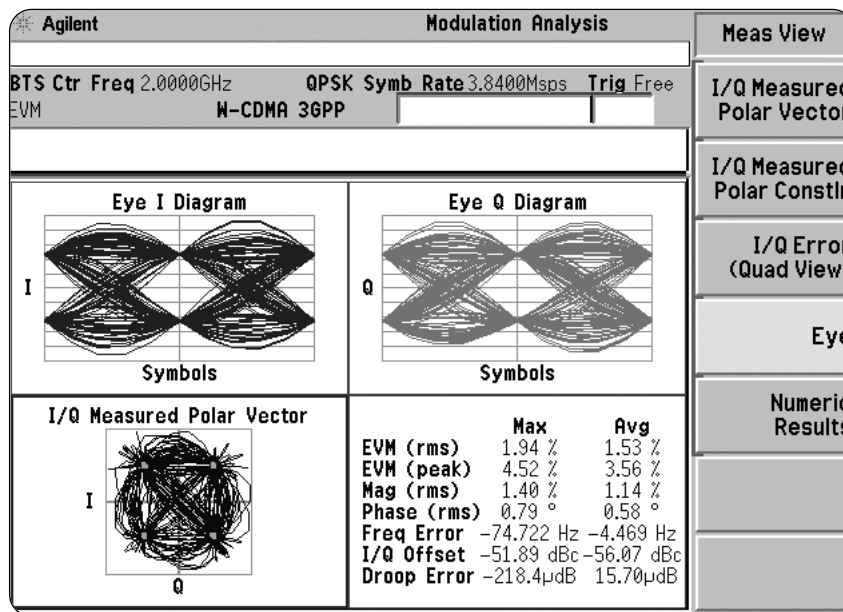# Agilent
Modulation Analysis Measurement Personality for the ESA-E Series Spectrum Analyzers

Product Overview

Now the ESA-E series spectrum analyzers can perform vector analysis of second-and third- generation digital communication systems, providing QPSK, EDGE (8PSK) and GSM (GMSK) error vector magnitude (EVM), related metrics, with eye and constellation diagrams. Take advantage of the link to the 89601A VSA software to realize flexible demodulation and analysis capability.

Agilent Technologies

Accurate, easy modulation analysis for designing, integrating, and troubleshooting advanced digital RF communication systems

As a cellular R&D engineer, you are under constant pressure to come up with reliable, efficient products that meet the specifications defined by second- and third-generation (3G) cellular communications standards. As a result of this moving 3G target, you are in need of many pieces of equipment to address your measurement needs.

The Agilent ESA-E series spectrum analyzers (E4402B, E4404B, E4405B, and E4407B models only) with the modulation analysis measurement personality (Option 229) provide the flexibility of general-purpose spectrum analysis combined with the numerical and visual tools to help you quickly identify and quantify impairments to digitally modulated signals for all major cellular standards. Essentially, the ESA-E now provides you with spectrum and vector measurements in one measurement tool, thus reducing your need for additional equipment, preserving measurement accuracy, and minimizing system development time.

Multi-format modulation analysis

Vector modulation analysis can be performed on any signal that uses a QPSK, OQPSK, π/4 DQPSK, GMSK, or EDGE (8PSK) baseband modulation format. These include the following cellular standards:

- cdmaOne (IS–95 and J–STD–008)
- cdma2000 SR1
- W-CDMA (3GPP)
- NADC
- EDGE
- GSM
- PDC
- TETRA

