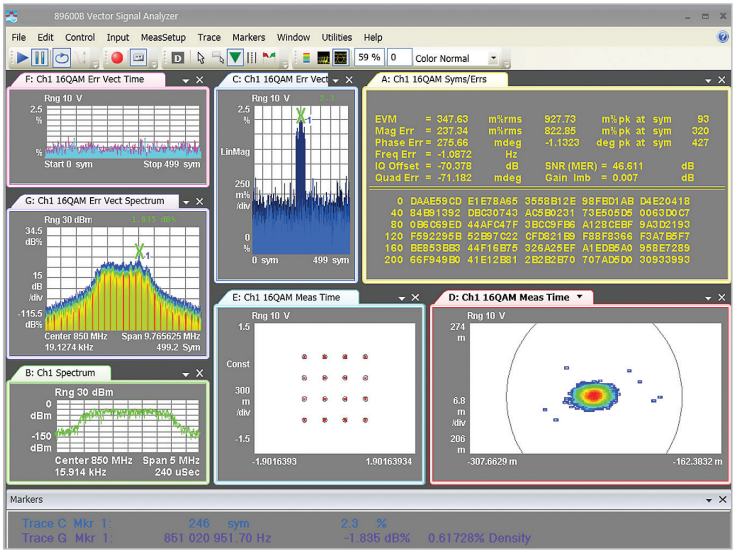
Keysight 89601B/BN-AYA
Vector Modulation Analysis
89600 VSA Software

Technical Overview



Key Features

- Over 35 digital modulation formats, including PSK, QPSK, QAM, FSK, VSB, custom APSK, SOQPSK
- Over 15 standard communication formats, including GSM/EDGE/EDGE Evolution, Wi-SUN, ZigBee, *Bluetooth*®
- Troubleshoot signals using modulation error analysis tools: EVM, IQ errors, and more
- Identify linear errors with adaptive equalization
- Automate tests with SCPI or .NET programmability

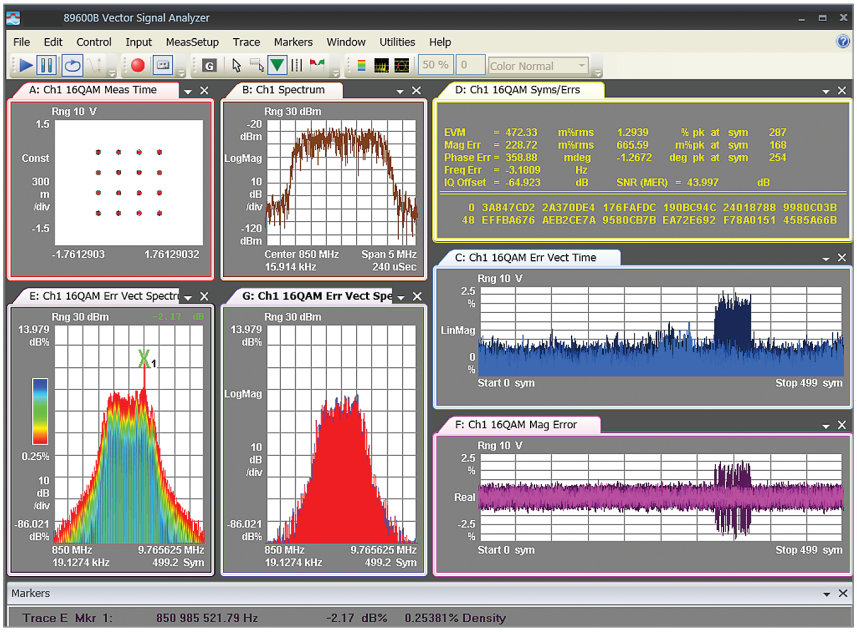
KEYSIGHT TECHNOLOGIES

Flexible Vector Modulation Analysis

Option AYA is designed to analyze a wide range of digital modulations and standards including types as simple as BPSK or as complex as 4096 QAM, with presets for many cellular, wireless networking, and digital video standards as well. Flexible measurement parameter setup, powerful error analysis, including EVM, and insightful displays help explain every aspect of a signal.

The many modulation types in Option AYA are just some of over 75 signal standards and modulation types supported by the 89600 VSA software. The 89600 VSA software is a comprehensive set of tools for demodulation and vector signal analysis. These tools enable you to explore virtually every facet of a signal and optimize your most advanced designs. As you assess the tradeoffs, the 89600 VSA helps you see through the complexity.

