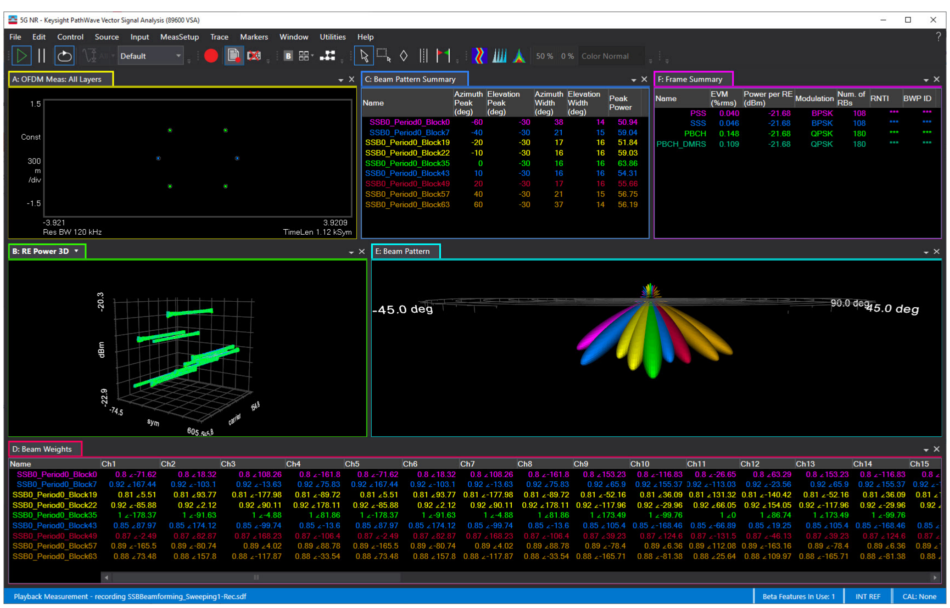


Figure 11. Example of downlink beamforming with magnitude and phase weightings and corresponding beam patterns.

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 to share same spectrum used by LTE today. Analyze the DSS signal, as defined in 3GPP release 15 and 16 specifications, with simultaneous demodulation of the 5G NR and LTE carriers and view the results side-by-side.

You can choose to demodulate both carriers simultaneously or you can also demodulate each carrier sequentially. In all cases, the results can be viewed side-by-side as shown in Figure 12 below. The side-by-side presentation of results for each carrier reveals interactions that may not be visible otherwise.

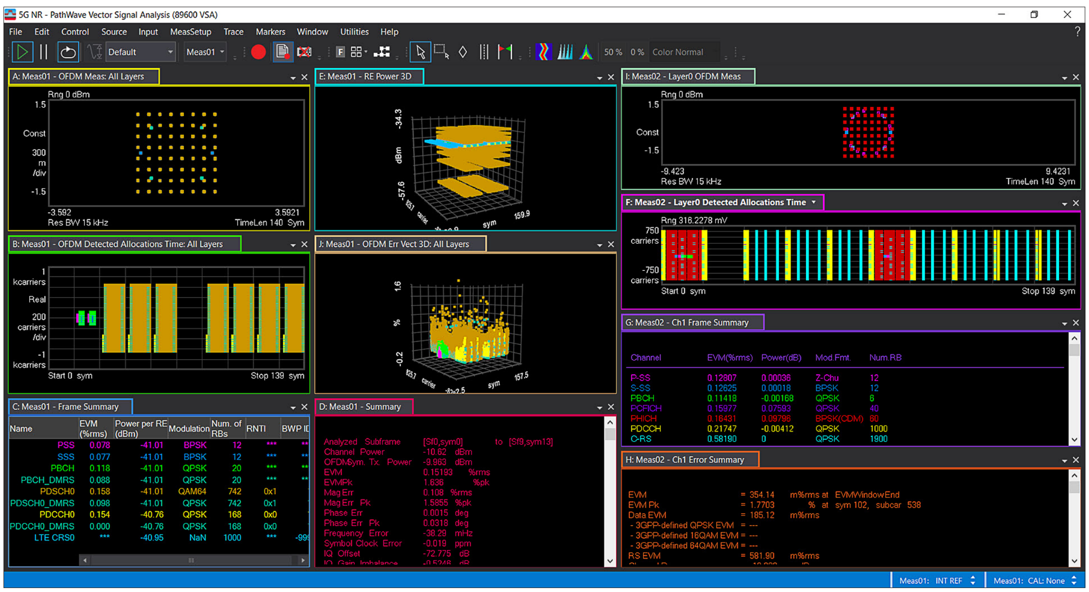


Figure 12. VSA's DSS analysis capability shows demodulation of 5G NR and LTE carriers and side-by-side presentation of measurement results.

