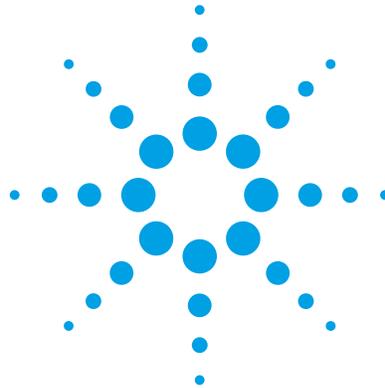
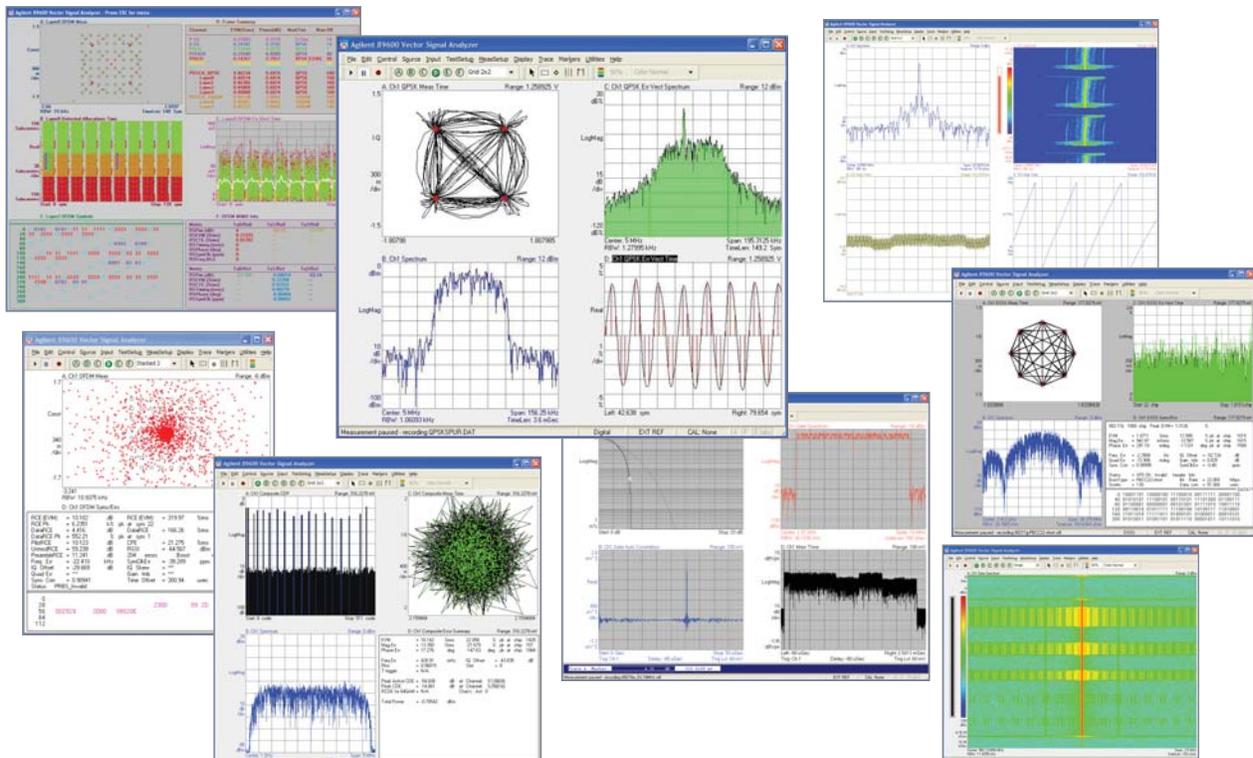


Agilent 89600 Vector Signal Analysis Software

Technical Overview



- Reach deeper into signals
- Gather more data on signal problems
- Gain greater insight



Agilent Technologies

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Introduction

This technical overview covers the features, capabilities, and benefits of the 89600 Series vector signal analysis software. For detailed software specifications, please see the *89600 Series Vector Signal Analysis Software Data Sheet*, publication number 5989-1786EN. Specifications for some hardware platforms supported by the 89600 VSA software can be found in *Hardware Measurement Platforms for the Agilent 89600 Series Vector Signal Analysis Software*, Data Sheet, literature number 5989-1753EN.

Advanced Digital Signal Processing to Uncover and Identify Problems

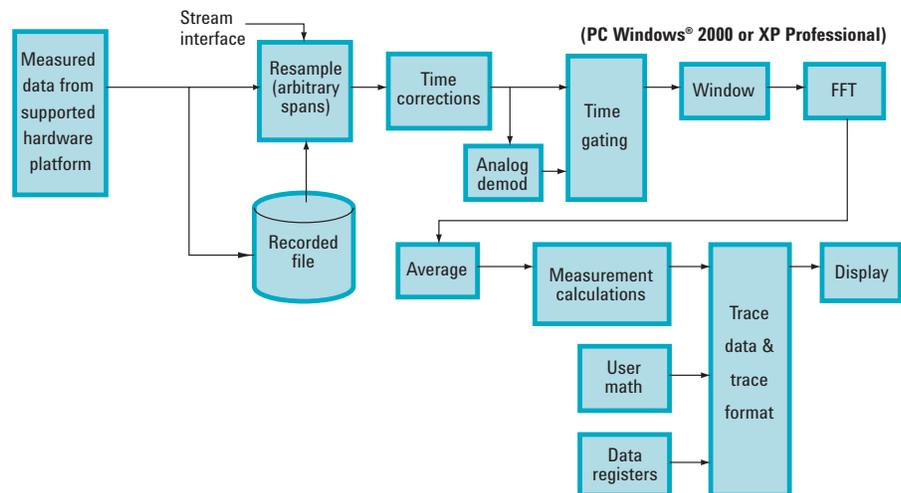


Figure 1. The VSA software architecture provides DSP demodulation algorithms with user-controlled modulation parameters for flexible demodulation of a range of new and emerging formats, including 3G, WLAN, LTE, and WiMAX. Data can come from several sources, including multiple supported hardware platforms, recorded files, and stream data from Agilent EEsosf's ADS simulation software.

In RF/wireless communications applications, the Agilent 89600 vector signal analysis software lets you characterize complex, time-varying signals with detailed and simultaneous spectrum, modulation and time waveform analysis. Use these tools to uncover system problems—problems you really need to see and track down.

The 89600 VSA software connects your measurement hardware to your PC environment, using familiar, PC-based tools, providing a tightly linked software/hardware test and measurement environment. Use these tools to track down problems at any stage of your design process: from simulation to final prototype.

More than spectrum analysis

The 89600 VSA software provides traditional spectrum displays and measurements, but today, spectrum analysis isn't enough. New digital formats require new measurements.

Familiar tools such as spectrum analyzers with demodulation may indicate that a problem exists, but they can't help you understand the cause of the problem. For instance, incorrect filtering, spurious interference, incorrect interpolation, DAC overflow, symbol mis-timing and other errors may all increase adjacent channel power and distort the constellation. So how do you determine what the real problem is?

The 89600 VSA software provides you the tools to identify the root cause of the problem and to analyze continually changing phase, magnitude, and frequency. Some tools, like the constellation and vector diagrams, are familiar to radio designers. Others, like the spectrogram display are tools for qualitatively understanding system behavior. And still others, like error vector time and spectrum, are entirely new measurements bringing new capabilities and requiring new displays.

PC-based for ease-of-use

The 89600 software relies on a PC for its processing. Improvements in PC capabilities automatically improve the VSA software's performance. New capabilities for integrating test instrumentation and design automation software are also made possible because the VSA software can accept measurement data from a wide range of supported hardware platforms, or time series data from computational tools—and all with a familiar, easy-to-use Windows® GUI.

Vector Signal Analysis (Option 200)

Option 200 is a required option that provides the baseline capability for the 89600 VSA software.

Powerful display formats, signal recording and playback, plus superlative help text provide you with the tools you need for analyzing signals.

Precise analog demodulation

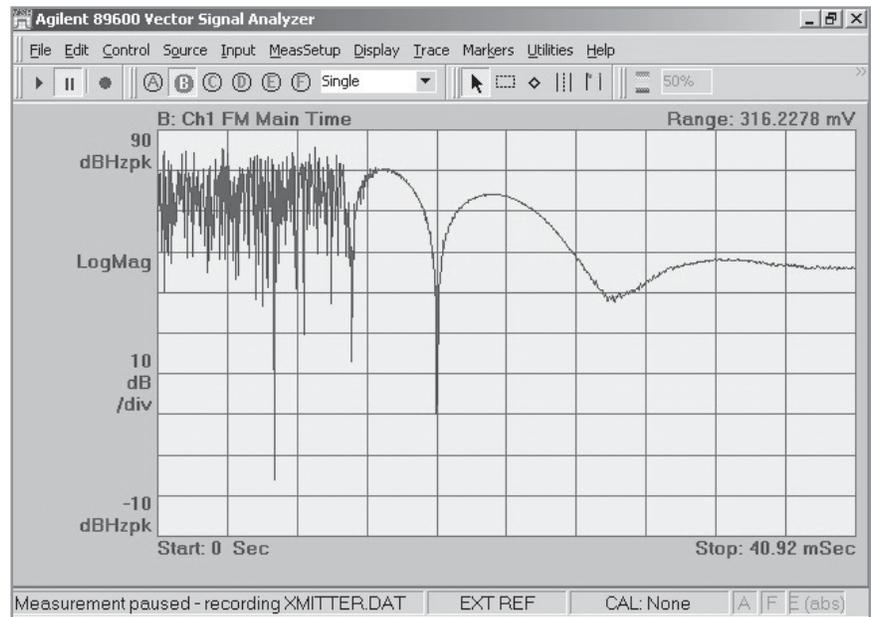


Figure 2. This FM demodulation of a transmitter at turn-on shows the frequency settling characteristics. Use AM or PM demodulation to show amplitude and phase settling performance as well.

Characterize amplitude-modulated, frequency-modulated, and phase-modulated signals in both the frequency and time domains with the built-in analog demodulation capabilities of the 89600 VSA software.

Use analog demodulation to analyze unintentionally modulated signals.

For example:

- Use FM and PM demodulation to examine phase and frequency trajectories during frequency hops or establish the phase-lock-loop lock-up time of oscillators and synthesizers.
- AM demodulate a burst signal to evaluate the time needed for the signal to stabilize.
- AM and PM demodulate sidebands to determine the type of modulation present in phase noise.
- Take the FFT of a demodulated AM/FM/PM noise signal for insight into spurious signals coupling through from other parts of the circuit. Often just the frequency alone of interfering AM/FM/PM modulation provides information about the root cause of the interference.

Flexible vector analysis tools

Analyze time, frequency, and amplitude domain behavior and more with one of the most complete set of vector and scalar analysis tools on the market today.

Measurements include:

- Time
- Gated time
- Spectrum
- Power spectral density
- CCDF and CDF
- Auto-correlation
- Coherence

Use the time tools to measure pulse width, rise and fall times, and observe the shape of your TDMA signals. These tools are particularly useful for setting the trigger level, hold-off and delay on your pulsed signals.

Use the spectrum tools to find the center frequency and bandwidth of your signal, find spurs, and more. A complete set of marker and time gating functions complement the spectrum display.

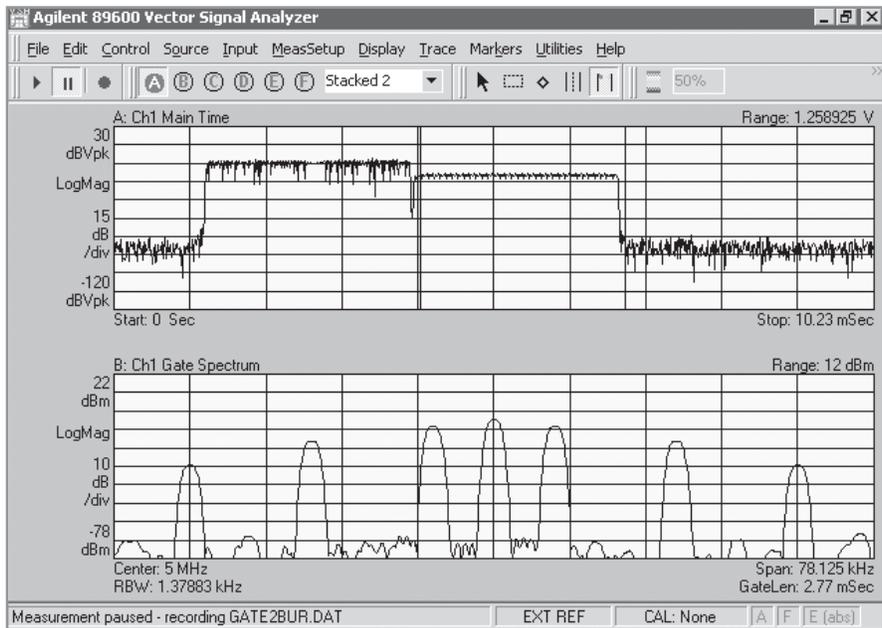


Figure 3. Look at time and frequency characteristics of your signal simultaneously. The top display shows the time trace of a bursted signal with gate markers on the second part of the burst. The bottom display shows the frequency spectrum of just the portion of the signal in-between the gate markers.

Statistically-based amplitude measurements provide a better description of system or component behavior on noise-like digital communications signals. Measure peak to average power ratio and more with the complementary cumulative distribution function (CCDF), probability distribution function (PDF) and cumulative distribution function (CDF) tools provided in Agilent's VSA software.

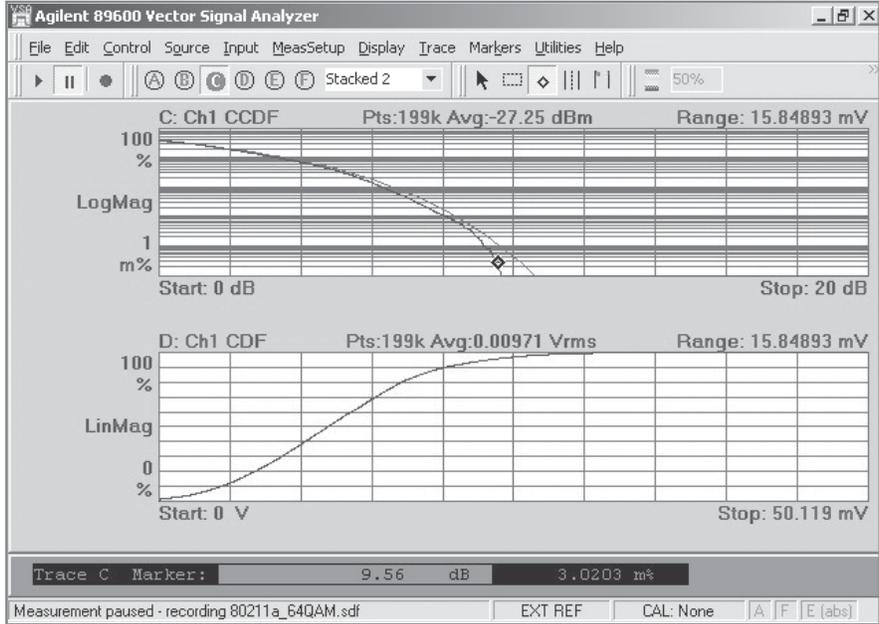


Figure 4. Both CCDF and CDF functions are available. The CCDF marker readout at the bottom of the display indicates that the signal exceeds 9.56 dB above the average signal level only .003% of the time, useful information when calculating design headroom.

Display format and scaling

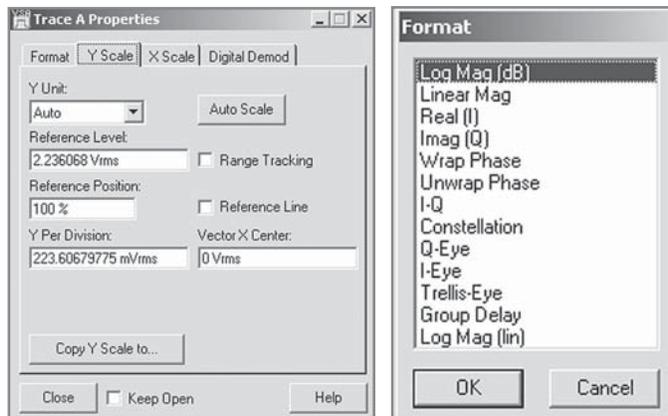


Figure 5. Example trace formats available.

Scale your display the way you want it, with the units you need using the flexible display formatting and scaling tools provided standard in the 89600 VSA software. Select from a complete list of formats including log and linear displays of the signal magnitude, displays of only the real (I) or imaginary (Q) part of the signal, vector and constellation displays, eye displays, trellis displays and group delay. Scaling is automatic with manual override provided for all parameters, including reference level and units per division for both the X and Y-axes.

See six screen displays, simultaneously

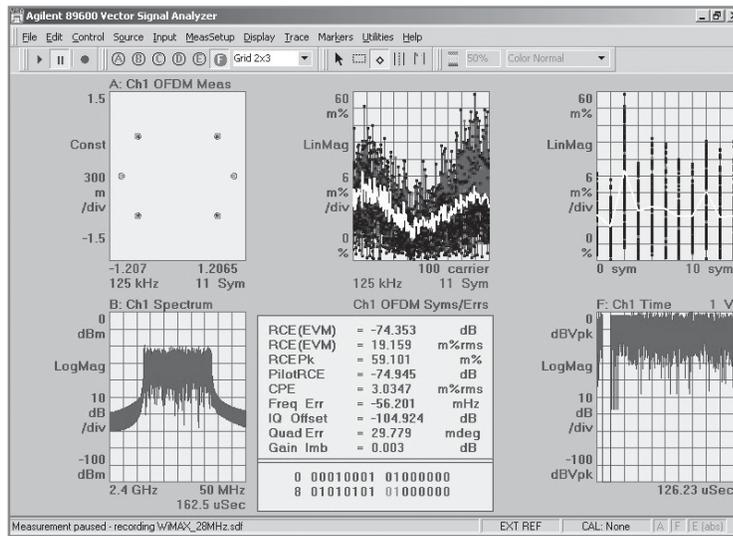


Figure 6. Display one, two, three, four, or six displays, simultaneously. You can choose to have them appear stacked, or in a symmetrical grid. You also control the information displayed for each display, which varies depending on the analysis option invoked.