Format-specific measurement setups

The ESA-E is based on softkey menus that enable you to easily navigate and quickly set up measurements for today's most popular cellular standards. The ESA-E's new modulation analysis measurement personality automatically sets up standard-specific configurations for the correct demodulation format, symbol rate, and measurement filter.
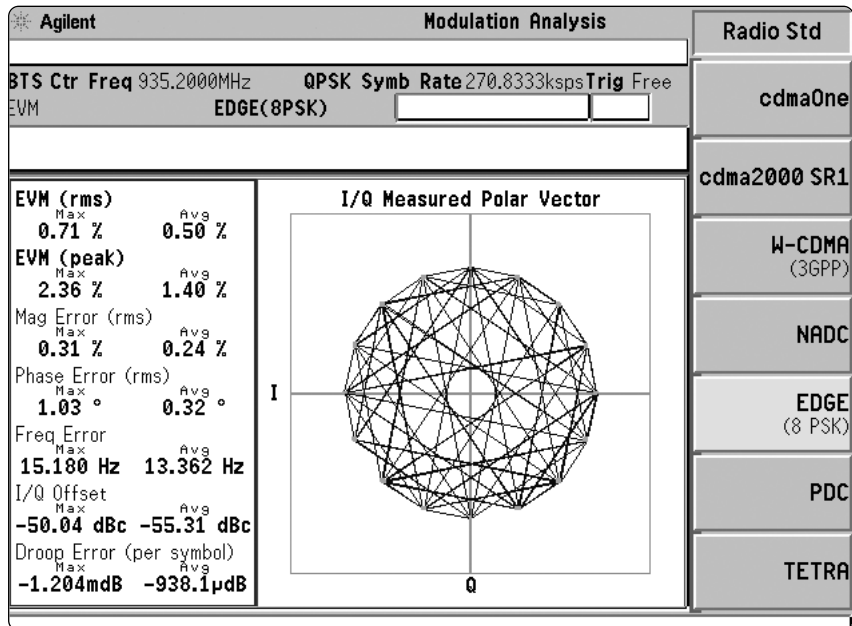

Figure 1. Convenient one-button selection for all of today's most popular cellular formats. The ESA-E provides standard-specific measurement configurations for modulation analysis.

User configurable

The ESA-E with modulation analysis does not require external filtering or coherent carrier signals — the filters and symbol rates defined by the communication standards are built-in. You can choose to alter the settings if the signal you are analyzing differs from a defined radio standard.
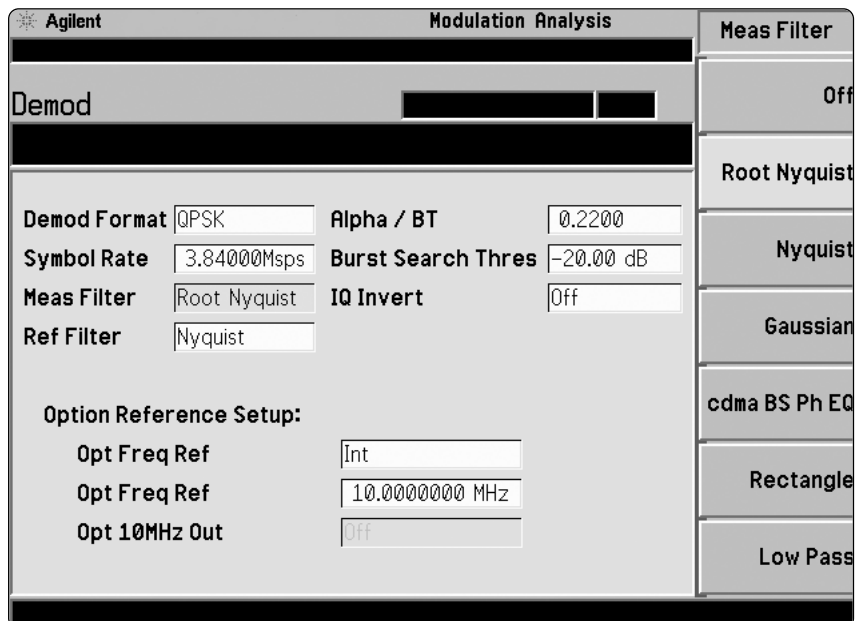

Figure 2. User configurable demodulation format, symbol rate, and filtering with the intuitive measurement-setup environment.

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Detect, quantify, and locate errors in a transmitted signal

It is useful to measure the signal being transmitted, but imagine the additional benefit of detecting, quantifying, and locating errors in the signal. The ESA-E's new modulation analysis measurement personality enables you to do just that.

• A variety of measurement displays help you detect the most common types of errors.

• A quantitative measure, available through the comprehensive results table, helps you define errors.

• A symbol dot feature helps you locate errors. Dots can be activated to identify the symbol locations in conjunction with traces — a pattern in the errors will help you pinpoint the cause of the error.

Detect baseband filtering, modulation, and IF and RF impairments with EVM, related metrics, and display tools

EVM
The modulation analysis measurement personality for the ESA-E series spectrum analyzers allows you to measure the most widely used modulation quality metric in digital communication systems, EVM, at the touch of a button. EVM provides a simple, quantitative figure of merit for digitally modulated signals. With proper use, EVM and related metrics can help identify the type and the source of degradation present in a signal.