If you want more flexibility on digitally modulated signal analysis, consider Option BHK (custom IQ modulation analysis) on 89600 VSA software. This additional option enables longer symbol length analysis capability with fully customized IQ map for signal quality measurements.



Option AYA's error measurements combined with insightful displays highlight and identify even transient anomalies for a wide range of modulation formats.

Technology overview

Vector modulation, also referred to as digital or complex, refers to modulation where both amplitude and phase are used simultaneously to carry information on a signal. Common examples are BPSK, QPSK, QAM and their many derivative forms.

Because they use two dimensions to carry information, these systems can transmit more data over the same bandwidth, making them more spectrally efficient. However, this comes at the cost of increasing complexity in system design, test, and build.

Versatile tools are needed to deal with the many inventive ways vector modulation is used. Both phase and amplitude must be acquired and analyzed. The modulation format and symbol rate used are specific to the application, and numerous transmit and receive filter designs exist to minimize spectral splatter.

Try before you buy!

Download the 89600 software and use it for 30 days to make measurements with your analysis hardware, or use our recorded demo signals which are available by selecting File› Recall › Recall Demo › QPSK (or QAM, DTV, APSK, Zigbee) on the software toolbar. Request your free trial license today:

www.keysight.com/find/89600_trial

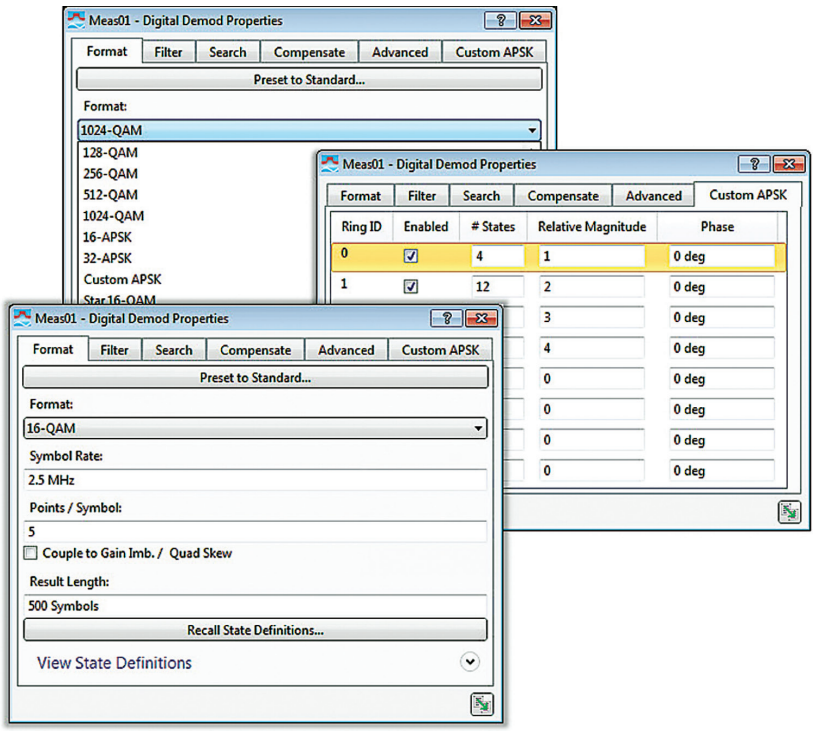
Analysis and Troubleshooting

Complex modulation formats require modern tools for troubleshooting. Option AYA provides a rich set of fl exible vector modulation displays, useful for everything from examining simulations to measuring prototype hardware's results output. In all cases, error measurements help track down the source of problems in a signal.

Advanced digital demodulators

Successfully demodulate a signal knowing just the carrier frequency, filter type, and symbol rate; no need for external filtering, coherent carrier signals or symbol-clock timing signals.