Spectrogram display format

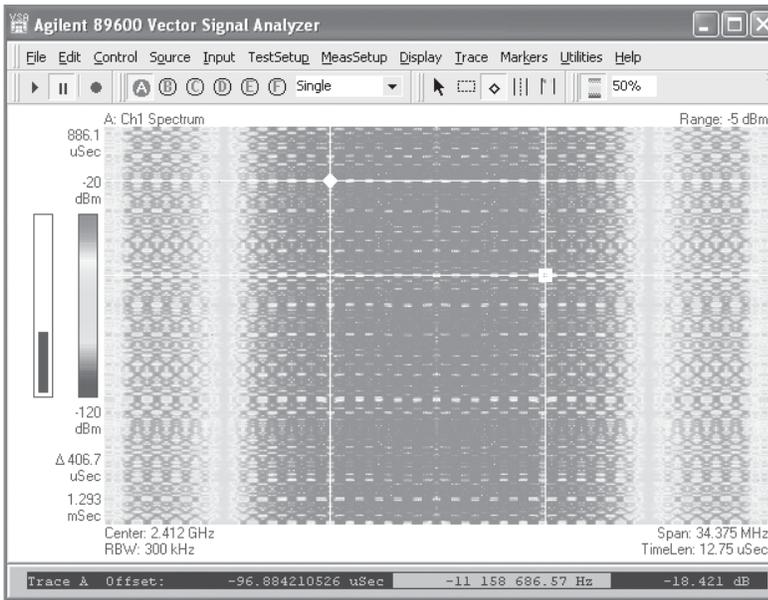


Figure 7. View the spectral behavior of wide bandwidth hopping signals over time using spectrogram displays. Grey-scale views provide even greater resolution.

Take advantage of the spectrogram display to view the behavior of your signal over time. This three-dimensional display is noted for its ability to track the frequency and amplitude behavior of signal, particularly frequency hopping signals and signals with poor signal-to-noise ratio. Use it to also survey signal environments for a quick pictorial view.

For a more in-depth view, use scale markers to expand a portion of the display. Offset and delta markers provide detailed timing information on signal events. Use them to determine time differences between events in both the time and frequency domains.

Signal capture and playback

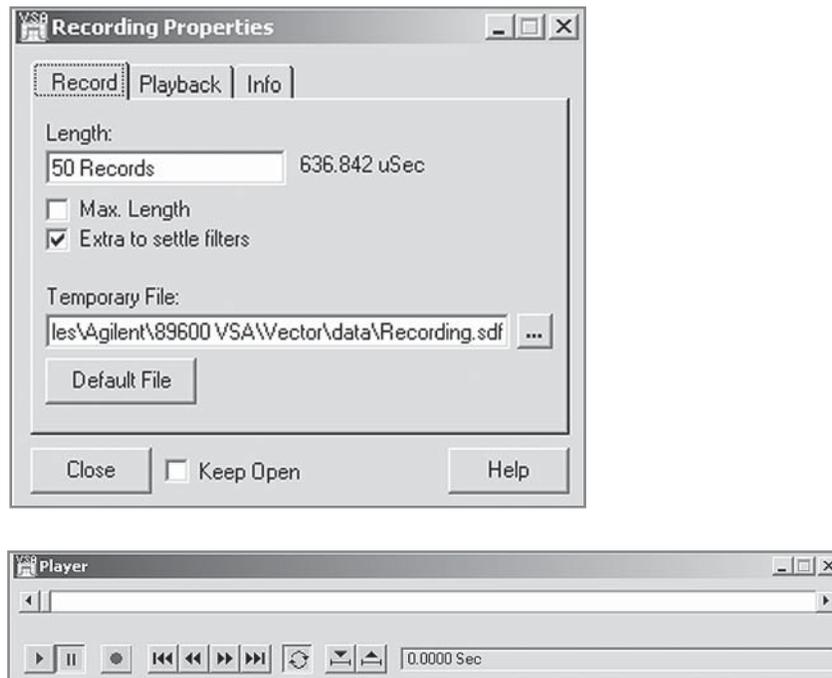


Figure 8. The signal recording user interface is familiar and simple to use.

The 89600 VSA software lets you capture your digitized signal in your measurement hardware and transfer it directly to your PC's disk drive. You can play the signal back at a later time, import it into other applications, and create and play your own recording through an Agilent signal generator.

Why record signals?

- No gaps – offers continuous time record at full bandwidth of your hardware.
- Provides powerful post processing with more control over the analysis.
- Allows slow playbacks with overlap processing. Overlap processing allows you to vary the amount of new information included in each display update. The end result is to provide a “slow motion” view of your signal—extremely useful in understanding transients and transitions.
- Offers porting of simulations back to design software.
- Allows you to archive – saving signal records for future analysis.

You have full control of the playback including:

- Start and pause
- Drag the bar to any position in the record to begin playback
- Back up and rewind
- Loop the recording
- Set start and stop times
- Re-record
- Set span and center frequency (within the extent of the original capture)

Signal generator download control

Record a time domain signal using the recording feature, and link it to a supported Agilent signal generator. You can record the signal at one frequency, and using the zoom mode feature, transfer the signal to the generator at a different frequency. For ease of use, you can control key features of the signal generator from the 89600 VSA software front panel.

Trace math

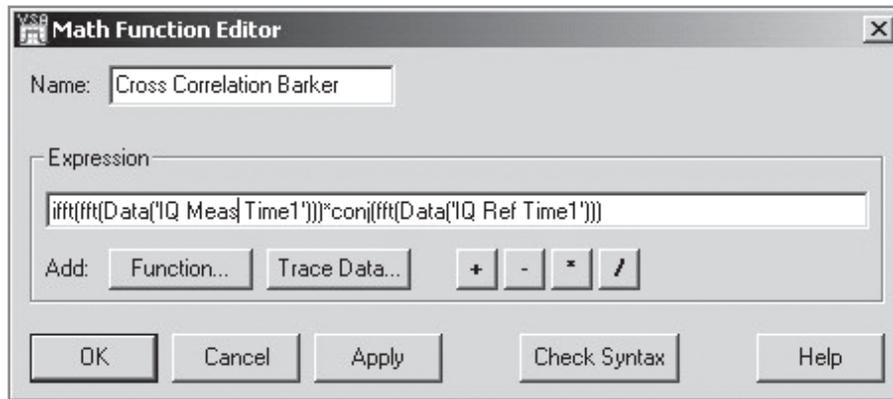


Figure 9. Create math functions for simple tasks like unit scaling, or for sophisticated new measurements like this Barker code cross correlation function.

Math functions let you create mathematical expressions that operate on trace data. Use math functions to:

- Perform mathematical operations on trace data.
- Create a mathematical expression that you can apply as a filter to a waveform.
- Manipulate data in the data registers.

Math functions can be simple or complex. For example, a simple math function may add two data registers. Another math function may compute the inverse FFT of channel 1 spectrum-data. Or a more complex math function may combine operations on trace data or data registers.

Easy-to-Use Windows Graphical User Interface

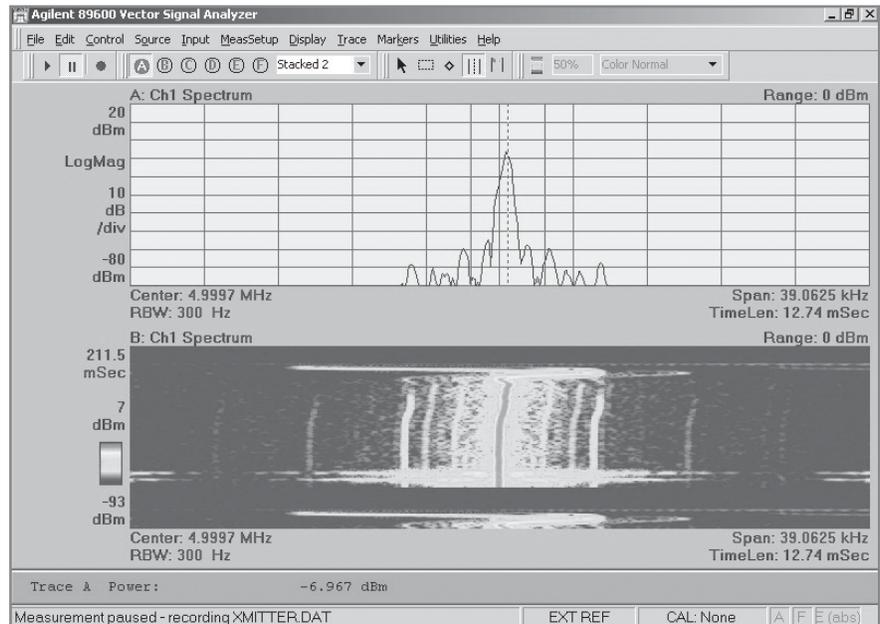


Figure 10. Marker-based measurements, such as band power (shown here) or time gating, or several others, are easy to set up. Just position the marker cursor by dragging and dropping, or type in numeric values manually.

Changing parameters such as center frequency, span, or scale, is easy. Simply place the cursor on the display annotation, and a special cursor will appear. Double click and enter the parameter or use the up/down arrows. If you are familiar with Microsoft® Windows® applications, you can quickly master the 89600 VSA software.

Versatile markers highlight signal behavior

The 89600 VSA offers markers which: display current location, calculate offset (delta) values, provide frequency counter capability, integrate between two lines to determine bandpower, calculate occupied bandwidth (OBW), let you set up zones to calculate adjacent channel power (ACPR), and conduct limit tests.

To display signal parameters using the marker function, simply place a marker on the highest signal using the marker search functions. The marker parameters are shown at the bottom of the display. Use the offset marker to measure parameters between two points on the display.

The ACPR marker allows you to easily perform generic adjacent channel power ratio measurements. You can configure the reference channel and up to five separate adjacent channels. Measurement results are displayed at the bottom of the display, or in the ACP Summary table.

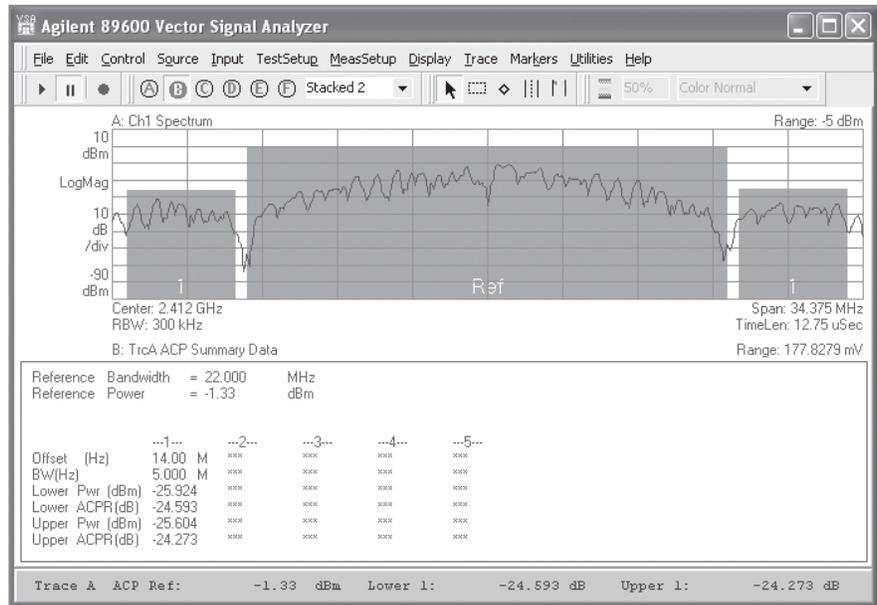


Figure 11. ACPR measurement with summary table enables you to specify up to five adjacent channels.

The OBW marker allows you to easily perform occupied bandwidth measurements. The OBW measurement determines the band of frequencies that contain a specified percentage of the total power within the measurement span.

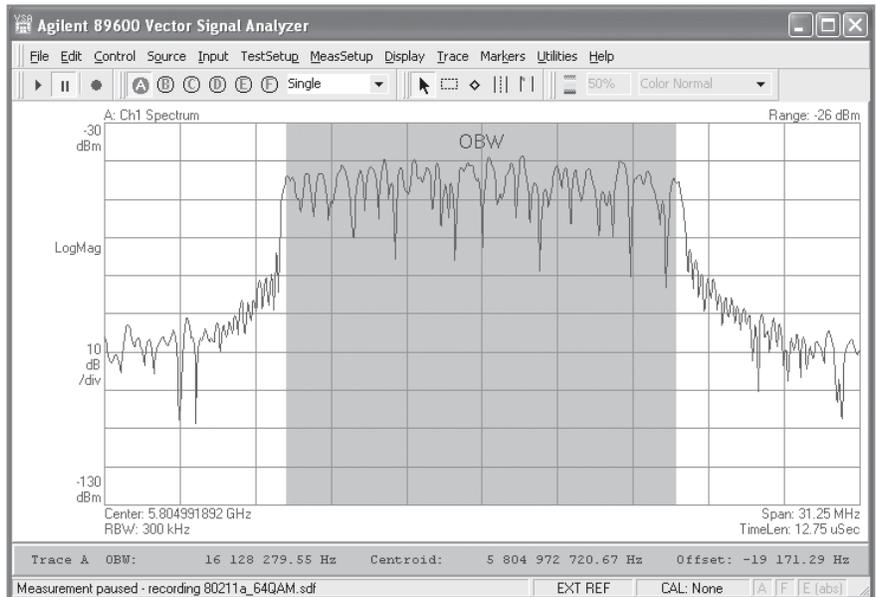


Figure 12. The OBW measurement with summary table can determine the centroid frequency, or you can manually set the centroid frequency to the center frequency.

Limit lines can be created to compare trace data to your defined limits and indicate a pass or fail condition.

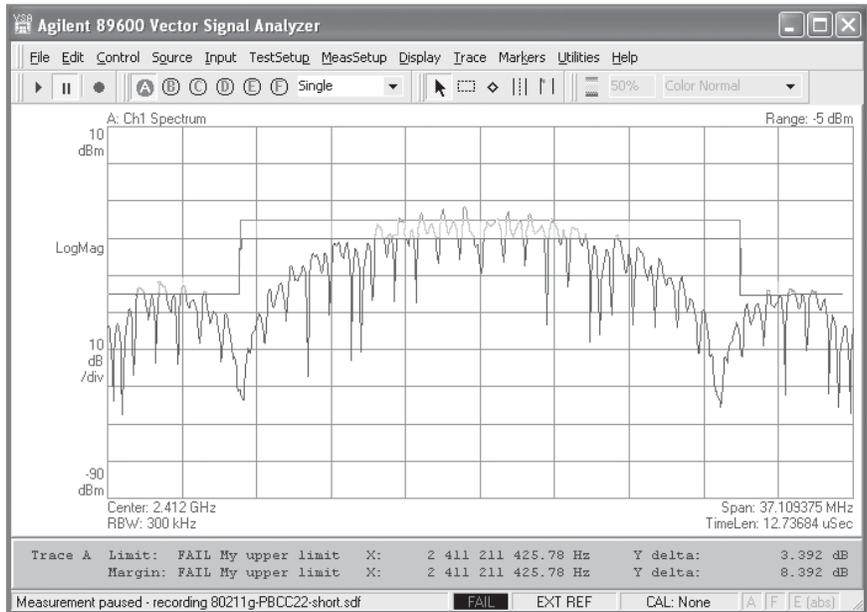


Figure 13. Set the pass and fail color indication for either the limit, or the margin, or both. You define your own limits using the built-in limit line editor.

These more sophisticated marker measurements allow more sophisticated setup. For example, you define a table of values, as for ACPR or simple limit tests. For more complex limit tests, you can either define a set of limit points segment by segment, or import a measurement and add a margin limit around it. For all of these and other markers, the results are displayed at the bottom of the display.

Markers can be coupled across all six displays, allowing you to “walk” through your signal and see its behavior in multiple domains—a very powerful and useful feature.

Highlight signals

For a closer look at a signal, use the highlight box to enhance signal viewing by scaling traces in. Place the box around the signal of interest and select the desired scaling. You can scale both the X- and Y-axis, or scale each separately.

Multi-channel ready

The 89600 VSA software comes fully equipped to control and process up to 4 RF channels or dual I + jQ measurements using the ch1 + jch2 measurement mode. All basic vector signal measurements (Option 200), markers, displays, and record/playback functions are available on 1-, 2-, 3-, or 4-channels.

The built-in ch1 + jch2 mode combines two base band channels for automatic analysis of a single, composite signal. All measurements, including spectrum, time, and error analysis, are available on the combined signal. Or, use each of these channels as an individual measurement input for multi-channel analysis at baseband frequencies.

Powerful and sophisticated trace data provide you with the capabilities to perform all basic VSA time, frequency, and statistical measurements, plus analog and digital demodulation. In addition, the following multi-channel measurements are available:

- Auto-correlation and cross-correlation
- Coherence
- Frequency response
- Impulse response
- Cross spectrum
- Averaging (cross channel measurements) for Nx1
- Dual ch1 + jch2, including cross channel measurements

Use these tools to develop and analyze complex multi-antenna, radar, or signal surveillance systems. If you're working on LTE FDD or TDD, IEEE 802.11n MIMO or Mobile WiMAX (IEEE 802.16e OFDMA) systems, those individual measurement options will take full advantage of the software's capability. See the Option B7Z section for information on IEEE 802.11n WLAN MIMO analysis. See the Option B7Y section for information on Mobile WiMAX. For information on LTE FDD or LTE TDD, see the Option BHD and BHE section.

Check hardware specifications, literature part number 5989-1753EN, for multi-channel specifications. A complete list of supported platforms, including those providing multi-channel analysis can be found by going to www.agilent.com/find/89600.