Related EVM metrics
Different error mechanisms affect signals in different ways: in magnitude only, in phase only, or in magnitude and phase simultaneously. Knowing the relative amounts of each type of error can quickly confirm or rule out certain types of problems. These EVM-related metrics are provided by the modulation analysis personality and include I/Q magnitude, I/Q phase, I/Q frequency, I/Q offset (carrier feedthrough), and amplitude droop.

Analysis display tools
The best way to verify most I/Q impairments is to look at the polar constellation display in conjunction with EVM metrics. A glance at a polar constellation diagram provides insight into the characteristics of signal impairments, such as I/Q gain imbalance and quadrature error.

To help you detect errors in a signal's transmission that may not be apparent using traditional analysis, the ESA-E's modulation analysis personality includes the following display tools:

• I and Q eye diagrams
• Polar vector and constellation
• Magnitude error versus symbol display
• Phase error versus symbol display
• EVM versus symbol display

Here is how the ESA-E benefits you

Easy to use

Analyze and visualize I/Q modulation with confidence and simplicity
- One-button switching between popular format configurations
- Easy-to-use display tools (eye, constellation, and vector diagrams) help speed troubleshooting
- User-selectable demodulation format, filtering, and symbol rate, with an intuitive measurement-setup environment
- Built-in help key for quick reference without manuals

Spectrum analysis

Maximize measurement capability and confidence
- 99 dB third-order dynamic range to view low level distortion and intermodulation
- 10 to 300 Hz digital resolution bandwidths that are up to 220 times faster than analog equivalents
- Continuous automatic background alignment that guarantees repeatability over varying temperatures

Upgradeable

Ready for the next generation of cellular standards
- Versatile card cage architecture
- Instrument firmware and software upgrades available on the web
- Wide bandwidth digital demodulation platform
- Choose the performance you need, when you need it, and upgrade in the future

Flexible

Choose the options you need now and add others in the future
- Measurement personalities for Bluetooth™ wireless technology, GSM, and cdmaOne are three of many available
- Turn the ESA-E series spectrum analyzer into a modulation analysis tool or a Bluetooth, GSM and/or CDMA communications analyzer
- Load all four format-specific measurement personalities into one ESA
- Over 30 hardware options to choose from

PC-connected

Fast

Portable

Great for R&D plus more

Easy analysis of performance data
- Option 231 (link utility) adds the flexible digital demodulation and analysis capabilities of the 89601A VSA software to the ESA-E series[1]
- Store measurement results in spreadsheet format using the built-in floppy disk drive or transfer data directly to your PC with IntuiLink software[2]
- BenchLink Web Remote software enables remote control of an ESA-E over the Internet.
- Industry standard SCPI programmable instrument language for remote control
- GPIB (Option A4H), RS-232 (Option 1AX) interface available

Finish your job quicker
- 5-minute warm-up time for full accuracy
- 45 measurement updates per second for higher probability of intercept and real-time response
- Quick modulation analysis measurement setup

Sophisticated measurement performance anywhere
- Rugged case, water-resistant front panel
- Snap-on battery (E1779A) or 12 Vdc adapter (Option A5D)
- Carrying/operating/transit case (Option AYT/AYU/AXT)

R&D
- Affordable spectrum and vector modulation analysis on every engineer's bench
- Unparalleled flexibility with seven measurement personalities to address your measurement needs

Manufacturing
- Spurious testing to 26.5 GHz and external mixing capability to 325 GHz
- Flexible troubleshooting tool for production rework
- Excellent accuracy for narrower test margins and improved yield
- Engineering analysis of root cause

Maintenance
- Portable troubleshooting tool for field repair engineers
- All-weather use

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1. For more information please see the product note 5988-4097EN.
2. For more information about IntuiLink software visit our Web site at http://www.agilent.com/find/IntuiLink

Here are the specific modulation analysis measurements

The ability to look at a signal and deduce the source of a problem is important to successful design. The ideal troubleshooting instrument has the flexibility and measurement capability to help you determine the source of errors in the RF, IF and baseband sections of the transmitter. The Agilent ESA-E spectrum analyzer with the new modulation analysis personality provides you powerful measurement capability to characterize and troubleshoot the IF and RF section of modern digital communication systems.