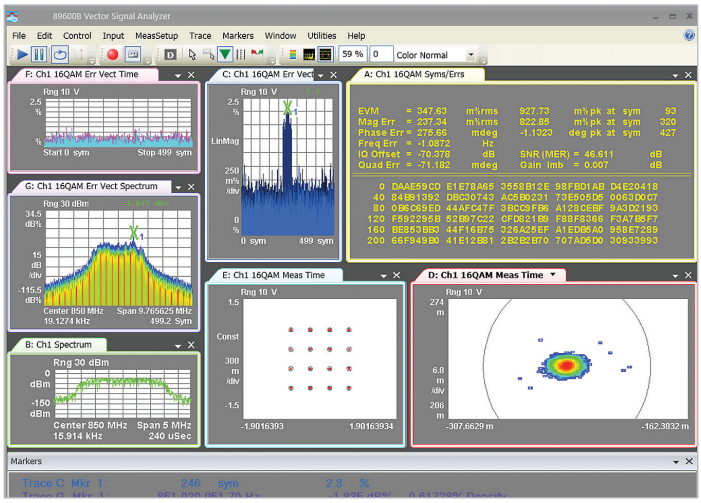
Use the custom APSK capability to analyze signal types like on-off keying, 64 APSK as well as non-standard formats. Define a custom constellation based on up to 8 arbitrarily spaced rings and up to 256 points.



Flexible digital demodulation lets you adjust many important modulation parameters, and customize your own APSK signal analysis

Unique error analysis tools

Reveal both RF and DSP problems using error vector magnitude (EVM), error vector spectrum and adaptive equalization.

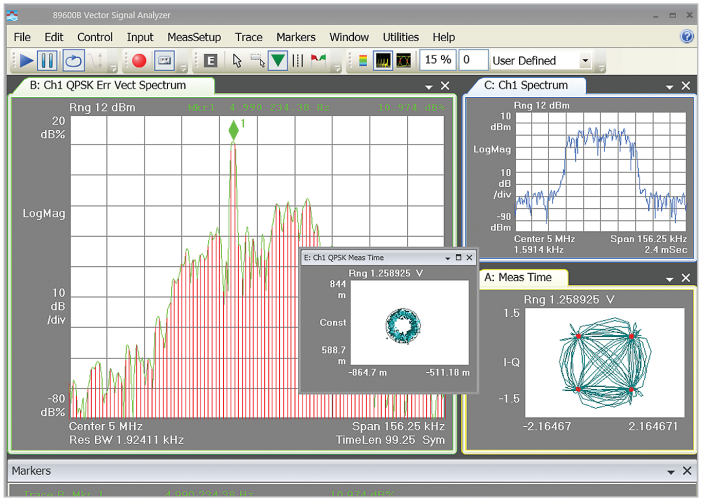


Unlimited traces, with unlimited markers, may be displayed simultaneously, each sized to meet your needs.

Error vector magnitude

Pinpoint marginal conditions before they become system performance problems using the powerful EVM analysis tool.

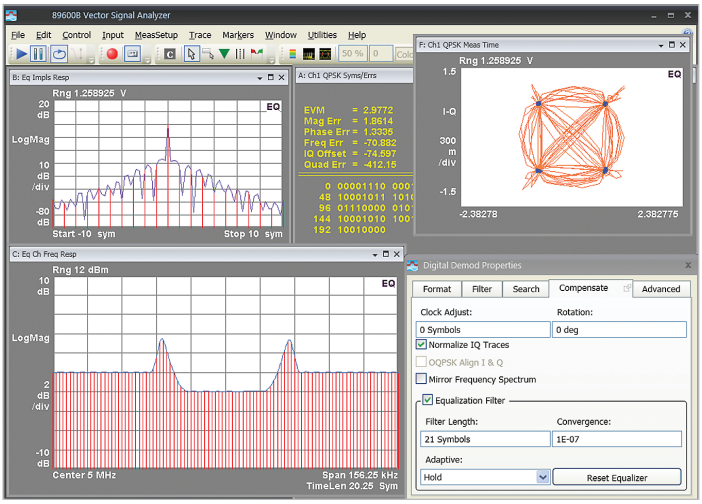
- Compare the phase and magnitude of the input signal with an ideal reference signal stream
- View the average error as a single overall number, or on a symbol-by-symbol basis
- Use the EVM time or spectrum measurement to identify systematic impairments not visible otherwise



The EVM spectrum measurement shows an interfering signal coupling in from another part of the circuit.