Spectrum analyzer application

The 89600 VSA software includes a one or two-channel spectrum analyzer application. Use this application to identify signals present in a wide span and to evaluate small signals very close to the noise floor. This application makes scalar measurements, as opposed to vector measurements. Scalar measurements provide displays of amplitude versus frequency for both narrow and wide spans.

Scalar measurements step the application's local oscillator (LO) during the measurement. Each step of the LO produces a segment of the selected frequency span. In other words, the application sets its LO, performs an FFT, then steps its LO to a higher frequency, performs another FFT, and so forth. Because of this, not all hardware measurement platforms support the use of the spectrum analyzer application.

Use this application when you need:

- Very narrow resolution bandwidth with high speed
- Very low noise floor with wide spans
- High signal-to-noise dynamic range
- Maximum flexibility of frequency span, resolution bandwidth, and speed
- Wider frequency spans

Help text

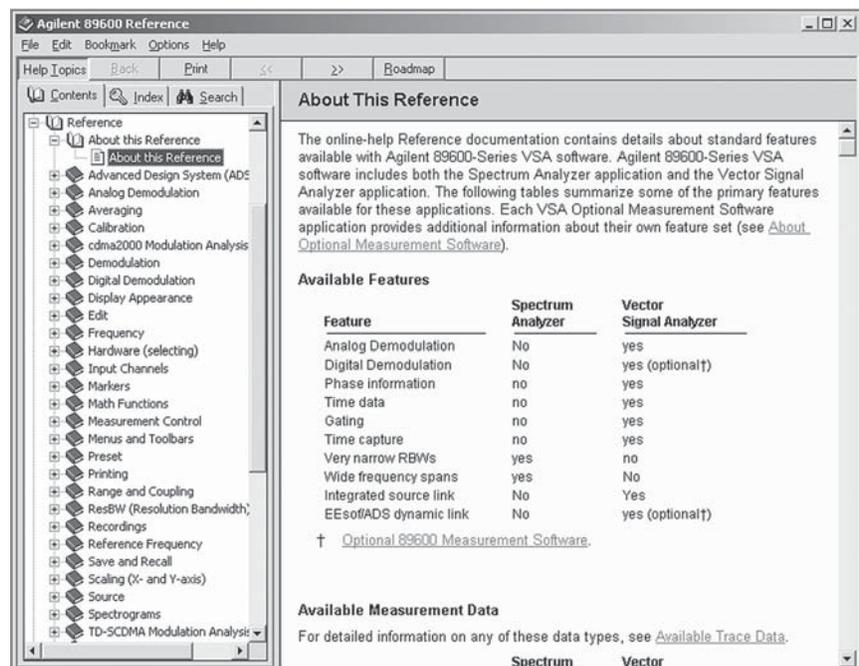


Figure 14. Everything, from reference information, to tutorials using recorded signals, to programming examples, is included in the incredibly comprehensive help text.

Over 5000 equivalent paper pages of help text, application information and tutorials are provided with the 89600 software. A complete set of search tools and hot links provide ready access to all of this information.

Powerful Modulation Analysis Options

The real power of the VSA software is its ability to analyze complex, time-varying signals. The 89600 VSA software analyzes a wide variety of general communications formats, 2G, 3G, WLAN, WiMAX™, UWB, broadband access, and many more.

You can quickly evaluate and troubleshoot digitally modulated signals with both qualitative displays and quantitative measurements. Then, visualize system performance rapidly and intuitively with familiar display formats.

Multiple modulation analysis options are available:

- Option AYA flexible modulation analysis
- Option B7T cdma2000®/1xEV-DV modulation analysis
- Option B7U W-CDMA/HSPA (enhanced) modulation analysis
- Option B7W 1xEV-DO modulation analysis
- Option B7X TD-SCDMA modulation analysis
- Option B7N 3G modulation analysis bundle (an ordering convenience equivalent to options B7T, B7U, B7W, B7X combined)
- Option B7R WLAN modulation analysis
- Option B7S IEEE 802.16-2004 OFDM modulation analysis
- Option B7Y IEEE 802.16 OFDMA modulation analysis
- Option B7Z IEEE 802.11n MIMO modulation analysis
- Option BHA TEDS modulation analysis and test
- Option BHB MB-OFDM ultra-wideband modulation analysis
- Option BHC RFID modulation analysis
- Option BHE LTE TDD modulation analysis
- Option BHD LTE FDD modulation analysis

The supported modulation formats are listed in the Table 1.

All the error analysis tools described in this section apply to all modulation analysis options. Specialized modulation formats may have additional tools besides.

Table 1. Choose from the many available modulation analysis options to meet your measurement needs. The modulation formats supported by each option are listed below.

Supported modulation formats				
Available with Option AYA				
APCO 25, Phase 2 HCPM, Phase 2-HDQPSK	DECT	DVB64	HIPERLAN/1 (HBR)	PHP (PHS)
Bluetooth™	DTV8	DVB128	HIPERLAN/1 (LBR)	TETRA
CDMA base	DTV16	DVB256	MIL-STD 188-181C CPM (Opt 21)	VDL mode 3
CDMA mobile	DVB16	EDGE, EDGE Evolution (EDGE2)	NADC	WLAN (802.11b)
CDPD	DVB32	GSM	PDC	ZigBee (IEEE 802.15.4-2003)
General modulation formats, available with Option AYA (With variable center frequency, symbol rate, filtering type and alpha/BT)				
BPSK, 8PSK		VSB 8-, 16-		Offset QPSK
QPSK		FSK 2-, 4-, 8-, 16-level		EDGE
Pi/4 DQPSK		DQPSK		DVBQAM 16, 32, 64, 128, 256
MSK type 1, type 2; CPM (FM)		D8PSK		APSK 16/32 (12/4QAM)
QAM 16-, 32-, 64-, 128-, 256-, 512-, 1024-, Star-16, 32		$\pi/8$ D8PSK		
3G Wireless communications formats				
3GPP LTE FDD			Option BHD	
3GPP LTE TDD			Option BHE	
The following formats are included in Option B7N:				
cdma2000®/1xEV-DV			Opt B7T	
W-CDMA/HSPA			Opt B7U	
1xEV-DO			Opt B7W	
TD-SCDMA			Opt B7X	
Broadband wireless access formats				
IEEE 802.16-2004 OFDM			Opt B7S	
IEEE 802.16 OFDMA			Opt B7Y	
Wireless networking formats				
WLAN (IEEE 802.11a,b,g,p,j); WLAN (HiperLAN/2)			Opt B7R	
IEEE 802.11n MIMO (WLAN-HT)			Opt B7Z	
Public safety radio formats				
TETRA Enhanced data service			Opt BHA	
Ultra-wideband formats				
MB-OFDM			Opt BHB	
RFID formats Option BHC				
EPCGlobal Class-1 Generation-2 UHF (ISO 18000-6 Type-C)				
ISO 18000-4 Mode-1 ¹				
ISO 18000-6 Type A ¹				
ISO 18000-6 Type B ¹				
ISO 18092				
ISO 14443 Type A				
ISO 14443 Type B				
ISO 15693				
General RFID modulation formats and coding with Option BHC				
<i>Forward:</i> DSB-ASK, SSB-ASK, PR-ASK, FSK-2, OOK; None (NRZ); Manchester, FM0, PIE (ISO 18000-6 Type-A), PIE (EPC C1Gen2), Modified Miller; ISO 15693 1 out of 4, ISO 15693 1 out of 256				
<i>Return:</i> DSB-ASK, FSK-2, OOK; None (NRZ); Manchester, FM0, Miller, Miller-2, Miller-4, Miller-8, Modified Miller, Subcarrier Manchester, Subcarrier BPSK1, Subcarrier BPSK2, Subcarrier BPSK4, Subcarrier BPSK8; ISO 15693: Single Subcarrier Manchester Low Rate, Dual Subcarrier Manchester Low Rate, Single Subcarrier Manchester High Rate, Dual Subcarrier Manchester High Rate.				

1. Beta

Advanced digital demodulators

The 89600 VSA software offers a wide range of digital demodulators. These advanced technology demodulators do not require external filtering, coherent carrier signals, or symbol-clock timing signals to successfully demodulate a signal, just the carrier frequency and symbol rate.

In addition to demodulating your signal, the 89600 digital demodulators use your signal to generate an ideal reference signal called I/Q reference or FSK reference. It then compares your measured signal to this ideal reference to quantify and locate errors in your signal. Built-in filters can be applied to both the measured and reference signals for maximum flexibility comparing the signals or probing points in your communication system.

Unique error analysis tools highlight problems

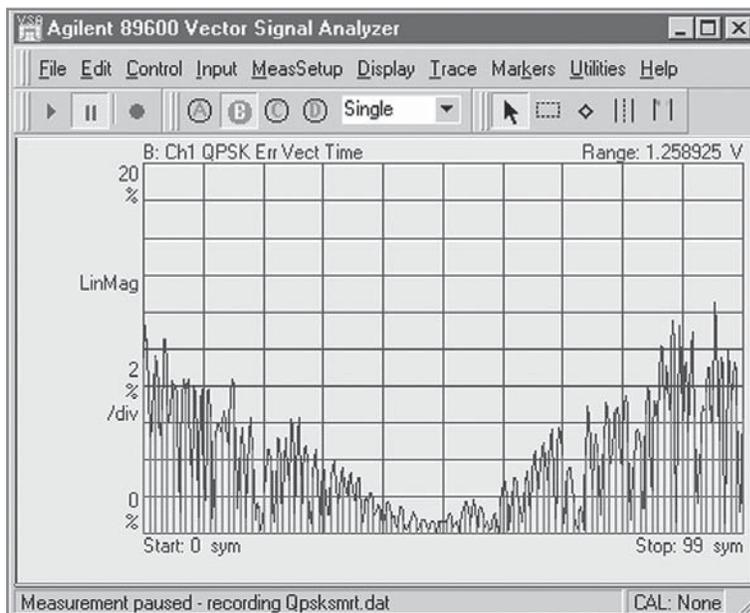


Figure 15. The "v" shape in the EVM versus time display indicates a symbol clock timing error. Trace math can help determine the approximate clock rate.

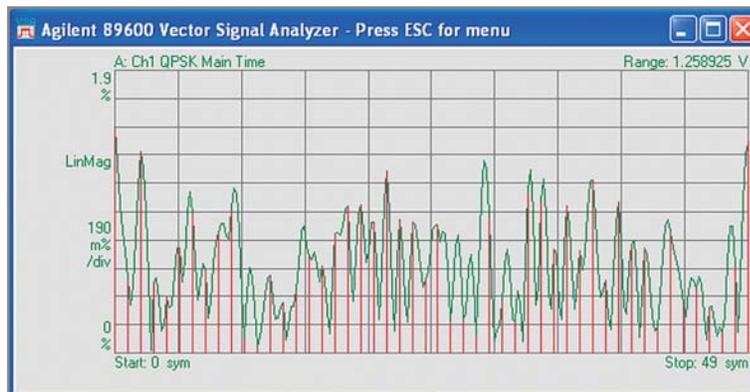


Figure 16. This signal shows higher EVM in between the symbols (shown in green) than at the symbol clock times (shown in red), a clear indication of filtering errors. You can try and determine the correction needed by using the adaptive equalization filter.

Agilent 89600 VSAs offer sophisticated error analysis that lets you see both RF and DSP problems. The key is the EVM measurement. The error vector time plots an error signal versus time diagram. With it, you can identify problems such as clock timing errors, DAC overflow, compensation errors and more—all with one screen. Other tools include error vector spectrum and adaptive equalization.

Error vector magnitude (EVM)

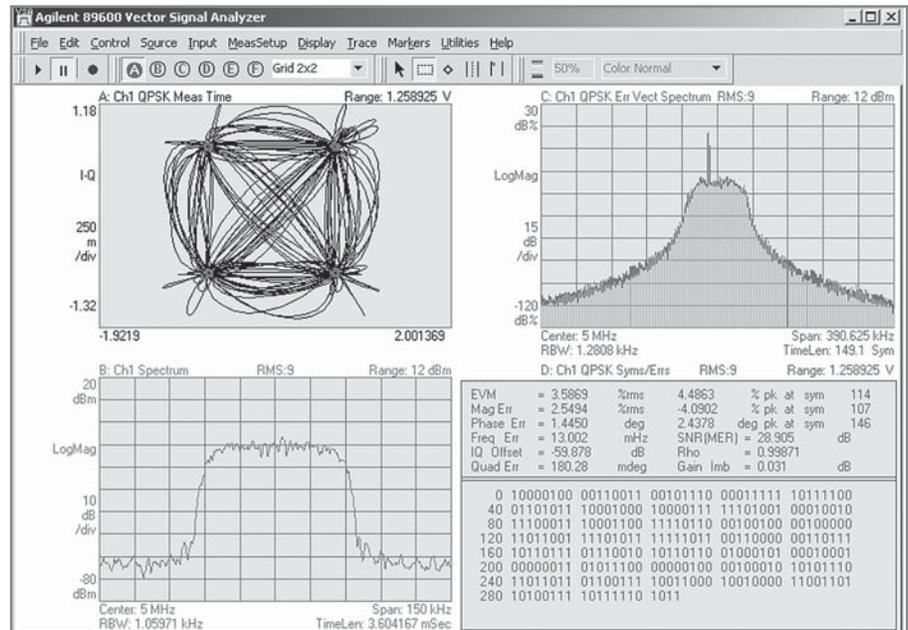


Figure 17. This signal's spectrum, constellation, and EVM error look reasonable. But the error vector spectrum display (top right) clearly shows the presence of an interferer. Further investigation shows that this frequency is related to a subsystem in another part of the DUT. It is obviously leaking through to the point where this measurement was made.

EVM is a powerful analysis tool that helps you pinpoint marginal conditions before they become system performance problems. EVM compares the phase and magnitude of the input signal with an ideal reference signal stream. The average error over time is displayed as a single percent, or the error can be viewed on a symbol-by-symbol basis.

Use the FFT of the error vector time signal to identify systematic impairments you couldn't otherwise see. Identify spurs coupling from other parts of the system by looking at the error vector spectrum for peaks.

Adaptive equalization

Adaptive equalization identifies and removes linear errors from I-Q modulated signals by dynamically creating and applying a compensating filter. These errors include group delay distortion, frequency response errors, and reflections or multi-path distortion. You can also uncover DSP errors such as miscoded bits, or incorrect filter coefficients.

Equalization is a tool designers can use to identify and correct linear errors. Pre-distorting a signal to correct for linear errors can be simpler, faster, and cheaper than modifying hardware to make the corrections. Further, some wide-band signals are almost impossible to measure without adaptive equalization.

Digital Modulation Analysis (Option AYA)

Option AYA demodulates a wide range of standard communication formats, such as GSM, EDGE, and EDGE Evolution. But it also offers a wide range of demodulators for FSK, BPSK, QPSK, offset QPSK, QAM, APSK, and VSB, all with variable filter type and alpha, symbol clock rate, and bandwidth. You can even apply your own proprietary filtering by providing the filter's impulse or frequency response.

Whether you are designing to a published standard or a proprietary specification, the 89600 VSA flexible modulation analysis capability has the tools you need to evaluate and characterize signal performance and dig down to the root of your modulation problems.

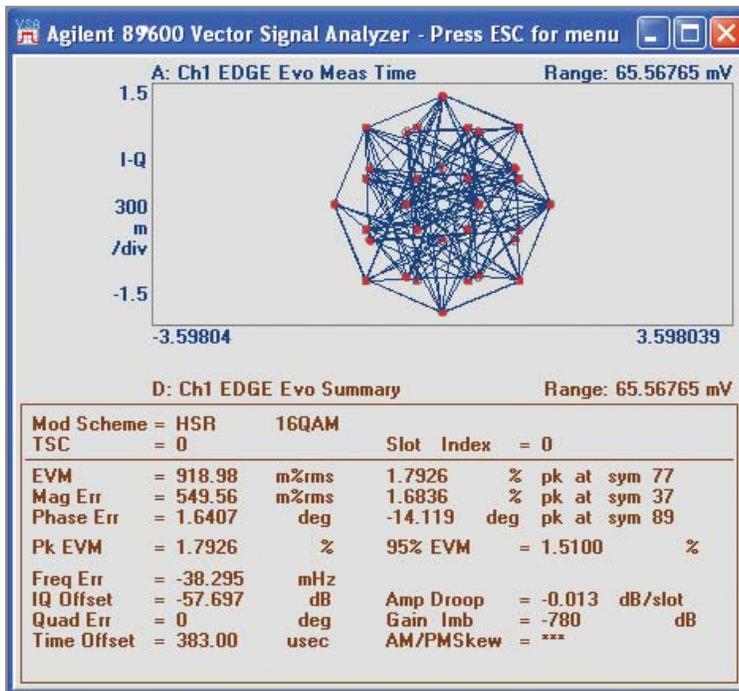


Figure 18: The VSA software auto-detects many important EDGE Evolution signal parameters, and reports the results in a summary table. You can choose to see the de-rotated IQ constellation.

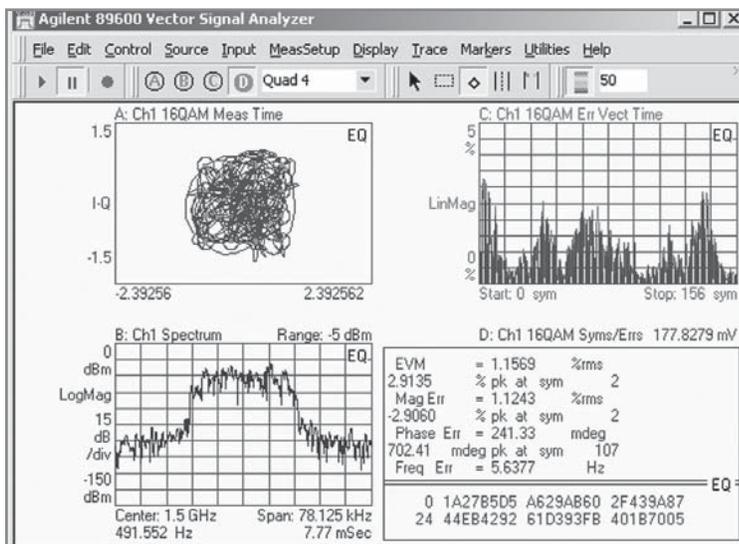


Figure 19: 16QAM signal with spectrum and error vector magnitude versus time display.