Power Suite Measurements

The 89600 VSA newly introduced 89601PSMC option for Power Suite measurements providing adjacent channel power (ACP) and spectral emissions mask (SEM) measurements.

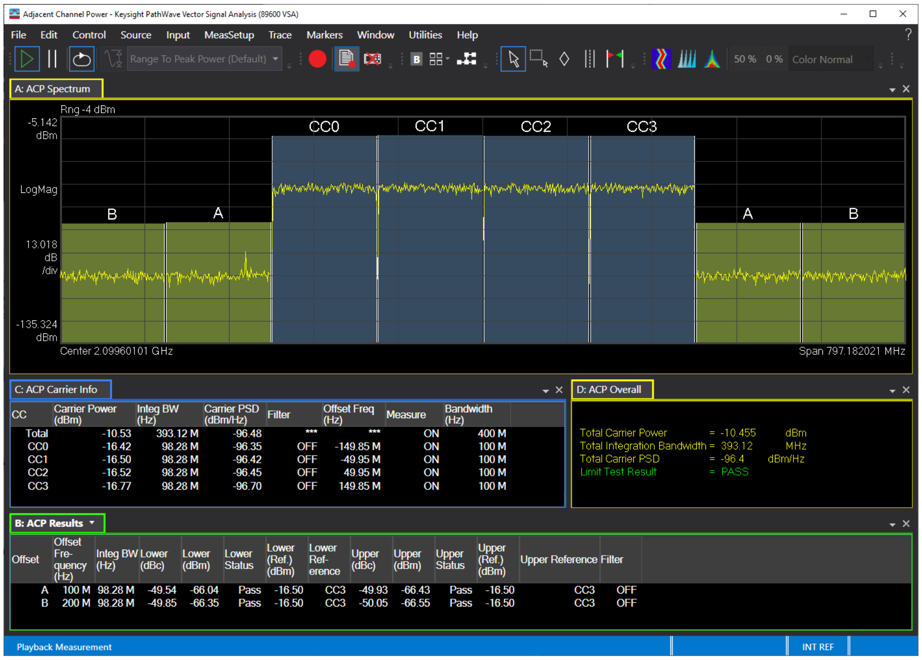


Figure 13: 5G NR multi-carrier ACP measurement with four contiguous component carriers