Adaptive equalization

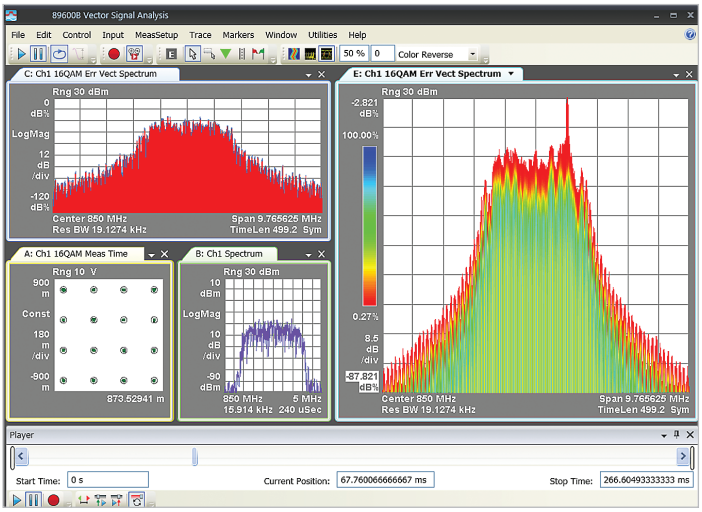
Identify and remove linear errors such as group delay distortion, frequency response errors, and reflections or multi-path distortion from I-Q modulated signals. Uncover DSP errors such as mis-coded bits or incorrect filter coefficients.



The equalizer channel frequency response is used to evaluate multi-path effects, and its impulse response coeffi cients are available for download. When running the equalizer, the Demod Properties window remains conveniently visible for access to the Run/Hold control during tuning.

Save and recall signals for more effective troubleshooting

Capture a signal for later analysis or for comparison with later design iterations. Even if a production line across the world suddenly fails important tests, or you're working with remote design teams, you can analyze the vector signal using Option AYA tools by recording the signal and re-analyzing at your convenience. A player window provides detailed access to the recording. You can also use the stop/play buttons on the main toolbar.



Save a signal and re-analyze it later with the Option AYA tools. Here, the spectrum and constellation appear to be fine. Even the EVM spectrum (trace C) is fine. But the cumulative history display of the EVM spectrum (trace E), which can highlight signal performance over >500 hours, detects a transient error.

Software Features

Signal setup

Signal acquisition	
Number of input channels supported	2, plus dual ch1 + jch2
Carrier lock	Internally generated
Triggering	Single/continuous, external, pulse search (searches data block for beginning of TDMA burst and performs analysis over selected burst length)
Supported data formats	
Carrier types	Continuous, pulsed (burst, such as TDMA)
Modulation formats[1]	FSK: 2, 4, 8, 16 level (including GFSK) MSK (including GMSK) Type 1, Type 2, CPM, BPSK, QPSK, OQPSK, DQPSK, D8PSK, π/4DQPSK, SOQPSK, 8PSK, 3π/8 8PSK (EDGE); π/8 D8PSK; QAM (absolute encoding): 16, 32, 64, 128, 256, 512, 1024, 2048, 4096; QAM (differential encoding per DVB standard): 16, 32, 64, 128, 256; Star QAM: 16, 32; APSK: 16, 16 w/DVB, 32, 32 w/DVB; VSB: 8, 16; custom APSK
Data block length[1]	10 to 4,096 symbols, user adjustable
FSK deviation reference	Frequency deviation reference value for FSK signals (automatic or manual)
Samples per symbol	1 to 20, user adjustable
Symbol clock	Internally generated
Maximum symbol rate	Frequency span/(1 + α) (maximum symbol rate doubled for VSB modulation format). Symbol rate is limited only by the measurement span; that is, the entire signal must fit within the analyzer's currently selected frequency span.
State definitions	Recalls state definitions for the current demod format from a .CSD state definitions file; editor available as well.
Single button pre-sets	**EDGE Evolution analysis and pre-set available as separate mode**
Cellular	CDMA (base), CDMA (mobile), CDPD, EDGE, GSM, NADC, PDC, PHP (PHS), W-CDMA
Wireless networking	BluetoothTM, HiperLAN1 (HBR), HiperLAN1 (LBR), IEEE 802.11b, Wi-SUN (IEEE 802.15.4g), ZigBee 868 MHz, ZigBee 915 MHz, ZigBee 2450 MHz
Digital video	J.83A/DVB-C, J.83B/DOCSIS, J.83C/ISDB-C, DVB-S2 16APSK, DVB-S2 32APSK, ATSC, ATSC-M/H
Other	APCO 25, APCO-25 P2 (HCPM), APCO-25 P2 (HDQPSK), DECT, TETRA, VDL mode 3 MIL-STD 188-181C:CPM (Option 21), SOQPSK-TG (IRIG 106-04)