W-CDMA/HSPA (Option B7U)

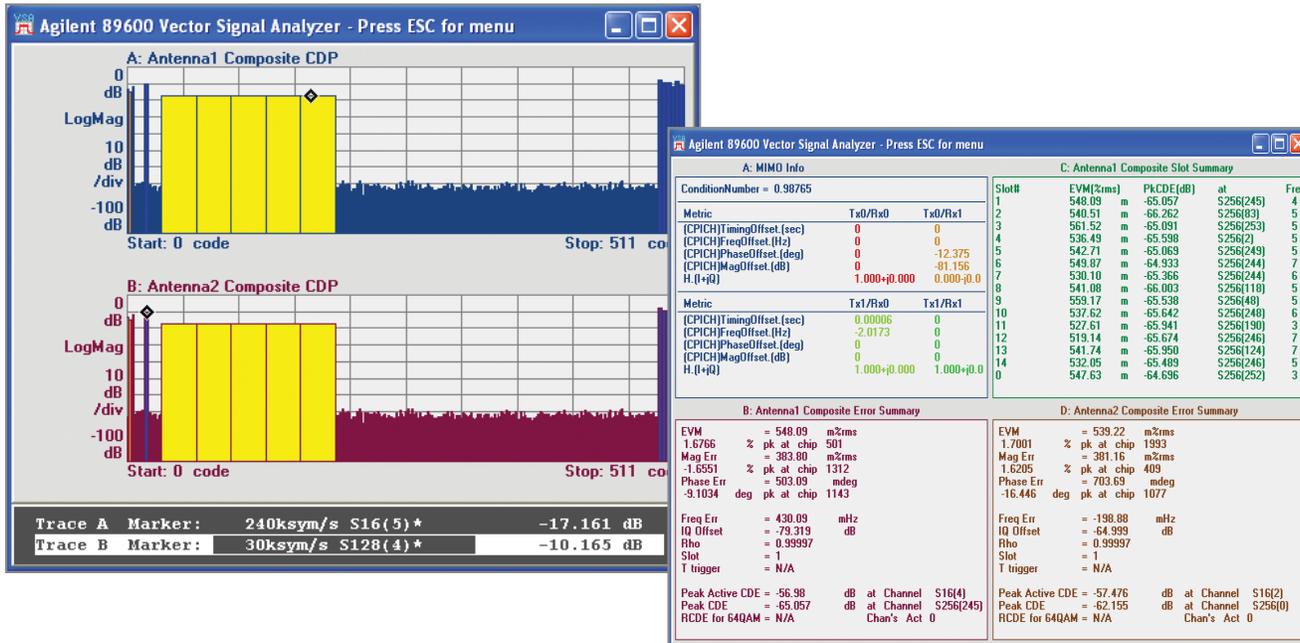


Figure 20. Option B7U provides enhanced HSPA uplink, downlink, and MIMO analysis. View data at the single channel, composite channel, code domain, and MIMO antenna 1 or antenna 2 for detailed troubleshooting.

Measure, evaluate and troubleshoot your W-CDMA and Enhanced HSPA (HSPA+) signals with the tools in Option B7U. Use these tools to descramble, despread, and demodulate W-CDMA uplink and downlink signals. The analyzer automatically identifies all active channels regardless of the symbol rate or spread code-length.

Measure 2x2 DL MIMO for HS-PDSCH with supported 2-channel hardware. Take advantage of new MIMO measurement traces to get an overall view of the signal quality, or to dive down into the individual antenna CDE or CDP performance.

Speed measurement set-up with standard pre-sets for uplink (mobile station or user equipment) and downlink (base station). Use the single layer and composite code-domain power and code-domain error displays (the composite display shows all code layers simultaneously) to determine the overall performance of your signal and the behavior of specific layers and channels.

Take advantage of the composite and single channel constellation, trellis and eye diagrams, IQ magnitude/ phase error displays, and error vector traces to search out specific errors. Statistical displays like CCDF, CDF, or PDF can help you determine the operating point for your amplifiers.

Use the measurement offset and interval controls to select specific data slots for analysis.

For the HSDPA portion of your W-CDMA signal, automatically detect the modulation scheme for HS-PDSCH. Also, despread the HS-PDSCH channels manually or automatically.

For HSUPA signals, Option B7U automatically or manually detects modulation, and supports all HSUPA spread code lengths. Half-slot EVM measurements allow partial slot measurement offset to verify EVM and phase discontinuity requirements when HSUPA control and feedback channel (HS-DPCCH) is present.

cdma2000/1xEV-DV (Option B7T)

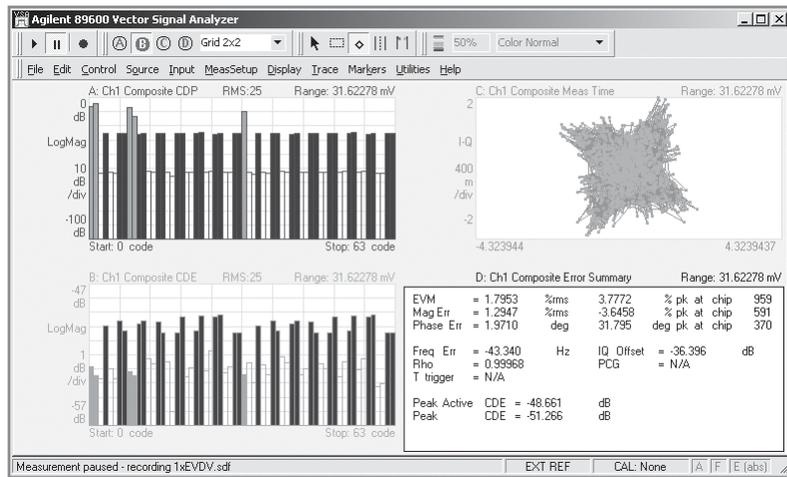


Figure 21. Use the extensive 89600 Option B7T toolset to evaluate the performance of your cdma2000/1xEV-DV signals. Notice the code domain power and error displays, vector constellation display and error summary table. These traces are for the composite (entire) signal. Similar tools are available for layer and channel analysis.

The robust and flexible features provided in Option B7T give you the tools you need to test your cdma2000/1xEV-DV signals to their standards and identify the cause if the signal fails to meet its standard. Descramble, despread, and demodulate both the forward and reverse link signals. The software automatically identifies all active channels regardless of symbol rate or Walsh code.

Signal analysis capabilities are identical to the advanced tools provided for W-CDMA analysis. These include single layer and composite code-domain power and code domain error traces, composite and single channel constellation, trellis and eye diagrams, EVM, IQ magnitude and phase error traces and much more.

1xEV-DV features include automatic detection of the modulation on the F-PDCH channels, automatic active channel identification and optional predefined F-PDCH active channel configuration for adaptive modulated signals.

Statistical analysis tools are available help to analyze high peak/RMS ratio signals, like cdma2000.

TD-SCDMA (Option B7X)

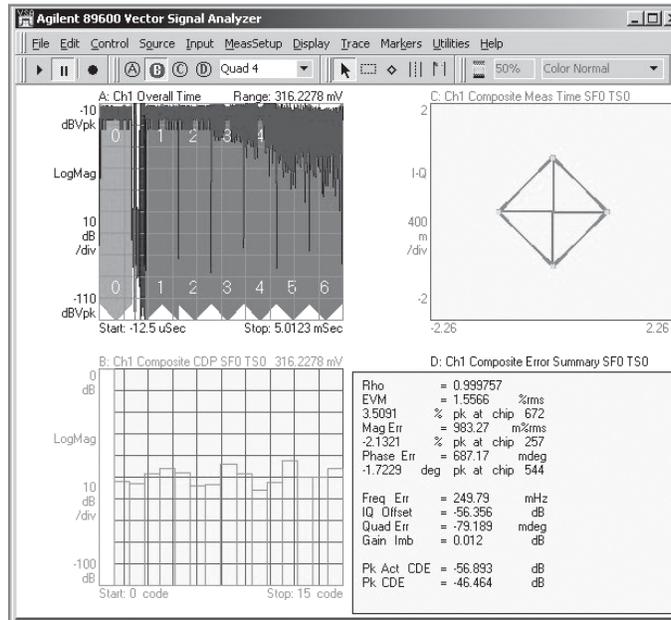


Figure 22. Composite TD-SCDMA modulation analysis.

Troubleshoot and analyze your time division synchronous code domain multiple access (TD-SCDMA) modulation and RF performance with Option B7X for Agilent's 89600 VSA software.

This analysis package handles the 3GPP N-TDD 1.28 Mcps version of TD-SCDMA, including HSDPA (16QAM, 64QAM, and 8PSK). Demodulate HSDPA 16QAM and 8PSK modulated code channels, with automatic detection of code channel modulation type with manual override and automatic detection of multiple midamble shifts. Single code domain layer or composite power and code domain displays are provided. Normalize code-domain power to display code domain power relative to total signal power. Automatic measurements include rho, EVM, frequency error, I/Q offset and I/Q skew.

1xEV-DO (Option B7W)

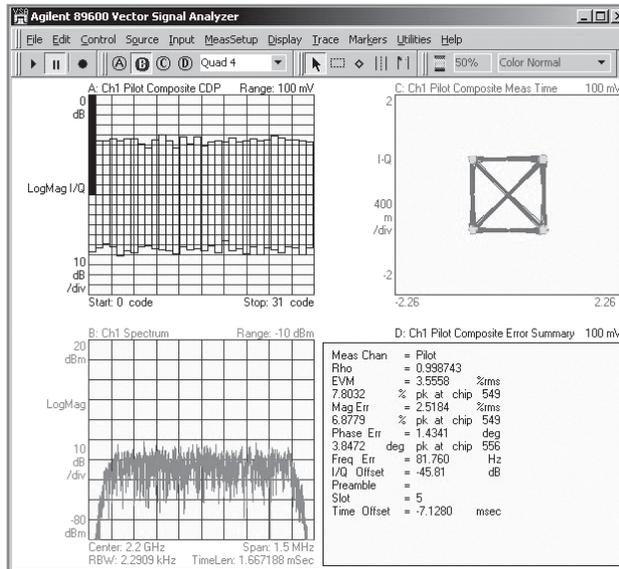


Figure 23. Multiple views of a composite 1xEV-DO signal.

Measure and analyze 1xEV-DO modulated signals with the capabilities offered as part of Option B7W. Descramble, despread, and demodulate 1xEV-DO modulated signals. You can also analyze the reverse link (mobile station or access terminal) and forward link (base station or access network) channels. The analyzer automatically identifies all active channels regardless of the symbol rate or Walsh code length.

The advanced technology demodulator used in this option does not require coherent carrier signals, or symbol-clock timing signals, and comes with an internal IS-2000 filter. All you have to do is enter carrier frequency, chip rate, reverse/forward link direction, and set the long code mask. The analyzer will do the rest.

Measurement results include CDP (composite or layer specific), code domain error (composite or layer specific), EVM, IQ offset, rho, overall 1 rho, and overall 2 rho. CCDF, CDF, and PDF analysis traces are also available to provide statistical views of your signal's operation.

3G-Modulation Analysis Bundle (Option B7N)

Evaluate and troubleshoot your 3G modulation signals with Option B7N 3G modulation analysis. Whether your signal is cdma2000, or W-CDMA, TD-SCDMA, or 1xEV-DO, HSPA or 1xEV-DV, the tools and analysis flexibility in Option B7N help you test your signal to its standard and troubleshoot the problem if the signal fails to meet its standard.

Option B7N is a cost-effective ordering bundle of all the supported 3G modulation analysis options (B7T, B7U, B7X, B7W). However, you can also purchase the modulation analysis options separately.

LTE FDD Modulation Analysis (Option BHD) LTE TDD Modulation Analysis (Option BHE)

Agilent LTE modulation analysis options enable comprehensive 3GPP LTE troubleshooting. Option BHD provides LTE FDD modulation analysis, while Option BHE provides LTE TDD modulation analysis.

Both options provide:

- Analysis of UL and DL signals, supporting up to 50 users x 250 allocations
- Analysis of all LTE bandwidths
- Up to 4x4 DL MIMO analysis, including multi-layer results analysis and display
- DL and UL auto-detection
- Simultaneous analysis of multiple UL channels
- DL test models for verification per the E-UTRA standard
- Up to 6 simultaneous displays, color-coded by channel/signal type
- Channel-selective measurements to troubleshoot by resource block, sub-carrier, slot, or symbol

Powerful Visualization Tools

Consistent color-coding by channel type throughout data and error displays

Detected allocations provide high level view of signal for overall structure verification

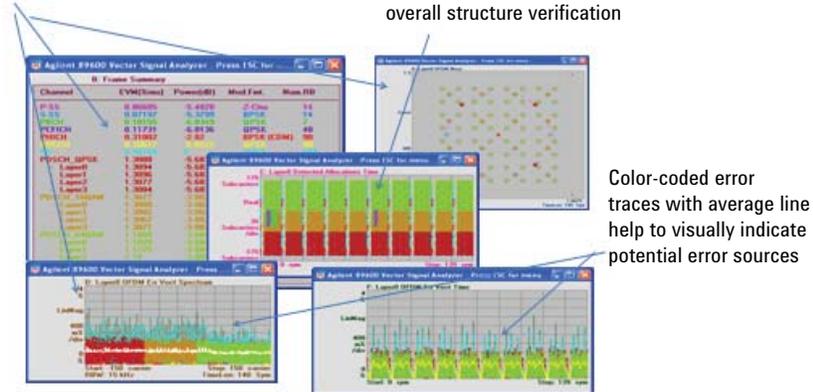


Figure 24. The 89600 VSA LTE analysis options provide graphical tools to help you quickly visualize your signal and begin to identify and examine errors.

LTE analysis is a complicated task. The 89600 VSA software helps make it easier by providing up to six simultaneous, user-selectable displays. Color-coding by user channels and signals lets you quickly see if errors are due to any specific channel or signal. You can select which channels and signals you want to include in measurements, for easier display of potential problems.

Complete Measurement Setup Control

Signal measurements use auto-detection of both UL and DL channels, as well as auto-detection of CP length, Cell ID, and RS-PRS. But you can adjust many shared channel and control channel/signal parameters.

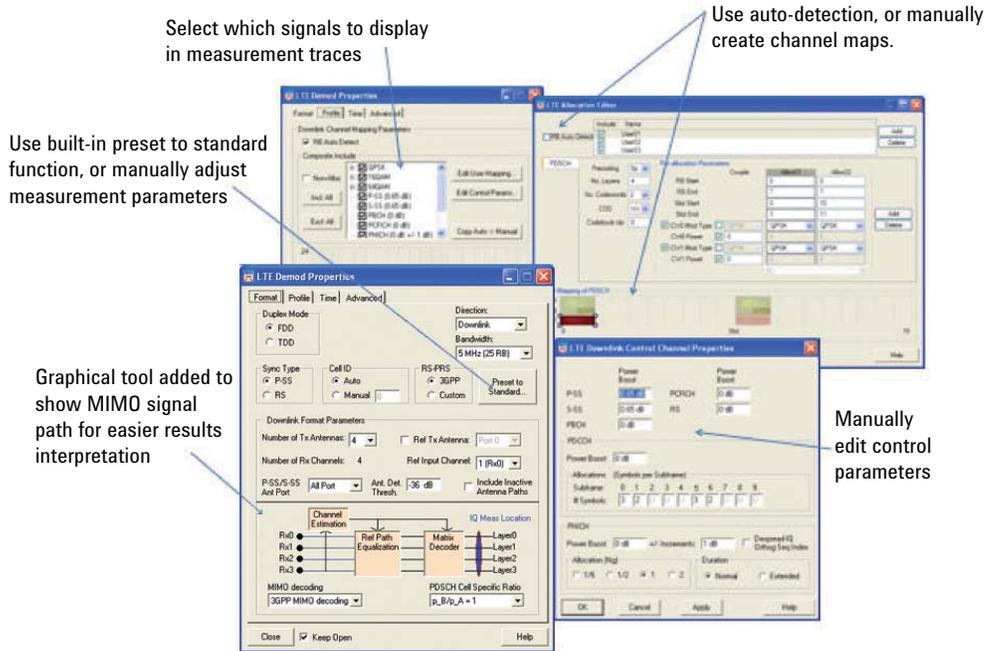


Figure 25. Use Preset to Standard and UL/DL Auto Detection for fast LTE measurement setup. Manual control of a wide range of parameters allows for measurement adjustment during early design stages.

You can adjust the measurement offset and interval to gate the measurement and select only specific intervals for analysis. Or you can choose to display only certain channels/signals. This flexibility lets you focus the analysis on potential errors and adjust your setup to measure even early LTE designs which might not yet be fully realized or compliant.

4x4 MIMO Analysis

The 89600 VSA software supports analysis of 2- or 4-antenna MIMO signals using a combination of Tx Diversity or Spatial Multiplexing pre-coding. Per-layer error analysis measurements including Error Vector Spectrum and Error Vector Time, plus decoded symbols, IQ constellation displays, and more are available. Powerful MIMO-specific measurement tools such as equalizer condition number and equalizer channel frequency response help quantify the quality of MIMO systems and identify problems by carrier or MIMO path.



Figure 26. Trace D displays the equalizer frequency response for all detected ports of a 4x2 MIMO system. The marker readout indicates problems with the Tx0/Rx1 path. The MIMO info table shows that this path has high RS EVM. Note the matching color-coding between the two traces.

Up to 2x2 MIMO analysis can be done using dual MXA/EXA signal analyzers, 2-channel 89600S VXI-based VSA analyzer, or 2-channel supported Agilent Infiniium and Infiniivision Series oscilloscopes. For 4x4 MIMO analysis, the 89600 VSA software supports the oscilloscopes.