Common errors like I/Q error, symbol rate errors, wrong filter coefficients, wrong interpolation, IF filter tilt or ripple, LO instability, interfering tone, and AM-PM conversion all manifest themselves in differing, but identifiable ways in EVM. The ESA-E's modulation analysis personality provides you several key EVM measurements.

Key measurements

- Peak and rms EVM
- Peak and rms magnitude error
- Peak and rms phase error
- Frequency error
- EVM vs symbol display
- Magnitude error vs symbol display
- Phase error vs symbol display
- Polar vector display
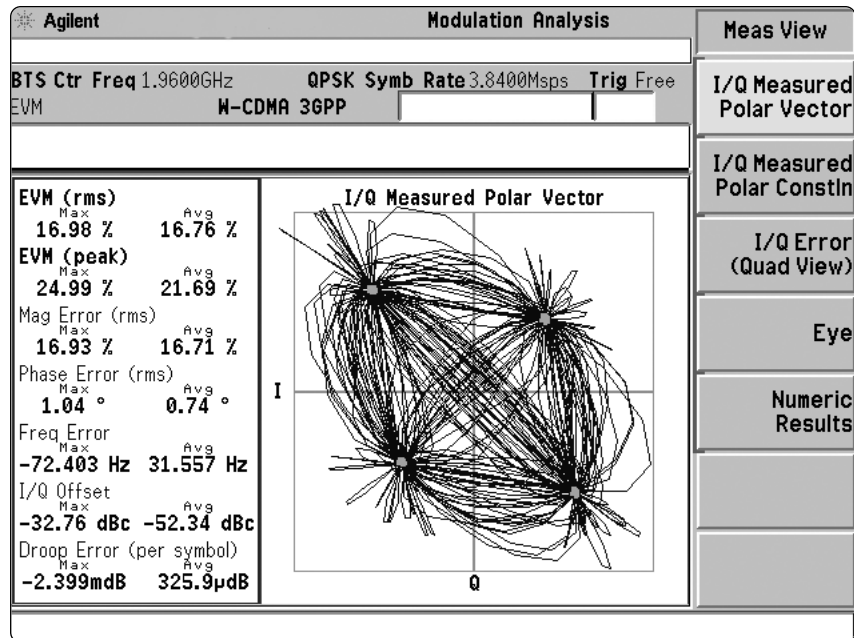- Polar constellation display
- I and Q eye display

Figure 3. I/Q polar vector display for a W-CDMA signal. A vector and constellation display used with EVM ensures that errors like quadrature errors are easily identified. You can measure and view the modulation accuracy of a signal at the touch of a button with a wide variety of numerical and graphical displays.
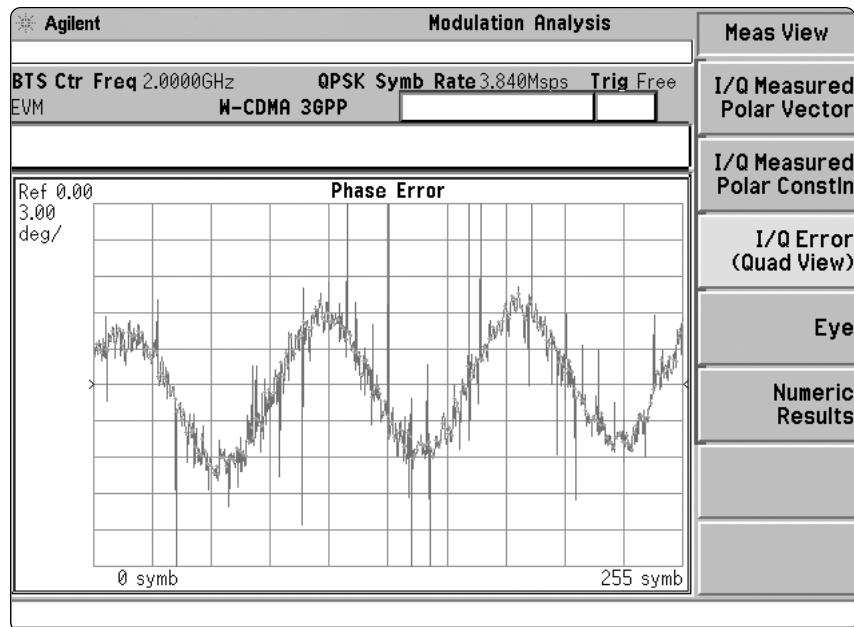