Filtering

Filter types	Raised cosine, square-root raised cosine, IS-95 compatible, Gaussian, EDGE, low pass, rectangular, half-sine (reference filter only, for use with ZigBee), none, user defined, 1REC, 3RC, EDGE (Windowed RC), SOQPSK-TG
Filter length	40 symbols: VSB (any filter α); QAM, DVB-QAM, BPSK, QPSK, DQPSK, 8-PSK, D8PSK, 16-APSK, 16-APSK w/DVB, custom APSK (filter α < 0.4) 30 symbols: Star 16-QAM, Star 32-QAM, CPM, SOQPSK (any filter α); Offset QPSK (low SNR mode) 20 symbols: all other cases
User-selectable alpha/BT	Continuously adjustable from 0.05 to 10
User-defined filters	Maximum 40 symbols in length or 801 points when alpha < 0.4, maximum 20 symbols or 401 points otherwise

1. For more flexibility with format and longer symbol length, consider Option BHK (custom IQ modulation analysis).

Search parameters

Pulse search	Defined search length in ms or symbols
Constellation synch search	User-selected synchronization words, plus ability to edit search pattern
Search offset	Determines the location of result length within search length

Compensate

Clock adjust	Determines when the analyzer's digital demodulator samples the I/Q trajectory
IQ normalize	Turns normalization on/off; when on, the analyzer normalizes or scales the demodulated trace data results to a nominal value of 1
Mirror frequency spectrum	Allows correct demodulation of frequency spectrums that are mirrored (flipped) about the center frequency
OQPSK align I & Q	On/off; OQPSK only
EVM normalization reference	Allows selection of the normalization value for certain error summary metrics from default Constellation Maximum to Reference RMS
Adaptive equalization	**Removes linear errors from modulated signals by dynamically creating and applying a FIR (feed-forward) compensating filter**
Type	Decision directed, LMS, feed forward, equalization with adjustable convergence rate
Filter length	Sets the length of the analyzer's equalization filter; 3-99 symbols, odd values only
Filter taps	1,2, 3, 4, 10 or 20 taps/symbol
Convergence	Determines the rate at which the equalization filter converges
Run/hold	"Run" reshapes the equalization filter after each subsequent measurement; "hold" keeps the filter at the current values
Reset equalizer	Resets the equalization filter to a unit impulse response
Measurement results provided	Equalizer impulse response, channel frequency response
Supported modulation formats	All supported modulation formats, except FSK and GSM/EDGE/EDGE Evolution

Advanced

APSK ring ratios	Sets ring ratios for DVB 16 APSK and 32 APSK formats
CPM auto {h1,h2}	Sets the value of the modulation indexes, H1 and H2, for CPM signals
StarQAM R2/R1	Determines the Ring 2 to Ring 1 ratio for StarQAM format measurements
Low SNR enhancement	Enables additional filtering of the frequency and phase estimates during the synchronization part of demod for many digital demod formats

Custom APSK

Signals	Defined by constellation states on concentric rings (ex. on-off keying, high-order PSK)
Parameters	Maximum of 256 states arranged on up to 8 concentric rings

GSM/EDGE/EDGE Evolution setup provided as part of Option AYA

Standard supported	· 3GPP TS 45.912
	· 3GPP TS 45.001
	· 3GPP TS 45.002
	· 3GPP TS 45.003
	· 3GPP TS 45.004
	· 3GPP TS 45.005
	· 3GPP TS 51.021
GSM/EDGE/EDGE Evolution format	
Preset to standard	Sets default format parameters; manual setting available
Burst type	Sync (SCH); Normal (TCH & CCH); HSR (TCH &CCH); Mixed (NB/HB); Access (RACH)
Burst sync mode	Training Seq (TSC); RF Amp; Polar Mod; None
TSC Index	Auto select or Manual, 0-7
Modulation scheme	Auto select or Manual: GMSK, 8PSK (EDGE), 16QAM, 32QAM, HSR QPSK, HSR 16QAM, HSR 32QAM
Discard non-matching slots	Yes, no
HSR pulse shape filter	Narrow, wide; only for HSR, Access bursts
GSM/EDGE/EDGE Evolution time	
Search length	Length of time acquired by the analyzer over which pulse search is performed; sec or slots
Time slot	Auto select or manual, 0-7
GSM/EDGE/EDGE Evolution advanced	
Normal symbol rate	Specifies the symbol rate for normal (not HSR) signals
High symbol rate	Specifies the symbol rate for HSR signals
Burst search threshold	Specifies the relative threshold from the peak power level, which is used to determine the burst rising and falling edges
IQ constellation type	Determines constellation displayed: meas filtered only; meas and complementary filtered; derotated meas and complementary filtered