Market Leading WLAN Analysis (Option B7R)

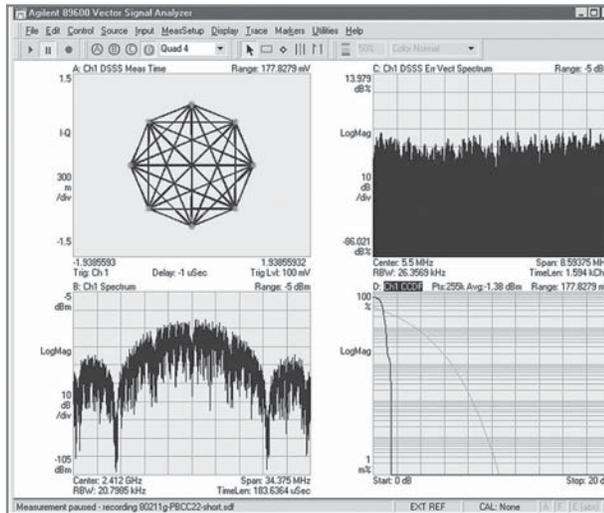


Figure 27. Demodulate the optional PBCC modes of IEEE 802.11g.

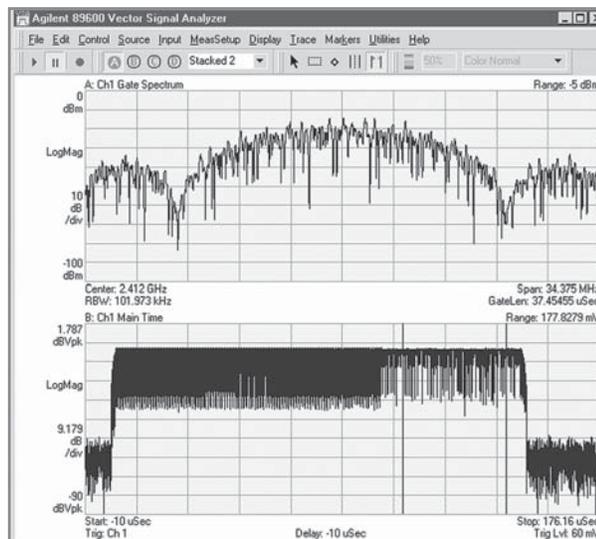


Figure 28. Time gating is a powerful tool for selective analysis of time waveforms. The time gate (two vertical lines in the lower trace) allows FFT analysis on only the payload portion of the waveform.

Agilent is an industry leader in base band, RF, and modulation quality measurements of WLAN signals. The 89600 VSA software WLAN analysis option offers:

- IEEE 802.11a OFDM modulation analysis
- IEEE 802.11b DSSS/CCK/PBCC modulation analysis
- IEEE 802.11g modulation analysis
- IEEE 802.11a/b/g standards-based testing
- IEEE 802.11p DSRC modulation analysis
- IEEE 802.11j 10 MHz modulation analysis

Two modes, DSSS/CCK/PBCC and OFDM, are offered with Option B7R. Use these modes together to analyze the IEEE 802.11g signals and use them separately to analyze IEEE 802.11b or IEEE 802.11a signals. For IEEE 802.n MIMO analysis, see Option B7Z.

IEEE 802.11b modulation analysis

Select the DSSS/CCK/PBCC mode and automatically detect, despread, descramble, and demodulate the payload in all four mandatory IEEE 802.11b formats (1, 2, 5.5, 11 Mbps). This mode handles the optional PBCC modes, the optional short preamble, and the CCK preamble of the CCK-OFDM format in IEEE 802.11g. Additionally, you can choose a root-raised-cosine (RRC) reference filter for applications requiring channel 14 support. Examine the constellation diagram, measure EVM, frequency error, quadrature error, gain imbalance, and more with Option B7R WLAN analysis option.

Use the time domain measurement capability to evaluate your signal's power versus time behavior. Use the time gating feature to analyze the spectrum of just a portion of the burst. All of these and more are available with the DSSS/CCK/PBCC mode for IEEE 802.11b analysis.

IEEE 802.11a modulation analysis

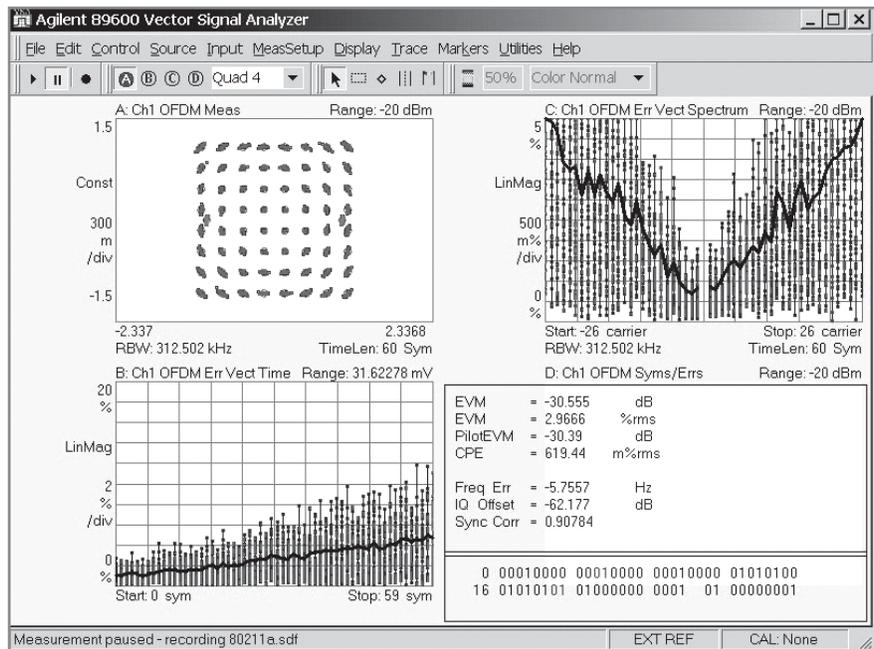


Figure 29. View the EVM spectrum or EVM time of an IEEE 802.11a OFDM burst. The EVM spectrum error shows a 'V'-shaped pattern, indicating a timing error of some sort. The most likely causes are an I-Q time offset, or symbol clock error.

Demodulate and analyze IEEE 802.11a, IEEE 802.11g, and HiperLAN2 compatible signals with the OFDM modulation analysis mode provided in Option B7R. This high performance capability supports demodulating OFDM bursts down to the bit level. Use the compound constellation display to automatically determine and display all modulation formats (BPSK, QPSK, 16QAM, 64QAM) present in the burst.

Evaluate modulation quality using EVM displays of the overall burst, of each symbol, or of each sub-carrier in a symbol. View all of this data in an efficient graphical display that reveals overall patterns in the EVM – a key to finding the root cause of signaling problems.

View the average phase and magnitude behavior of the pilot sub-carriers using the common pilot error display. Measure the magnitude and phase settling of the OFDM burst using the preamble error display. These features provide you a powerful package for analyzing and troubleshooting OFDM signals.

IEEE 802.11a/b/g test suite

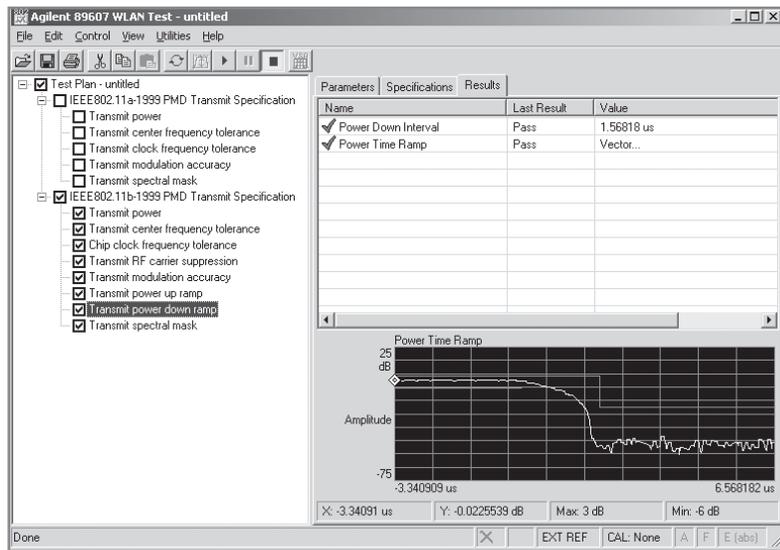


Figure 30. One-button, standards-based measurements of your IEEE 802.11 signal quickly help you determine if the signal has any problems.

Speed the process of testing your IEEE 802.11a/b/g signal to its standard with the WLAN test suite (supplied as part of the WLAN analysis Option B7R). This separate applet automatically executes standards-based transmitter tests of your signal. You specify the tests to perform, set the center frequency and other signal parameters, and the applet does the rest.

The tests provided in WLAN test suite include: transmit power, center frequency and symbol clock frequency tolerance, modulation accuracy, and spectral mask. Standards-based test limits are pre-programmed into the software, but can be modified as your need requires. You can even change the profile of the limit lines. Results are available as pass/ fail or measured data, and are available to download to a spreadsheet, report, or a network.

IEEE 802.11n MIMO Modulation Analysis (Option B7Z)

Analyzing IEEE 802.11n 2-, 3-, or 4-channel MIMO signals is extraordinarily challenging because multiple OFDM signals transmit on the same frequency at the same time. The advanced troubleshooting and evaluation tool set provided by Agilent's IEEE 802.11n MIMO modulation analysis option is specifically designed to handle this challenge and more.



Figure 31. The 89600 software with Option B7Z provides 2x2, 3x3, or 4x4-MIMO analysis and allows you to see important parameters associated with each channel or data stream, individually or simultaneously.

Multi-channel WLAN-HT MIMO measurements

MIMO evaluation and troubleshooting requires simultaneous multi-channel signal acquisition and analysis. Most spectrum analyzers are only single-channel instruments. In contrast, Agilent Infiniium and supported InfiniiVision oscilloscopes, Agilent Acqiris digitizers, and Agilent's VXI-based modular vector signal analyzer have multiple channels and are well suited to the task.

The 89600S series VXI-based analyzers offer two channels of simultaneous signal acquisition and analysis with enough analysis bandwidth for both 20 MHz and 40 MHz IEEE 802.11n signals, 70 dB of dynamic range and up to 1 GB of signal capture memory.

Agilent's multi-channel Infiniium and 6000/7000 InfiniiVision Series scopes provide up to 4x4 MIMO analysis with up to 40 GSa digitizing to sample your IEEE 802.11n signal directly, without the need for down conversion. Analysis bandwidth is as high as 13 GHz, dynamic range is 40+ dB, memory depth is available up to 64 MSa, and their host of high performance time domain markers, triggering and displays help make these products a versatile choice for WLAN-MIMO measurements.

When combined with the appropriate 2- or 4-channel front end, Option B7Z provides support for multiple data streams, plus NxN channel matrix values. In addition, for measurements where significant IQ impairments exist, often because they will be removed later, Option B7Z provides IQ impairment estimation and compensation, allowing you to make demodulation measurements like EVM which exclude the IQ impairments. And for systems designed for 6 GHz frequencies, you can make measurements with and without undersampling, allowing you to choose between measurements with the best EVM or longer result length.

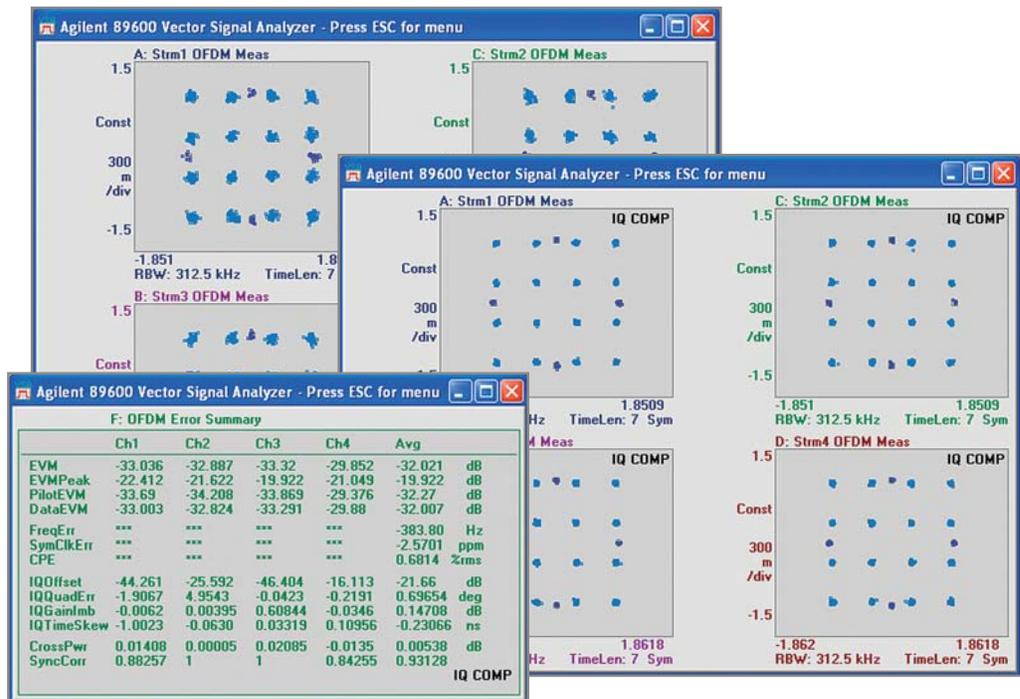


Figure 32. Use the wealth of information available for 4x4 MIMO analysis to improve your designs. Note the constellations with and without IQ compensation. The IQ mismatch removed is reported in the Error Summary table. Note the "IQ COMP" indicator in each trace where the IQ mismatch was compensated out.

Powerful measurements for all formats

Evaluate and troubleshoot multiple IEEE 802.11n operating formats: HT-greenfield, HT-mixed, Non-HT duplicate, and HT-duplicate. Measure EVM, I/Q parameters, and view the constellation of up to four spatial streams at once. Read the contents of the L-SIG and HT-SIG fields. CCDF, power vs. time, and time gated measures are all provided. A MIMO condition number trace provides a numeric method of comparing the equalizer channel response matrix maximum singular value to its minimum singular value.

Choose the way you want to see the important equalizer channel frequency response: with or without the phase ramps removed. With phase response ramps present, you can see the phase and timing differences between the channels and data streams. But sometimes the phase and timing offsets can get in the way, such as when you might want to compare the phase profiles of all transmitters. Typically that profile is masked by a large phase ramp due to the applied cyclic delay. Disabling the display of these phase ramps allows you to better compare the phase responses of all transmitters.

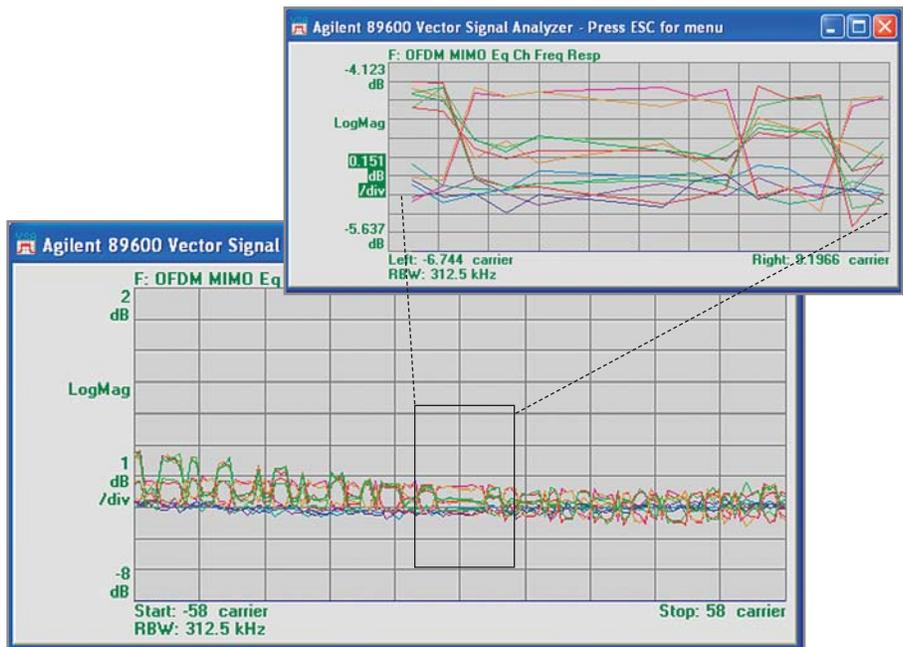


Figure 33. Up to 16 equalizer channel frequency response traces are available, one for each stream present on each channel. Use the x-axis expand capability to see detailed behavior of all equalizer frequency response data.

IEEE 802.16-2004 OFDM Analysis (Fixed WiMAX) (Option B7S)

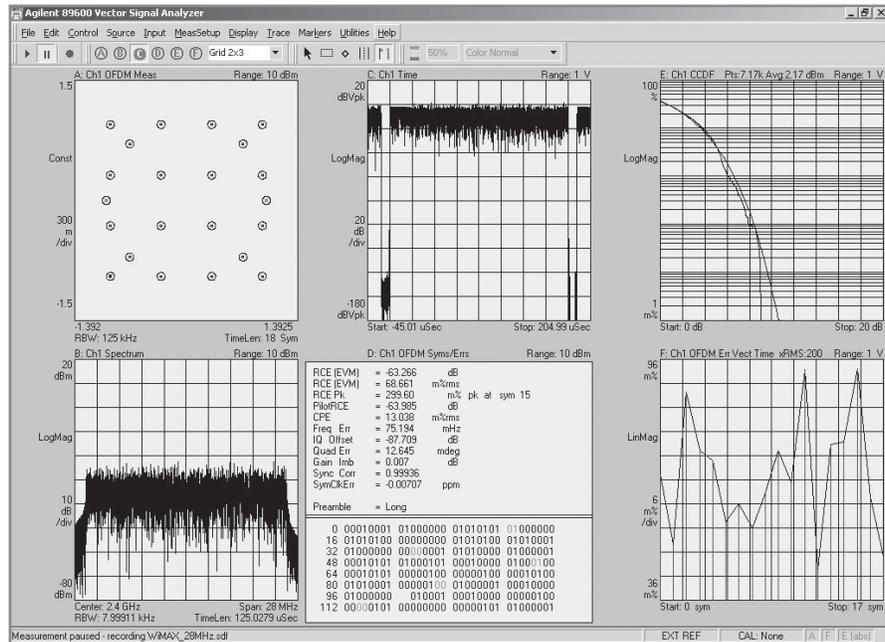


Figure 34. Familiar and new tools combine to provide invaluable troubleshooting information. Here the six displays simultaneously show (l to r) I-Q constellation, time, CCDF, spectrum, modulation error summary, and error vector vs. time.