Figure 4. Phase error versus time for a W-CDMA signal. Identify any residual of interfering PM tones with a phase error versus time graph. In-band PM is easily seen as a periodic sinewave like that shown above. The polar constellation combined with the phase error versus time graph is a powerful tool in identifying I/Q errors due to sources such as LO instability. A skillful eye can easily detect many types of errors by taking advantage of the flexible display formatting offered by the ESA-E series with the modulation analysis personality.
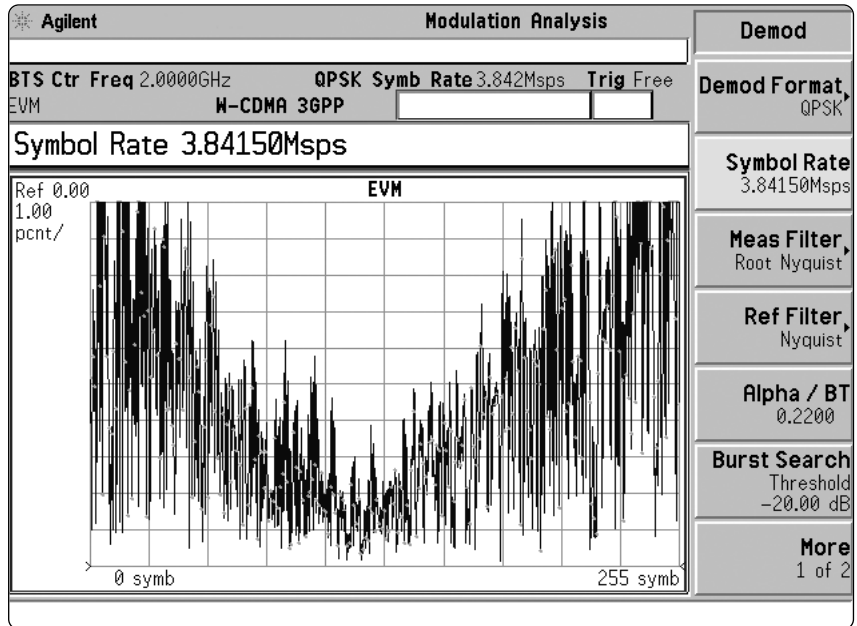
Figure 5. EVM versus symbol rate for a W-CDMA signal. Flexible measurement views enable you to identify errors like symbol rate errors with the EVM versus time display. EVM growing linearly to form a characteristic V-shape indicates the presence of a symbol rate error.
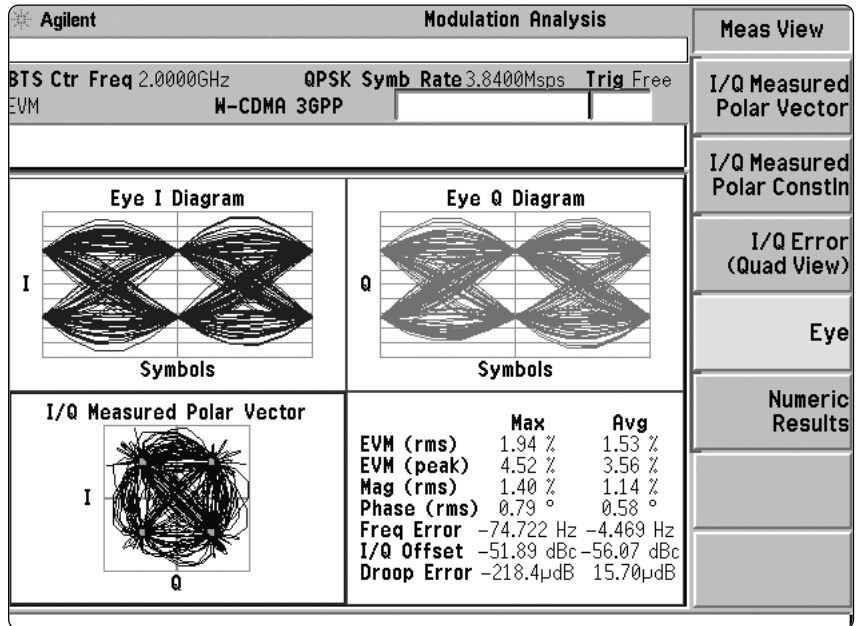

Figure 6. EVM eye view for a W-CDMA signal. Identify at a glance, inter-symbol interference caused by baseband filtering and other impairments with an easy to set up I and Q eye diagram display. A good eye is wide open at each symbol with compact crossover points.