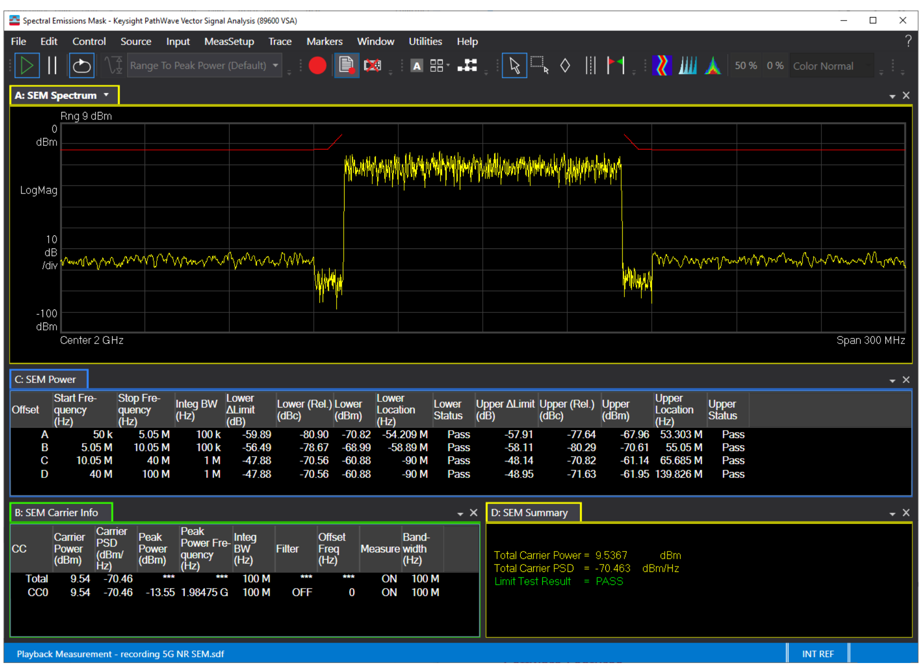


Figure 14: SEM measurement of a single carrier 5G NR signal

Software Features

Core supported features

Feature	Description
Standard	3GPP TS 38 series v15.8.0 (Release 15) and v16.5.0 (Release 16)
Numerology, waveform, signal structure	
Numerology (μ)	μ 0 – 4: 15 kHz, 30 kHz, 60 kHz normal CP, 60 kHz extended CP, 120 kHz, 240 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): 5, 10, 15, 20, 25, 30, 40, 50, 60, 70, 80, 90, 100 MHz
	FR2 (mmWave): 50, 100, 200, 400 MHz
Number of component carriers (CC)	Up to 16
	Note: Simultaneous capture of all CCs or sequential capture of each carrier is supported.
Number of bandwidth part (BWP)	Up to 4 BWPs per component carrier
	Note: DL Initial BWP with CORESET0 configuration is supported
Multiple antenna technologies	Up to 8x8 MIMO in DL and 4x4 MIMO in UL. Codebook and non-codebook based precoding support in UL
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
Uplink	PUCCH (Format 0/1/2/3/4), PUCCH-DMRS, PUSCH (multiple users), PUSCH-DMRS, PUSCH-PTRS, PRACH with multiple occasions, SRS
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)
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
	Note: For PDSCH, 1024QAM per MCS Table 5.1.3.1-4 is supported as defined in 3GPP Rel-17. General purpose 8PSK and 1024QAM modulation formats are supported for PUSCH and PDSCH special use cases. MCS tables are provided in 3GPP TS 38.214 specification.

Feature	Description
Channel decoding	
PDSCH and PUSCH	LDPC decoding for PDSCHs and PUSCHs. Measurement results include Codeword (PDSCH only), slot index, effective code rate, number of code blocks, CRC pass/fail and descrambled, deratematched, decoded CB or decoded TB data
	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	Predefined FDD and TDD test models for downlink. FR1 TM1.1,1.2, 2.0,2.0a, 3.1,3.1a, 3.2, 3.3. FR2 TM1.1, 2.0, 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 and symbols
	Note: Multiple subframes, multiple symbols, or a combination of subframes and symbols can be used as a measurement interval
Analysis start boundary	The time alignment boundary of the analysis region can be frame, half-frame, subframe, or slot

Feature	Description
Equalizer and tracking	
Source	Equalization source can be RS or RS + Data
Time basis	The frequency of the equalizer training can be per slot, subframe, frame, result length
Tracking	Tracking is done in amplitude, frequency and phase, timing
Sync mode and sync adjust	
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
Prioritize PDSCH-DMRS	Synchronization prioritizes using PDSCH-DMRS over SS/PBCH
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	
Symbol phase compensation	Applies per symbol phase compensation at the measurement center frequency or at a different RF frequency
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 RE, per RB, All REs
Symbol time adjustment	Determines where within the cyclic prefix IFFT begins as a percentage of the IFFT duration
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	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
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

Supported measurements

Feature	Description
Pre-demodulation measurements (uplink and downlink)	
CCDF	Displays the complementary cumulative distribution function (CCDF) for the selected input channel
CCDF summary	Summary data including 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
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, 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
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, power, modulation format, number of RBs and CRC for each channel present within each slot, color-coded by channel type
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
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
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

Basic vector signal analysis and hardware connectivity (89601200C) (required) 5G NR Modulation Analysis (89601BHNC)

Software license type	Software license	Support subscription
Node-locked perpetual	R-Y5A-001-A	R-Y6A-001-z [2]
Node-locked subscription	R-Y4A-001-z [1]	Included
Transportable perpetual	R-Y5A-004-D	R-Y6A-004-z [2]
Transportable subscription	R-Y4A-004-z [1]	Included
Floating perpetual (single site)	R-Y5A-002-B	R-Y6A-002-z [2]
Floating subscription (single site)	R-Y4A-002-z [1]	Included
Floating perpetual (regional)	R-Y5A-006-F	R-Y6A-006-z [2]
Floating subscription (regional)	R-Y4A-006-z [1]	Included
Floating perpetual (worldwide)	R-Y5A-010-J	R-Y6A-010-z [2]
Floating subscription (worldwide)	R-Y4A-010-z [1]	Included
USB portable perpetual	R-Y5A-005-E	R-Y6A-005-z [2]
USB portable subscription	R-Y4A-005-z [1]	Included

1. z means different subscription license duration. F for six months, L for 12 months, X for 24 months, and Y for 36 months. All subscription licenses have included the support subscription same as the subscription license 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.

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
5992-2383EN	Pre-5G Modulation Analysis 89600 VSA Software 89601B/BN-BHN - Technical Overview
5990-6553EN	PathWave Vector Signal Analysis (89600 VSA) Software - Brochure
5990-6386EN	PathWave Vector Signal Analysis (89600 VSA) Software - Configuration Guide
5992-4210EN	Option 89601200C Basic Vector Signal Analysis & Hardware Connectivity, 89600 VSA Software - Technical Overview

Web

- www.keysight.com/find/89600vsa
- www.keysight.com/find/89600_5g
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