Agilent is the industry leader in base band, RF, and modulation quality measurements for IEEE 802.16-2004 OFDM signals. Whether your measurements are on base band, IF or RF signals, or even simulated signals from ADS design simulations, the 89600 VSA software with Option B7S has the tools you need to troubleshoot your designs today.

Analyzing OFDM signals requires developers like you to think in the time and frequency domains simultaneously. You need OFDM-specific signal analysis tools to help you manipulate and break down the signal in order to effectively troubleshoot the situation. The 89600 vector signal analysis software helps you do this quickly and efficiently.

First, Option B7S provides comprehensive coverage of the IEEE 802.16-2004 standard:

- All IEEE 802.16-2004 modulation formats, including BPSK, QPSK, 16QAM, and 64QAM
- TDD, FDD, and H-FDD
- Uplink and downlink
- Bursted and continuous
- All frame lengths, guard intervals, and sampling factors
- Demodulation down to the raw bit level

Second, the software allows you to set up and adjust the demodulator for the best analysis of your signal.

- Automatically detect the signal modulation type on sub-carriers. You can also manually override the auto-detect feature for specific troubleshooting needs.
- Manually adjust the nominal signal bandwidth, guard interval, and sampling factor (Fs/BW ratio). Standard guard interval and sampling factors are provided.
- Adjust carrier pilot tracking to track amplitude, phase, or timing and identify errors that automatic pilot tracking can hide. These errors can cause you to inadvertently lower design margins.
- Verify your signal setup using the burst information provided—a text table conveniently shows burst power, modulation format, burst symbol length, and EVM.

The software also provides a wide range of error analysis measurements and displays. These include traditional spectrum analysis measurements such as:

- Band power
- Carrier-to-noise
- Peak-to-average power (CCDF)
- Amplitude
- Group delay

OFDM- and IEEE 802.16-2004 specific measurements

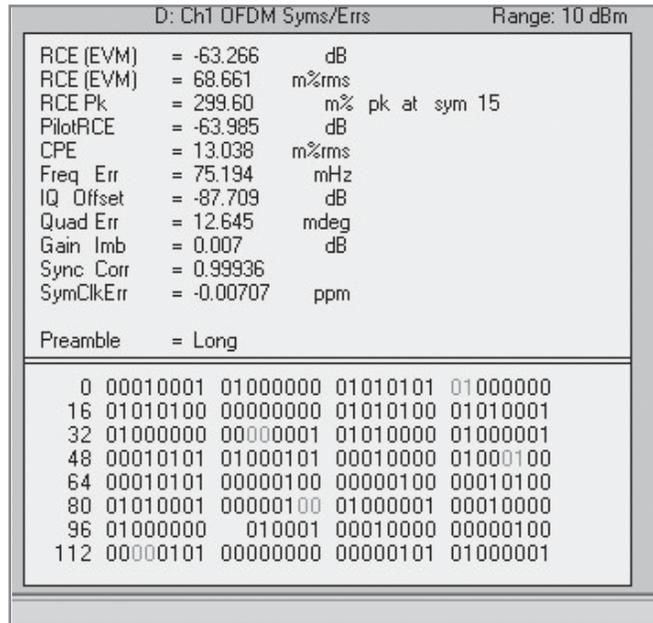


Figure 35. The modulation error analysis screen provides a wealth of information. Note that the RCE is provided in dB and %. The lower half of the display provides demodulated (encoded) bits. The pilot tones are shown in lighter colors. The error summary table also includes RCE for the pilot tones alone.

New measurements specifically for OFDM and more specifically for IEEE 802.16-2004 signals include:

- Relative constellation error (RCE) in % or dB
- RCE vs. symbol number
- RCE vs. sub carrier number
- Equalizer frequency and impulse response
- Error vector spectrum/time, including RMS error vector
- Quadrature skew, gain imbalance, I-Q offset
- Frequency error
- Symbol clock error
- Common pilot error (CPE)

In addition, these tools let you analyze your signal selectively by time or frequency for troubleshooting and uncovering problems that you've never been able to see before.

For instance, with the demodulation off, use time gating markers to analyze the desired portions of the time trace or spectrum of the signal, e.g., the short training signal, signal estimation sequences, signal symbol, etc. You can apply many other measurements to the time-gated area. This is especially useful when making measurements like peak to average power, when you may want to measure only the data portion of the burst, since including the timing and estimation sequences can bias the value lower.

- Focus your modulation analysis to a subset of the symbols, i.e., time-selective analysis.
- Focus your modulation analysis on just a single carrier, i.e., frequency-selective analysis. By viewing the constellation for just one carrier, you can determine if an interferer is internally generated or coming from outside the system.

IEEE 802.16 OFDMA Modulation Analysis (Option B7Y)

The IEEE 802.16 OFDMA PHY layer structure is the most complex structure for wireless networking. Option B7Y provides an advanced and comprehensive tool set to evaluate and troubleshoot signaling format. These tools work together to simplify analysis complexity for even the challenging Mobile WiMAX™ Wave 2 features.

Comprehensive tool kit

Option B7Y provides analysis of:

- PUSC, OPUSC, FUSC, OFUSC, AMC zones, including dedicated pilot option for PUSC and AMC beamforming
- Uplink and downlink
- All bandwidths from 1.25 MHz through 28 MHz
- All FFT sizes from 128 to 2048
- DL-PUSC signals using 2-antenna matrix A or B transmission schemes for STC/MIMO
- UL-PUSC signals containing data bursts with collaborative spatial multiplexing (SM) enabled
- CDMA ranging regions to aid with troubleshooting network entry
- IQ impairment compensation allows RCE measurements to be made even in early design phases or prior to calibration
- Downlink signals employing Cyclic Delay Diversity (CDD)

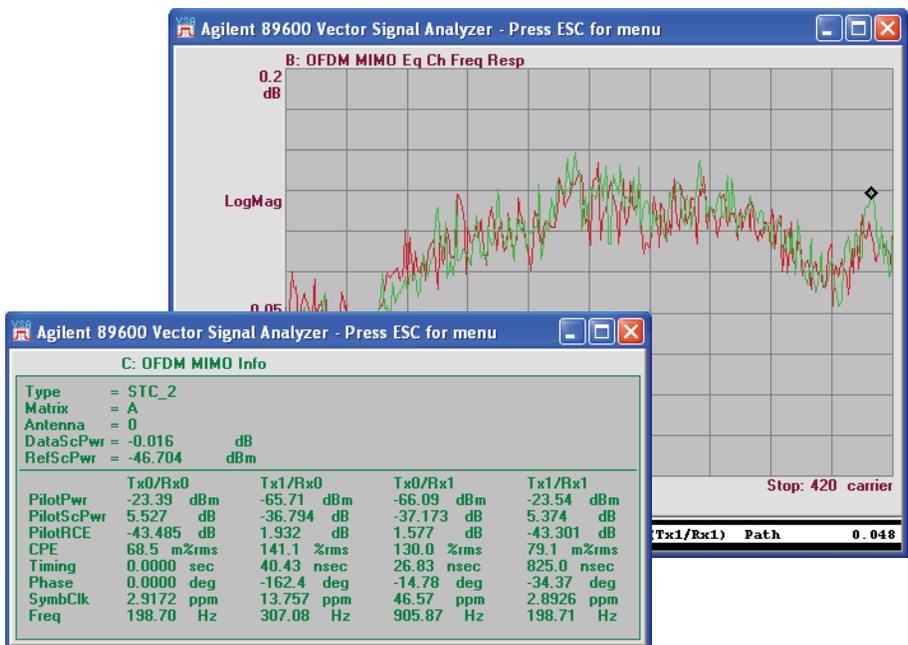


Figure 36. Detailed MIMO information is available for each Tx/Rx path in both tabular and graphical formats.

STC/MIMO measurements

Analyze DL-PUSC single-channel matrix A and B antenna 1 signal format transmissions, or use 2-channel analysis hardware to analyze 2-antenna matrix A and 2-antenna matrix B signals providing WiMAX STC/MIMO features. See the channel frequency response, equalizer impulse response, and common pilot error for each antenna. Other per-antenna path metrics, like power and pilot RCE, are displayed on a separate **MIMO Info** summary trace. Option B7Y decodes the MIMO DL Enhanced IE so that the software can auto-configure the measurement setup.

The software is designed to make WiMAX RCT testing easier. For instance, make DL-PUSC MIMO measurements even on single input channels where no preamble or non-MIMO zones exist. This can reduce the cost of making certain MIMO BTS transmission RCTs called out by the WiMAX forum. And the software's ability to make measurements even when slots are allocated but unused make it useful for analyzing and comparing signal profiles often used at WiMAX plugfests. Finally, the software can display the total power in a data burst as specified in several WiMAX RCTs.

Option B7Y supports the sophisticated transmission modes for BTS transmitters. For instance, you can use the DL-PUSC dedicated pilots mode to make RCE measurements for beamforming BTS transmitters. And a new cyclic delay diversity metric is provided on the selected input channel for BTS transmissions using CDD.

Advanced WiMAX features include collaborative spatial multiplexing (SM). Collaborative SM is a method where two independent mobile stations simultaneously transmit on the same subchannels at the same time. The base station extracts the data from each mobile station using MIMO channel separation techniques. The 89600 VSA software can analyze UL-PUSC signals from a single transmitter containing data bursts with collaborative SM enabled. See information on the transmission mode detected such as power, RCE, and data RCE.

Complex signals, easy-to-use analysis tools with auto-configuration

The 89600 VSA's OFDMA tools work together to simplify the complex analysis challenge presented by Mobile WiMAX.

Option B7Y can automatically decode the DL-MAP to provide dynamic auto-configuration of complex downlink signals, including those using MIMO/STC support. Even uplink signals for most Mobile WiMAX default profiles can be decoded to provide auto-configuration. Configurations decoded from downlink signals can be copied to user MAP Files in order to more easily analyze the signal, or to share signal configuration information with colleagues.

Measurement results are color coded by data burst, where appropriate. You can look at the compound constellation of a multi-burst data zone and tell at a glance if your data bursts are using the modulations you programmed. You are able to go to the error vector time display and easily determine which data burst an EVM spike belongs to.

The same works with the error vector spectrum display. Other analyzers make you move back and forth between measurements looking at symbol times and logical sub-carrier numbers to get the information you need, while Agilent uses color to simplify and streamline your analysis task. You can also couple markers across multiple displays to 'walk' through your signal and simultaneously look at its behavior in the time, frequency, modulation, and error domains.

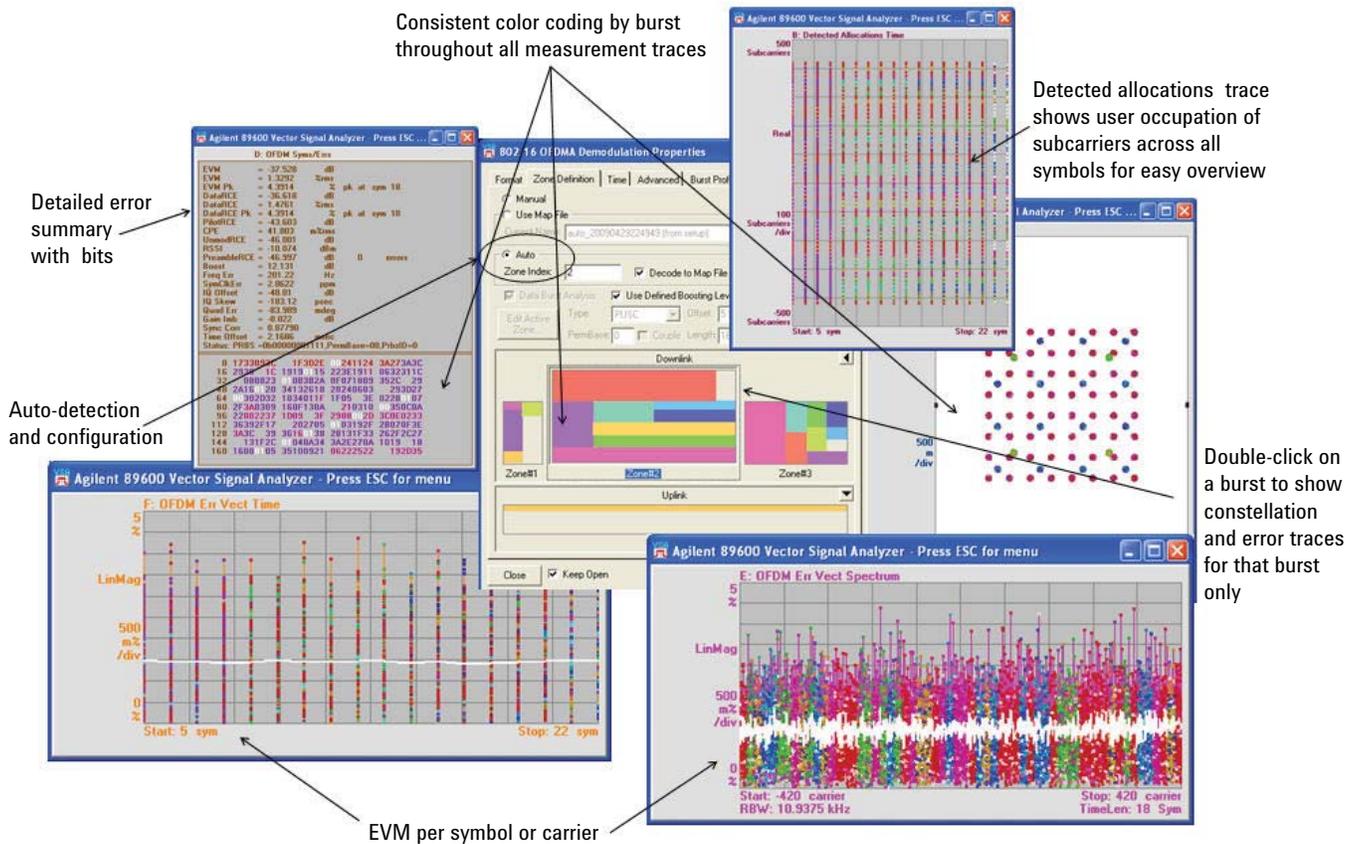


Figure 37. Use auto-detection or manually adjust a wide range of set-up parameters for troubleshooting. Color-coding throughout eases data interpretation, and 6 simultaneous user-selected displays let you choose the information that is important to you.

TEDS Modulation and Test (Option BHA)

Perform modulation analysis and standards-based tests for TETRA enhanced data service (TEDS) signals. Measurements include ACP power versus time, composite reference power, peak frequency error, sub-carrier reference power, and more.

Option BHA demodulator parameters are user-definable, giving you the ability to customize the analyzer to measure and analyze non-ideal signals. User-definable parameters allow you to choose from four TEDS slot formats (normal downlink, normal uplink, random access uplink, and control uplink), three quadrature amplitude modulation (QAM) types (4 QAM, 16 QAM, 64 QAM), and four channel bandwidths (25 kHz, 50 kHz, 100 kHz, and 150 kHz).

For measurement and analysis, you can display traces for the composite signal (including error summaries) and traces for selected sub-carriers (such as constellation diagrams). Additional demodulation parameters let you adjust for search length and what to include for error vector magnitude (EVM) errors (such as header symbols, droop, and pilot tracking). Development parameters include filter alpha, time scale factor, and mirror frequency spectrum.

The Option BHA TEDS test adds five individual TEDS tests, within two test groups, to your vector signal analyzer software, including:

Spectrum tests group

- Occupied bandwidth (OBW) test
- Adjacent channel power (ACP) test

Modulation tests group

- Modulation quality test
- Power versus time (PvT) test
- Adjacent channel power versus time (ACP PvT) test

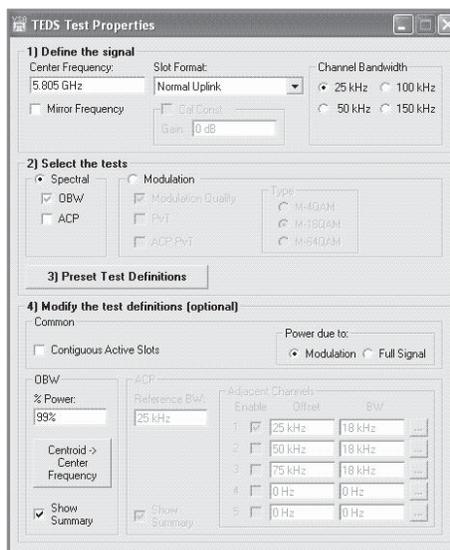


Figure 38. Define your TEDS test parameters with an easy-to-use menu setup. A test properties menu lets you set test parameters, select the test, preset test definitions, and even modify the test definitions if desired. Step-by-step configuration procedures are provided for each of the five TEDS tests. In addition, the test presets are defined for each of these tests.

MB-OFDM ultra-wideband modulation analysis (Option BHB)

Troubleshoot your WiMedia-based multi-band OFDM ultra-wideband PHY layer signals, such as those in certified wireless USB, with the industry's most complete set of easy-to-use measurement tools, providing you with an unparalleled view into your PHY layer signals. Use Option BHB running on the high performance Agilent DSO80000 Series oscilloscopes to help you identify the root causes of problems, sooner.

Supporting all time frequency codes (TFC), including FFI (non-hopped), and TFI and TFI2 (hopped) modes, Option BHB helps you analyze a wide range of formats, including QPSK modulation (utilized for data rates from 53.3 Mb/s to 200 Mb/s), and DCM (at data rates from 200 Mb/s to 480 Mb/s), and can automatically detect burst or standard preamble types.