Measurement results Not including GSM/EDGE/EDGE Evolution

Pre-demodulation (vector) trace results	
Auto-correlation	Correlation of a signal with itself
CCDF	Complementary cumulative density function
CDF	Cumulative density function of the measurement data used for demodulation
Correction	Displays frequency domain correction applied to raw measured time data
Gate Time	Portion of the main time-record to be used by the FFT function
Instantaneous main time	Entire time record used by the FFT function, without averaging
Instantaneous spectrum	Frequency spectrum of time trace; always un-averaged
Main time	Time record used by the FFT function
PDF	Probability density function
PSD	Power spectral density showing the power density of a signal as a function of frequency
Raw main time	Block of time data acquired by the hardware, including additional time samples for filter settling, with no time-domain corrections or re-sampling
Spectrum	Frequency spectrum of the time trace, including any averaging selected
Marker	Shows detailed summary tables of occupied bandwidth (OBW) or adjacent channel power (ACP) data of selected trace
Demod trace results	**Not including FSK**
Channel frequency response	Frequency response of adaptive equalizer on the given channel
Correction	Correction curve used to correct for the frequency response of the input hardware and input digital filtering
Eq impulse response	Impulse response of the adaptive equalizer
Error vector spectrum	Spectrum of the error vector time trace after windowing and FFT are applied
Error vector time	Difference between the IQ measured vector time and the IQ reference vector time
Instantaneous error vector spectrum	Unaveraged error vector spectrum trace
Instantaneous IQ meas spectrum	Unaveraged IQ measured spectrum trace
Instantaneous IQ ref spectrum	Unaveraged IQ reference spectrum trace
Instantaneous spectrum	Unaveraged spectrum trace
IQ mag error	Error between the magnitude of the measured IQ measured signal and the magnitude of the reference signal
IQ meas spectrum	Spectrum of the IQ Meas Time trace
IQ meas time	IQ data results for the measured input signal
IQ phase error	Error between the phase of the measured IQ measured signal and the phase of the reference signal
IQ ref spectrum	Frequency spectrum of the IQ Ref Time trace
IQ ref time	IQ data results that would have been derived for the ideal input signal
Offset EVM	Included on symbols/error table for offset QPSK only
Raw main time	Raw data read from the input hardware or playback file without time corrections or resampling
Search time	Acquired time data used to search for analysis timeslot
Spectrum	Averaged Instantaneous Spectrum derived from time data that has been windowed and passed through an FFT
Symbols/Errors	Table including demodulated symbol bits and summary error table containing digital modulation error information specific to each format
Time	Time record before digital demodulation and after pulse search

Measurement results FSK

FSK measurement	Time, spectrum
FSK reference	Time, spectrum
Carrier error	Magnitude
FSK error	Time, spectrum

Measurement results GSM/EDGE/EDGE Evolution

CCDF	Complementary cumulative distribution function for the active part of burst
CDF	Cumulative distribution function for the active part of burst
Correction	Correction data derived by the analyzer from the calibration
Error vector time	Error vector trace data results for each symbol
Instantaneous spectrum	Displays unaveraged frequency spectrum of the time trace data
IQ magnitude error	Magnitude error between the measured and reference IQ signals
IQ measured time	Result of resampling the data to an integer number of points per symbol and applying carrier/symbol locking, IQ origin offset and optional amplitude droop compensation, system gain normalization, and filtering to the input signal
IQ phase error	Phase error between the measured and reference IQ signals
IQ reference time	Data that would be derived from an ideal input signal (reference signal
PDF	Normalized probability density function histogram of the active part of the burst
Raw main time	Raw data read from the input hardware or playback file before time corrections and resampling, but including filter settling time
Search time	Shows time-data before pulse search and demodulation
Spectrum	Averaged frequency spectrum of the data from the time trace; derived from pre-demodulated time data, which is 25% longer than the timeslot that is demodulated
Subchannel A symbols	Raw data bits for each symbol in subchannel A
Subchannel B symbols	Raw data bits for each symbol in subchannel B
Summary	Error summary table show EVM, IQ errors, frequency errors, AM/PM skew, and more
Symbols	Table containing raw data bits for each symbol where the first bit in the table corresponds to the first bit of the first symbol in the demodulated timeslot
Time	Time data of the slot that was demodulated
Marker	Shows detailed summary tables of occupied bandwidth (OBW) or adjacent channel power (ACP) data of selected trace