For more detailed information on this option, including specifications, see *"Agilent 89600 Series VSA Software MB-OFDM Ultra-wideband Technical Overview and Self-Guided Demo,"* literature part number, 5989-5452EN for information on this and other Agilent products or go to www.agilent.com/find/vsascope.

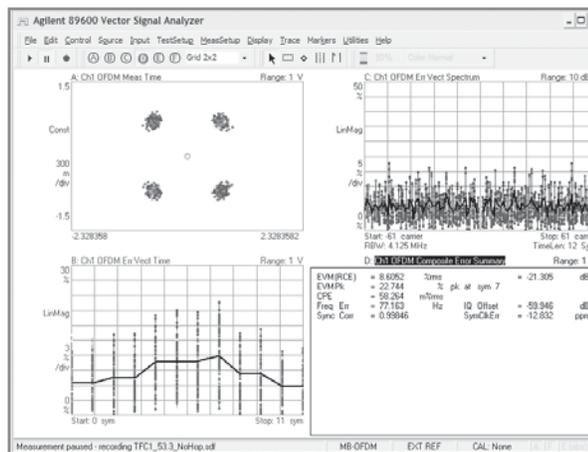


Figure 39. Option BHB MB-OFDM ultra-wideband modulation analysis offers detailed error analysis down to the individual carrier (Trace C, upper right) or individual symbol (Trace B, lower left). For an overall view, composite errors are shown in the table (Trace D, lower right).

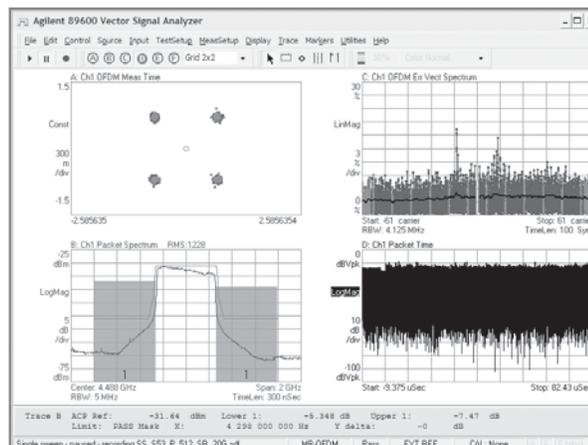


Figure 40. Use the powerful ACP calculation markers and limit lines on the packet spectrum displays to perform important spectral measurements.

RFID Modulation Analysis (Option BHC)

Use the powerful measurements and displays of the 89600 to troubleshoot RFID systems. Analyze both the forward (interrogator) and return (tag) signals of the popular EPCglobal Class 1 Generation 2, ISO 18092, ISO 14443 Types A and B, ISO 15693 and more. For other standards, you can use the built-in presets, or manually set the demodulation format, line coding, and bit rate or tari.

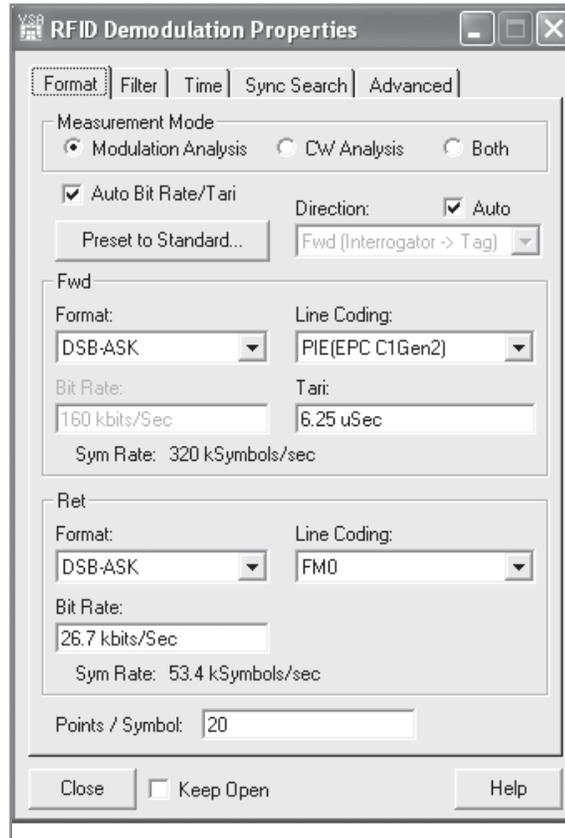


Figure 41. The demod properties format window provides a one-page easy setup of your RFID measurement. Use the preset to standard button, or individually configure the forward and return link's modulation format, line coding and bit rate or tari. As you change from analyzing a forward or return burst (via the burst index setting on the Time tab), these settings are automatically applied.

Measurement tables present detailed information on the CW interrogator signal, or a specified modulated burst. Time domain measurements, including burst overshoot/undershoot, burst turn on/off, rise/fall time and more are available for ASK-based systems. The interrogator-CW summary table provides similar information for the overall interrogator CW power up/down data. Finally, a burst summary table presents timing relationship information for all bursts detected in the acquisition block.

Measurements and displays, such as the error vs time trace, eye diagram, summary table, and spectrogram display formats provide a wealth of troubleshooting information, especially for interrogator designers using the new UHF frequencies.

The multitude of measurements and error information, combined with the ability to display any measurement anywhere you want on your screen, makes seeing what is happening with your signals at any point in time very easy.

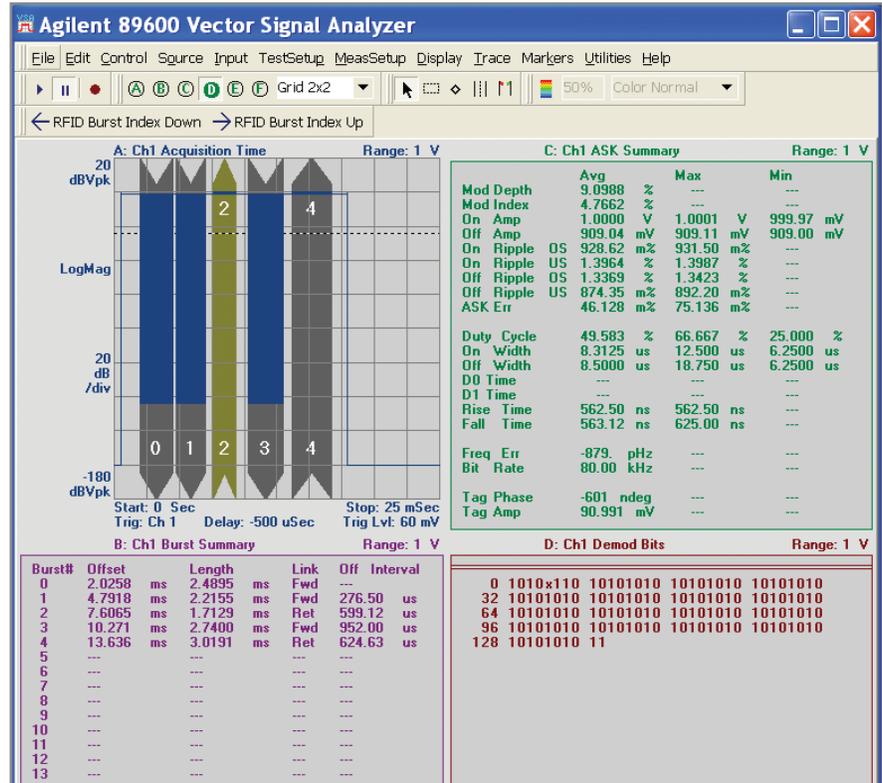


Figure 42. Option BHC RFID modulation analysis lets you analyze both interrogator and tag bursts. Up to 6 displays (4 shown here) provide both time error information and powerful modulation information. The user interface provides a visual identification of the link direction for each burst, as well as the selected burst for analysis. The RFID burst macro, provided, allows you to easily change the burst under analysis by pressing a key.

Tag amplitude measured from the RF envelope decreases and distorts as the phase of the tag gets close to 90 degrees. When the phase to CW is more than 90 degrees and amplitude is large enough, the tag signal distorts drastically as shown in Figure 43. Actual tag amplitude and its phase to CW provide the RFID system developer with some insight on this issue. Option BHC calculates the average tag phase to CW and tag amplitude and displays the results on the ASK summary table.

Add World-Class Vector Signal Analysis to Agilent Spectrum Analyzers, Oscilloscopes, and More (Option 300)

Link the 89600 VSA software to any one of a variety of Agilent instruments to sample your signal. Connection to the instruments is via GPIB, FireWire® (IEEE 1394), LAN, USB, or you can run it inside PC-based instruments. Choose the best instrument for your measurement, depending on the accuracy you need, or where in the block diagram you want to make measurements. For information on making measurements on design simulations, see the Option 105 and Option 106 sections which follow.

X-Series signal analyzers

PXA signal analyzer

Designed for the real world, Agilent's future-ready N9030A PXA signal analyzer's excellent measurement performance enables detailed analysis of complex signals, helps you enhance current designs, and accelerates future innovations.

MXA signal analyzer

The Agilent N9020A MXA signal analyzer provides the industry's fastest signal and spectrum analysis without compromising performance, offering the highest performance in a midrange analyzer. Bandwidths of either 10 MHz or 25 MHz are available. Baseband inputs allow ch1 + j ch2 analysis for all basic VSA time, frequency, and statistical measurements, as well as analog and digital demodulation. Two-channel measurements, like frequency response, cross-correlation, and coherence are also available.

Link two MXA analyzers together for 2-channel MIMO analysis. You can use an external PC, or run the VSA software embedded in one of the analyzers in a master-slave configuration.

EXA signal analyzer

Enhance yield and throughput with excellent speed and accuracy found in Agilent's N9010A EXA economy class signal analyzer. Combine the 10 MHz standard analysis bandwidth with versatile measurement capabilities found in the 89600 VSA software to reach new insights faster. Additionally, the Agilent EXA signal analyzer offers modern connectivity (LAN, USB 2.0, etc.) and an open Windows OS to attain and transfer test results quick and easily.

Use two EXA signal analyzers slaved together for cost-effective 2x2 MIMO analysis. You can use an external PC, or run the VSA software embedded on one of the analyzers in a master-slave mode.

CXA signal analyzer

The Agilent N9000A CXA is a versatile, low-cost tool for essential signal characterization that helps accelerate product testing and development on multiple levels: cost reduction, throughput, and design enhancement.

ESA-E Series spectrum analyzers

The ESA-E Series general-purpose, portable spectrum analyzers offer a wide range of performance, features, and flexibility with up to 26.5 GHz tuning range and 10 MHz of analysis bandwidth. Measurement control is via GPIB.

PSA Series high-performance spectrum analyzers

The Agilent PSA Series offers high performance spectrum analysis up to 50 GHz with powerful one-button measurements, a versatile feature set, a leading-edge combination of flexibility, speed, accuracy, dynamic range and up to 80 MHz of analysis bandwidth. Measurement control is via LAN, GPIB, or USB.

Wideband VSA System

Use the Agilent Infiniium scope and the Agilent E4440A Series performance spectrum analyzer to provide 300 MHz wide bandwidth vector signal analysis to 50 GHz center frequency. The PSA down converts input signals with 3.0 GHz to 50 GHz center frequency to an IF output frequency of 321.4 MHz. The IF signal is then digitized by the Infiniium scope. The 89600 VSA software, running on an external PC or embedded within the Infiniium scope, provides the analysis engine. Broadband calibration over the 300 MHz bandwidth is possible using an external source such as Agilent's MXG, PSG or ESG. For more information, see *Wide Bandwidth Vector Signal Analysis Measurements*, literature publication number 5989-9053EN.

Infiniium scopes

Combine the software with Agilent's Infiniium oscilloscopes (many models) to analyze super wide bandwidth signals. The oscilloscopes provide up to 13 GHz of analysis bandwidth and are well suited to digitizing down-converted satellite, LMDS, and MMDS signals, as well as WiMedia-based UWB or other extremely broadband signals. Multi-channel Infiniium scopes can also make the coherent 2-, 3-, or 4-channel MIMO measurements needed for IEEE 802.11n or LTE MIMO analysis, or 2-channel Mobile WiMAX measurements. User-selectable coupling of channels lets you set many scope setup parameters for one channel and copy them across to all the others for easy setup of multi-channel analysis. The digitized signals are transferred via GPIB, USB, or LAN to the PC running the 89600 software where the frequency, time, and modulation analysis tools of the 89600 VSA can be used to evaluate and troubleshoot the signal. For convenience, the 89600 VSA software can run internal to many of the Infiniium models. For complete information on supported Infiniium models, plus operational information, see the *Infiniium Oscilloscopes Performance Guide Using 89600 Vector Signal Analyzer Software*, literature publication number 5988-4096EN.

InfiniiVision scopes

The low price of Agilent InfiniiVision oscilloscopes combined with the measurement flexibility of the 89600 VSA software creates a powerful and affordable tool. Choose from a range of input channels, bandwidth and memory depth. Multi-channel basic vector signal analysis measurements and dual I+jQ analysis with InfiniiVision scopes is possible with models supporting 2-4 channels. For complete information on supported InfiniiVision models, plus operational information, see the *InfiniiVision Series Oscilloscopes Performance Guide Using 89600 Vector Signal Analyzer Software*, literature publication number 5989-4523EN.

Agilent Acqiris digitizers

Choose from the Acqiris product family of 6U PXI/Compact PCI standard digitizers with up to 12 bit, 100 MHz bandwidth or 10 bit-3 GHz bandwidth. The 89600 VSA software supports both 1- and 2-channel configurations. For more information, see the *Agilent Acqiris Broadband High-Speed Digitizers Using 89601A Vector Signal Analyzer Software*, literature publication number 5989-7672EN.

N4010 wireless connectivity test set

The N4010 is a test set designed to quickly and accurately measure emerging wireless connectivity formats in the 2.4 and 5 GHz bands. The N4010 offers bandwidth selections of up to 40 MHz, making the N4010 an ideal test platform for *Bluetooth*, including EDR Tx/Rx, WLAN, and ZigBee measurements. The N4010 with *Bluetooth* Option 101 is an effective measurement tool for development, integration, pre-qualification, and volume manufacturing.

Synthetic instruments

Agilent's synthetic instruments offer the highest-performing LAN-based modular instrumentation with the smallest footprint for automated test systems. The 89600 VSA software supports the N8201 26.5 GHz performance downconverter synthetic instrument module and the N8221 30 MS/s IF digitizer synthetic instrument module when they are used together to make an LXI (LAN extensions for instrumentation) spectrum analyzer.

Agilent logic analyzers: 16800/16900 or 1680/1690 Series or RDX

As the block diagrams of cellular, wireless networking, radar, and other systems utilizing digital modulation become more digital, analyzing the signal quality becomes more difficult. The Agilent 16800/16900 or 1680/1690 Series logic analyzers can send digital data harvested from these digital blocks to the 89600 VSA software. Then the software can interpret the data as digitized analog information for measurement and display of the signal using the wealth of tools available. No longer do you need to download data to homegrown math routines in order to check the demodulation or other signal parameters. Instead, you can take advantage of the 89600 software's consistent measurements and displays, as well as the same GUI with which your team has become familiar. Use your time to work on product design, not measurement design.

The VSA software can run in an external PC, or in the case of the Agilent 16900 Series logic analyzer, in the logic analyzer itself. For DigRF v4-specific analysis, link the 89600 VSA to the Agilent RDX analyzer. Set up your logic analyzer to collect the data, and then use the 89600 VSA software's measurements and displays to investigate the behavior of your signal before and after it transitions from digital to analog, or vice versa.

For information on using a logic analyzer and the 89600 VSA software to capture and analyze serial data, go to www.agilent.com/find/dvsa.

Multi-channel operation

The 89600 VSA software supports a wide range of hardware with multi-channel capability.

For platforms that support it, the software can take two inputs and combine them for I + jQ measurements, including baseband IQ. Cross-channel measurements, such as cross-spectrum, cross correlation, frequency response, or other 2-channel measurements are supported, as well as 2-channel VSA measurements. The 4-channel Infiniium and supported InfiniiVision scopes can make 4-channel VSA or dual I + jQ measurements.

Option B7Z IEEE 802.11n-HT provides 2x2, 3x3, and 4x4 MIMO measurements. For 2x2, 3x3, or 4x4 MIMO analysis, both the Infiniium and 6000/7000 InfiniiVision series of scopes are possible choices.

Option B7Y IEEE 802.16e OFDMA modulation analysis (Mobile WiMAX) supports 2x2 MIMO, and there is a wide range of hardware for this, including two MXA or EXA signal analyzers slaved together, the Infiniium and InfiniiVision series oscilloscopes and two logic analyzers for digital baseband analysis.

For 2x2 LTE MIMO analysis, you can use dual MXA/EXA signal analyzers for RF analysis. Two logic analyzers or RDX Test Solutions for Dig RF provide 2x2 digital baseband analysis.

Multi-channel analysis is also possible on design simulations using Option 105 Dynamic Link to Agilent EEsof ADS/SystemVue design simulation software, or using Option 106 with The MathWorks Simulink designs.

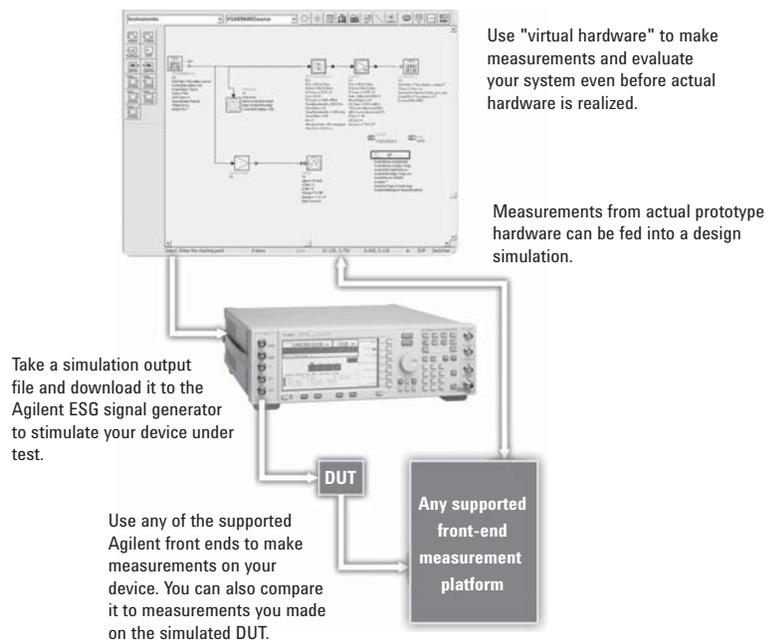
Agilent Connected Solutions (Option 105, Dynamic Link to Agilent EEsaf ADS/ SystemVue)

The powerful, PC-based 89600 Series VSA software enables tight, interactive integration with Agilent EEsaf's advanced design system to analyze computational data from a simulation. Dynamically link the 89600 software to any point in the digital model to analyze data by simply dragging the VSA icon to the desired spot in the schematic.

Since the VSA measurement software resides on a PC, it performs equally well analyzing measured data from the VXI mainframe or computational data produced by an ADS model.

You can record measured or computed data from ADS/SystemVue with the 89600 Series software and play it back for further analysis. All of the software features and functionality are available to make measurements on your design simulations.

"Virtual hardware" — uncover system problems before hardware even exists



Link real-world signals acquired by the 89600 to the ADS/SystemVue simulation to provide an actual signal environment for your designs.

With Option 105, you can substitute simulation results for real DUT measurements, or provide real hardware measurements as data input to simulations.

With connected solutions instrument links, you can use ADS/SystemVue simulation results to create signals and output them via the Agilent ESG signal generator. Use this to provide a signal source to your prototype hardware. This is useful when a) the signal type involves a new standard or modulation format; b) when you want to understand what changes to the previous hardware design stage imply to the next; or c) when one hardware stage is physically realized before others are available. Once it physically exists, hardware can be measured with the 89600 VSA software connected to a supported measurement platform, and compared to the simulation if desired.

Conversely, you can measure the output of real prototype hardware with the 89600 VSA, and use it to provide a source signal to a simulation. This is useful when you want to provide a source signal that is based on actual measurements on physical hardware.

Use this mix and match of simulated and measured results to evaluate your system – even with missing hardware.

Dynamic link to The MathWorks Simulink Simulation and Model-Based Design software (Option 106)

Gain the power of the 89600 VSA measurements and displays for Simulink-based designs with Option 106.

This option provides a VSA block set designed to work with Simulink tool sets and block sets. Use the VSA sink to accept data from the simulation, and then process and display it using the wealth of features and functionality in the 89600 VSA software.

The VSA source allows you to accept measured data from Agilent test equipment, and then feed it into the Simulink design. Like other front-ends to the VSA software, you can record and playback simulated signal output for additional analysis at a later time.

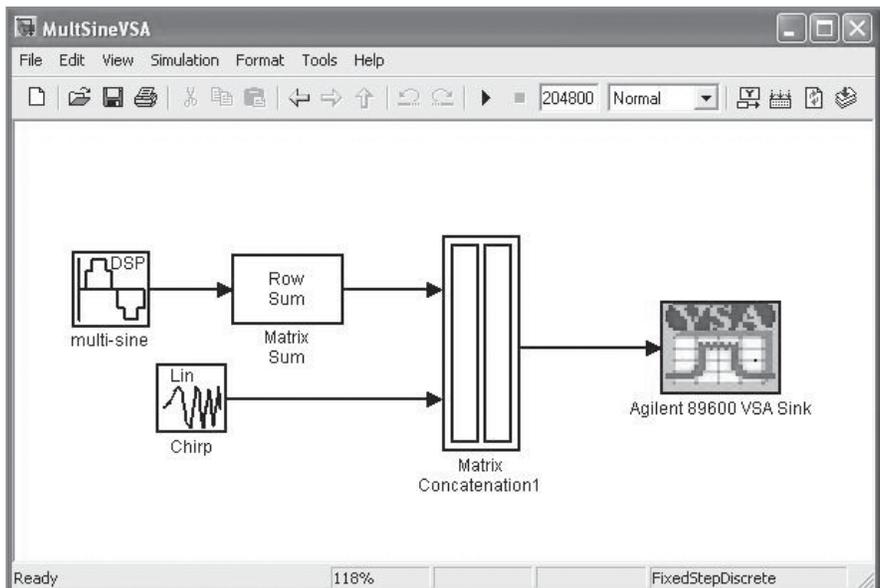


Figure 43. Block sets for a VSA source and sink, plus multiple example designs (demos) are provided with Option 106.

Optimize Your Resources with Flexible Licensing Capability

Take advantage of Agilent's flexible licensing capability for the 89600 Series vector signal analysis software. A software license is the key that unlocks the powerful measurement capability of the 89600 software on your PC.

Floating, node-locked, and limited term license are available, depending on your need. Let us help you choose the type of licensing that offers you the best value for your measurement needs.

Node-locked license (89601A)

Whether in the office or away, with node-locked licensing your software will always be ready to run. Install the license key directly on your PC, and your software is activated regardless of your network connectivity.

- Collect data in the lab and perform the analysis anywhere with your portable PC.
- Take your results with you to show to colleagues and engineering partners.
- Easily move your measurement hardware and software around the office.
- Your software license may be moved from one PC to another via floppy disk or LAN.

Your permanent node-locked license includes 12 months of software update subscription service. You may purchase an additional 12 months at initial order.

Floating license (89601AN)

Floating license capability allows many users to share licenses. A license installed on the license server is available to any PC that is connected to the network. The standard license server is a PC, and may be the same PC running the VSA software. Install the software on as many PCs as you like, and the number of licenses that reside on the network determines the number of users at any moment.

Floating licenses are a cost-effective method for sharing resources. Users can choose which options to check out, leaving other analysis options available for other users. When one user exits the software, all checked-out licenses return and become available for another user. Permanent floating licenses facilitate sharing of software so you can:

- Reduce cost by getting more usage from fewer licenses.
- Maximize the use of each software license.
- Increase productivity with all users operating the software from their own PC.

Floating licenses are ideal when working with design environments such as Agilent's EEsof advanced design system (ADS) design tools, and for development environments where the data is taken in one lab and analyzed in another.

One year of software update subscription service is included, and you can purchase an additional year at your initial order. Remember to order Option 200 (Basic VSA) in sufficient quantity to accommodate all users simultaneously accessing the 89601AN VSA software, as well as Option 300 (Hardware Connectivity) for those users who will be connecting the VSA to physical hardware.

Limited term floating license (89601N12)

Agilent also offers a 12-month limited term floating license. If your need is temporary, you can acquire this limited term license to operate the software at a significant cost savings.

This license is valid for 12 months and includes all the benefits of a floating license, all software options, and 12 months of software update subscription service.

Software update subscription service (89601AS/89601ASN)

Keep your software up-to-date with the software update subscription service. As a major new version of software becomes available, subscribers will automatically receive feature enhancements and bug fixes. Some new releases include new options available for order. The only way to get access to those new options and features is to be a software update subscriber. You will receive the new software CD, along with new licenses authorizing access to the new software revision license level.

All new orders for 89600 VSA software include a full year of update service, and you can add an additional year. Use the 89601AS (for fixed licenses) or 89601AN (for floating licenses) to renew your update subscription after your initial service expires. Order your update subscription service for the number of months you need, typically twelve, with a maximum of twenty-four months.

Running Your Software

The 89600 Series vector signal analysis software runs on either a desktop or laptop PC and is connected to the supported hardware front ends via LAN, GPIB, LAN/GPIB gateway, a USB/GPIB converter, USB, or an IEEE 1394 (FireWire) interface, depending on the hardware selected. When used to analyze Agilent EEsof ADS design simulations, of course, the software resides on the same PC as ADS. In some cases, for example X-Series signal analyzers, plus certain Infiniium scopes and logic analyzer models, the software can run on the instrument's internal computer.

You can use your own PC as long as it meets the requirements outlined in the "User-supplied PC requirements" section of this guide. Some hardware configurations allow you to purchase a laptop PC from Agilent. See the hardware selection guide for more information.

Windows XP Pro and Vista Business, Enterprise, or Ultimate operating systems are currently supported.

Help in Getting Started

Take advantage of Agilent's worldwide organization of trained specialists to help you get up and running quickly. They can help you with the many new and advanced features of the 89600 software and supported linked hardware.

We highly recommend that you unleash the full potential of the software by ordering the 1-day start up assistance.

Also recommended is additional phone service support with the remote productivity assistance.

For application-based training, Agilent provides specialized classes on digital radio troubleshooting, WLAN, and more.

Finally, your Agilent technical consultant will be happy to talk to you about your additional custom training needs.

Ordering Information

89601A

Vector signal analysis software with node-locked licensing

Note: For initial purchases including Option 200, a discount item, D12, will be applied to provide a discount corresponding to 1 year of software update service.

Options

Option 200 required

89601A-200	Basic vector signal analysis software
89601A-012	12 months bundled software update subscription service (qualifies for 12 month discount)
89601A-024	24 months bundled software update subscription service (qualifies for 12 month discount)
89601A-300	Hardware connectivity (required for use with hardware front ends; not required for analysis only, or for use with Opt 105 or Opt 106)
89601A-AYA	Flexible modulation analysis
89601A-B7N	3G modulation analysis bundle
89601A-B7T	cdma2000/1xEV-DV modulation analysis
89601A-B7U	W-CDMA/HSPA modulation analysis
89601A-B7W	1xEV-DO modulation analysis
89601A-B7X	TD-SCDMA modulation analysis
89601A-B7R	WLAN modulation analysis
89601A-B7S	IEEE 802.16-2004 OFDM modulation analysis
89601A-B7Y	IEEE 802.16 OFDMA modulation analysis
89601A-B7Z	IEEE 802.11n modulation analysis
89601A-BHA	TETRA modulation analysis and test
89601A-BHB	MB-OFDM ultra-wideband modulation analysis
89601A-BHC	RFID modulation analysis
89601A-BHD	LTE FDD modulation analysis
89601A-BHE	LTE TDD modulation analysis
89601A-105	Dynamic link to EEsof ADS/SystemVue
89601A-106	Dynamic link to The MathWorks Simulink Model-Based Design

Ordering Information *(continued)*

89601AN

Vector signal analysis software (floating license for 1 server)

Note: For initial purchases including Option 200, a discount item, D12, will be applied to provide a discount corresponding to 1 year of software update service.

Options

Note: multiple quantities of one option may be ordered per each server. Option 200 required. Every user must have Option 200, so the maximum quantity of any option may not exceed the quantity of Option 200. For multiple servers, order additional 89601AN.

89601AN-012	12 months bundled software update subscription service (qualifies for 12 month discount)
89601AN-024	24 months bundled software update subscription service (qualifies for 12 month discount)
89601AN-200	Basic vector signal analysis software
89601AN-300	Hardware connectivity (required for use with hardware front ends; not required for analysis only, or for use with Opt 105 or Opt 106)
89601AN-AYA	Flexible modulation analysis
89601AN-B7N	3G modulation analysis bundle
89601AN-B7T	cdma2000/1xEV-DV modulation analysis
89601AN-B7U	W-CDMA/HSPA modulation analysis
89601AN-B7W	1xEV-DO modulation analysis
89601AN-B7X	TD-SCDMA modulation analysis
89601AN-B7R	WLAN modulation analysis
89601AN-B7S	IEEE 802.16-2004 OFDM modulation analysis
89601AN-B7Y	IEEE 802.16 OFDMA modulation analysis
89601AN-B7Z	IEEE 802.11n MIMO modulation analysis
89601AN-BHA	TEDS modulation analysis and test
89601AN-BHB	MB-OFDM ultra-wideband modulation analysis
89601AN-BHC	RFID modulation analysis
89601AN-BHD	LTE FDD modulation analysis
89601AN-BHE	LTE TDD modulation analysis
89601AN-105	Dynamic link to EEsof ADS/SystemVue
89601AN-106	Dynamic link to The MathWorks Simulink Model-Based Design

Ordering Information *(continued)*

89601N12 Vector signal analysis software, 12-month limited-term package floating license for 1 server; includes 1-year software update subscription.

Options *Required. Multiple 801 options may be ordered per server.
For multiple servers, order additional 89601N12*

89601N12-801 Twelve-month floating license software package including VSA software options -200, -300, -105, -106, -AYA, -B7N, -B7R, -B7S, -B7Y, -B7Z, -BHA, -BHB, -BHC, -BHD, -BHE

89601AS Additional software update subscription service

Notes *Renewal orders only. (Use Opt -012 or -024 for initial orders containing Opt 200).
Twelve-month minimum required. Twenty-four-month maximum coverage, total.
Go to www.agilent.com/find/vsaupdate for descriptions of actual product and option structure.*

89601ASN Software update subscription service for 1 server (floating license)

Notes *Renewal orders only. (Use Opt -012 or -024 for initial orders containing Opt 200).
Twelve-month minimum required. Twenty-four month maximum coverage, total.
Go to www.agilent.com/find/vsaupdate for descriptions of actual product and option structure.*

Free Trial

Get a free, 2-week trial of all options for the 89600 VSA software.

Go to www.agilent.com/find/89600 and click on the free 14 day trial. Follow the instructions to download the software and experience the power of the 89600 VSA firsthand.

Product Upgrades

You may order any of the options after purchase. Depending on your software revision, purchase of 1-year 89601AS/ASN software update subscription service may be required. Because of this, when purchasing an upgrade, please indicate to your sales representative that you are doing so and provide your current software revision level.

Product Support and Training

Agilent provides both product-specific and application training, as well as specialized consulting services. Of particular interest are the following:

PS-S20-01	One day of start-up assistance (recommended)
PS-S10	Phone assistance (six hours recommended)
PS-T10-896xx	89600 users' course
PS-T11-896xx	Digital radio troubleshooting
PS-T12-896xx	Wireless LAN technology fundamentals
R1362A-250	VSA wireless LAN measurements

The 89600 users' course and W-LAN technology fundamentals are classes available on-site at your location. The VSA wireless LAN measurements and productivity assistance products are consulting services tailored to your needs.

User-Supplied PC Requirements

The 89600 VSA runs on a PC, either desktop, laptop or in an instrument. The following are the minimum requirements for a user-supplied PC. For best immunity to electrostatic discharge (ESD), use a desktop PC.

Operating System	Microsoft Windows XP Professional, Service Pack 2	Microsoft Windows Vista Business, Enterprise, or Ultimate	Microsoft Windows Windows 7 Business or Enterprise or Ultimate
CPU	600 MHz Pentium® or AMD-K6 > 600 MHz (> 2 GHz recommended)	1 GHz 32-bit (x86) (> 2 GHz recommended)	1 GHz 32-bit (x86) (> 2 GHz recommended)
RAM	512 MB (1 GB recommended)	1 GB (2 GB recommended)	1 GB (2 GB recommended)
Video RAM	4 MB (16 MB recommended)	128 MB (512 MB recommended)	128 MB (512 MB recommended)
Hard disk	1 GB available	1 GB available	1 GB available
Additional drives	CD-ROM to load the software; license transfer requires network access or a USB memory stick	CD-ROM to load the software; license transfer requires network access or a USB memory stick	DVD reader to load software; license transfer requires network access or a USB memory stick
Interface support	LAN, GPIB, USB, or FireWire ¹ interface (VXI HW only)	LAN, GPIB, USB, or FireWire ¹ interface (VXI HW only)	LAN, GPIB, USB, or FireWire ¹ interface (VXI HW only)

1. For a list of supported IEEE-1394 (FireWire) interfaces, visit www.agilent.com/find/89600 and search the FAQ's for information on "What type of IEEE-1394 interface can I use in my computer to connect to the 89600S VXI hardware?"

Related Literature

89600 Vector Signal Analysis Software, Data Sheet, literature number 5989-1786EN

Hardware Measurement Platforms for the Agilent 89600 Vector Signal Analysis Software, Data Sheet, literature number 5989-1753EN

Using the 89600 VSA software with Infiniium Series Oscilloscopes, Application Note, literature number 5988-4096EN

Using the 89600 VSA software with Agilent InfiniiVision Oscilloscopes, Application Note, literature number 5989-4523EN

Agilent Acqiris Broadband High-Speed Digitizers Using 89600 Vector Signal Analysis Software, Application Note, literature number 5989-7672EN

89607A WLAN Test Suite Software, Technical Overview, literature number 5988-9574EN

89604A Distortion Suite Software, Technical Overview, literature number 5988-7812EN

Related Web Resources

For more information, visit: www.agilent.com/find/89600

www.agilent.com/find/vsascope for information on using 89600 VSA software with an oscilloscope

www.agilent.com/find/dvsa for information on using 89600 VSA software with a logic analyzer



Agilent Email Updates

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Get the latest information on the products and applications you select.



www.lxistandard.org

LXI is the LAN-based successor to GPIB, providing faster, more efficient connectivity. Agilent is a founding member of the LXI consortium.

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www.agilent.com/find/channelpartners

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Remove all doubt

Our repair and calibration services will get your equipment back to you, performing like new, when promised. You will get full value out of your Agilent equipment throughout its lifetime. Your equipment will be serviced by Agilent-trained technicians using the latest factory calibration procedures, automated repair diagnostics and genuine parts. You will always have the utmost confidence in your measurements. For information regarding self maintenance of this product, please contact your Agilent office.

Agilent offers a wide range of additional expert test and measurement services for your equipment, including initial start-up assistance, onsite education and training, as well as design, system integration, and project management.

For more information on repair and calibration services, go to:

www.agilent.com/find/removealldoubt

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus

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United States	(800) 829-4444

Asia Pacific

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China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Thailand	1 800 226 008

Europe & Middle East

Austria	43 (0) 1 360 277 1571
Belgium	32 (0) 2 404 93 40
Denmark	45 70 13 15 15
Finland	358 (0) 10 855 2100
France	0825 010 700*
Germany	49 (0) 7031 464 6333
Ireland	1890 924 204
Israel	972-3-9288-504/544
Italy	39 02 92 60 8484
Netherlands	31 (0) 20 547 2111
Spain	34 (91) 631 3300
Sweden	0200-88 22 55
Switzerland	0800 80 53 53
United Kingdom	44 (0) 118 9276201

Other European Countries:

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