Display formats

The following trace formats are available for measured data and computed ideal reference data, with complete marker and scaling capabilities and automatic grid line adjustment to ideal symbol and constellation states.

Polar diagrams	
Constellation	Samples displayed only at symbol times
Vector	Display of trajectory between symbol times with 1 to 20 points/symbol
I-Q versus time	
I or Q only	Continuous versus time
Eye diagram	Adjustable from 0.1 to 40 symbols
Trellis diagram	Adjustable from 0.1 to 40 symbols
Error vector magnitude	Continuous versus time
Errors table	Measurements of modulation quality made automatically and displayed by the symbol/error trace type. RMS and peak values.
Formats other than FSK	Error vector magnitude, magnitude error, phase error, frequency error (carrier offset frequency), I-Q/origin offset, amplitude droop (PSK and MSK formats), SNR (8/16 VSB, 8PSK and QAM formats), quadrature error, gain imbalance For VSB formats: VSB pilot level is shown in dB relative to nominal. SNR is calculated from the real part of the error vector only. For DVB formats: EVM is calculated without removing IQ offset
FSK format	FSK error, magnitude error, carrier offset, frequency deviation, frequency deviation offset, zero crossing error, symbol clock error
Symbols table (detected bits)	
Table information	Bits are displayed in binary and grouped by symbol. Multiple pages can be scrolled for viewing large data blocks. The symbol marker (current symbol shown in inverse video) is coupled to measurement trace displays to identify states with corresponding bits. For modulation formats other than DVBQAM and MSK, bits are user-definable for absolute or differential symbol states.[1]

1. Synchronization words are required to resolve carrier phase ambiguity in non-differential modulation formats

Key Specifications[1]

This technical overview provides nominal performance specifi cations for the software when making measurements with the specified platform. Nominal values indicate expected performance, or describe product performance that is useful in the application of the product, but is not covered by the product warranty.

For a complete list of specifications refer to the appropriate measurement platform specifications guide.

X-Series signal analyzers

Accuracy		**PXA**	**MXA**	**EXA**	**CXA**	**BBIQ[2]**
Conditions	Modulation formats include BPSK, D8PSK, DQPSK, QPSK, (16/32/64/128/256/512/1024)QAM, (16/32/64/128/256)DVBQAM, π/4-DQPSK, 8-PSK. EVM normalization reference set to Constellation Maximum. Transmit filter is Root Raised Cosine with alpha=0.35. Center frequency 1 GHz. Signal amplitude of -16 dBm, analyzer range set to -10 dBm. Result length set to at least 150 symbols, or 3×{Number of ideal state locations}. RMS style averaging with a count of 10. Phase noise optimization adjusted based on symbol rate of measurement. Available span dependent on analyzer hardware bandwidth options.					
Residual errors	Symbol Rate/Span					
Residual EVM	1 Msps/5 MHz	≤ 0.5% rms	≤ 0.7% rms	≤ 0.7% rms	≤ 0.7% rms	≤ 0.5% rms
	10 Msps/25 MHz	≤ 0.5% rms	≤ 0.7% rms	≤ 0.7% rms	≤ 0.9% rms	≤ 0.5% rms
	25 Msps/40 MHz	≤ 0.7% rms	≤ 1.1% rms	≤ 1.1% rms	–	≤ 0.6% rms
	100 Msps/160 MHz	≤ 1.0% rms	≤ 1.3% rms	–	–	–
Magnitude error	1 Msps/5 MHz	≤ 0.4% rms	≤ 0.5% rms	≤ 0.5% rms	≤ 0.5% rms	≤ 0.5% rms
	10 Msps/25 MHz	≤ 0.5% rms	≤ 0.5% rms	≤ 0.5% rms	≤ 0.6% rms	≤ 0.5% rms
	25 Msps/40 MHz	≤ 0.6% rms	≤ 0.8% rms	≤ 0.8% rms	–	≤ 0.6% rms
	100 Msps/160 MHz	≤ 0.9% rms	≤ 1.0% rms	–	–	–
Phase error	1 Msps/5 MHz	≤ 0.5° rms	≤ 0.6° rms	≤ 0.6° rms	≤ 0.7° rms	≤ 0.6° rms
	10 Msps/25 MHz	≤ 0.6° rms	≤ 0.6° rms	≤ 0.6° rms	≤ 0.8° rms	≤ 0.6° rms
	25 Msps/40 MHz	≤ 0.6° rms	≤ 1.1° rms	≤ 1.1° rms	–	≤ 0.6° rms
	100 Msps/160 MHz	≤ 1.0° rms	≤ 1.3° rms	–	–	–
Frequency error	Added to frequency accuracy if applicable	≤ Symbol Rate / 500,000				
I-Q/ origin offset[2]		≤ -60 dB				
Accuracy						
Conditions	Modulation formats include MSK and MSK2. Transmit filter is Gaussian with BT=0.3. Center frequency 1 GHz. Signal amplitude of -16 dBm. Analyzer range set to -10 dBm. Result length set to 150 symbols. RMS style averaging with a count of 10. Available span dependent on analyzer hardware bandwidth options.					
Residual errors	Symbol Rate/Span					
Residual EVM	10 Msps/25 MHz	≤ 0.5% rms	≤ 0.9% rms	≤ 0.9% rms	≤ 1.0% rms	≤ 0.8% rms
	80 Msps/160 MHz	≤ 1.4% rms	≤ 1.8% rms	–	–	–
Phase error	10 Msps/25 MHz	≤ 0.4° rms	≤ 0.5° rms	≤ 0.5° rms	≤ 0.5° rms	≤ 0.5° rms
	80 Msps/160 MHz	≤ 1.3° rms	≤ 1.3° rms	–	–	–

1. Data subject to change.
2. I+jQ measurements performed using signal amplitude and analyzer range near 0 dBm, with a 0 Hz center frequency. I/Q origin offset metric does not include impact of analyzer DC offsets.

	PXA	MXA	EXA	CXA
Video modulation formats				
Residual EVM 8/16 VSB	Symbol rate = 10.762 MHz; alpha = 0.115; frequency < 3.6 GHz; 7 MHz span, full-scale signal, range ≥ –30 dBm, result length = 800, averages = 10			
	≤ 1.5% (SNR ≥ 36 dB)			
Residual EVM 16, 32, 64, 128, 256, 512, or 1024 QAM	Symbol rate = 6.9 MHz; alpha = 0.15; frequency < 3.6 GHz; 8 MHz span, full-scale signal, range ≥ –30 dBm, result length = 800, averages = 10			
	≤ 1.0% (SNR ≥ 40 dB)	≤ 1.0% (SNR ≥ 40 dB)	≤ 1.0% (SNR ≥ 40 dB)	≤ 1.0% (SNR ≥ 36 dB)

	PXA	MXA	EXA	CXA
GSM/EDGE/EDGE Evolution mode formats				
Accuracy	Signal within 2 dB of full scale signal range; span = 1 MHz; RMS averages = 20			
EVM	≤ 0.25%	≤ 0.5% (≤ 0.4%) [1]	≤ 0.5% [2]	≤ 0.5%
Frequency accuracy	≤ 0.5 Hz	≤ 1 Hz (≤ 0.2 Hz) [1]	≤ 1 Hz [2]	≤ 1 Hz
Frequency accuracy	± 400 kHz	± 400 kHz (± 400 kHz) [1]	± 400 kHz [2]	± 400 kHz

1. MXA Option BBA result.
2. Results valid for EXA with Option B25.

Additional Resources

Literature

89600 Vector Signal Analysis Software, Brochure, 5990-6553EN

89600 Vector Signal Analysis Software, Configuration Guide, 5990-6386EN

89601B/BN-200 Basic VSA and -300 Hardware Connectivity, Technical Overview, 5990-6405EN

Digital Modulation in Communications Systems – An Introduction, Application Note, 5965-7160EN

89601B/BN-BHK Custom IQ Modulation Analysis, Technical Overview, 5991-4221EN

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www.pxisa.org
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Italy	800 599100
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Netherlands	0800 0233200
Russia	8800 5009286
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