Flexible 3G Demodulation on the ESA

ESA to 89601A Vector Signal Analysis Software Link Utility

Opt 231 (link utility).[*]
This free link adds the flexible digital demodulation and analysis capabilities of the 89601A software to the frequency coverage and general-purpose spectrum analysis capabilities of the ESA spectrum analyzers. This means that with the ESA, not only can you identify that a problem exists, but you can now gain valuable insight into the precise error causing mechanism. Make complex measurements on 3G signals like composite EVM, code domain power and Peak code domain error or extend the capability of the existing GSM, cdmaOne and modulation analysis measurement personalities that the ESA offers.

The following are a few more of the many additional features offered as a result of this unique link.

- More Displays (trellis, spectrogram, EVM spec trum display and more)
- A user-adjustable adap tive equalizer allowing you to verify IF Filter and other linear distor tion effects.
- Recording of time wave forms, which allows you to re-analyze signals and store them for future comparisons.

- Flexible marker capabili ties including time gating, inte grated band power, and off set (delta) markers.
- A link to the Agilent ESG series signal sources for download and playback of signals in the signal capture memory.
- Complete save and recall of your signals, trace data, and measurement screens
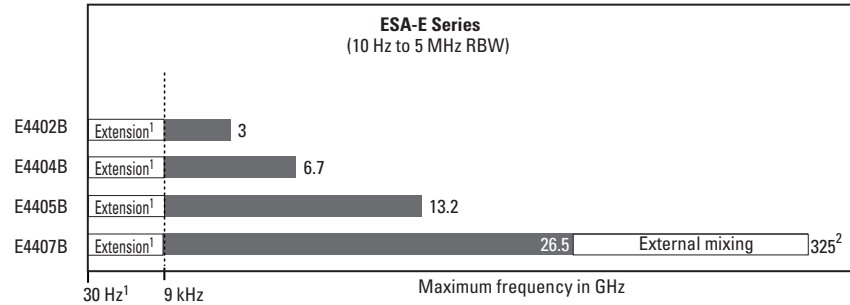
- Easy cut and paste to other PC applications

The ESA-E/89601A combination

requires a PC with a GPIB I/O[+] connection to the ESA-E spectrum analyzers for the software to run on. For more information on the performance of this combination and the configuration requirements for the ESA, please refer to the performance guide (5988-4097EN)

[*]The link is included free as part of the modulation anaylsis measurement personality (opt. 229)

[+]Option A4H is required if you want to take advantage of the Link to the 89601A VSA software.

First, choose your frequency range

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┌──────────────────────────────────────────────────────────┐
│                      ESA-E Series                          │
│                   (10 Hz to 5 MHz RBW)                     │
│                                                            │
│ E4402B  [Extension¹] ███  3                                │
│ E4404B  [Extension¹] █████  6.7                            │
│ E4405B  [Extension¹] █████████  13.2                       │
│ E4407B  [Extension¹] █████████████ 26.5 | External mixing 325² │
│                                                            │
│  30 Hz¹   9 kHz           Maximum frequency in GHz         │
└──────────────────────────────────────────────────────────┘
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Now, add modulation analysis

Here is how you order your ESA-E spectrum analyzer with modulation analysis

Task	Required option configuration
Modulation analysis	**ESA-E series spectrum analyzer plus options:** **229** - Modulation analysis measurement personality[3] **B7D** - Digital signal processing (DSP) and fast ADC **B7E** - RF communications hardware **B72** - 10 MB memory extension **1D5** - High stability frequency reference **A4H** - GPIB & Printing Ports[4]
Modulation analysis and performance spectrum analysis	**B74** - RF and digital communications hardware bundle Includes: DSP and fast ADC (Option B7D) RF communications hardware (Option B7E) High stability frequency reference (Option 1D5) Time gated spectrum analysis (Option 1D6)Preamplifier (Option 1DS) Narrow resolution bandwidths (Option 1DR) Memory extension (Option B72)[5]

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1. Optional
2. 110 GHz with Agilent mixers
3. The functionality of 231 is included as part of option 229 and should not be ordered together
4. Required only if you want to take advantage of the link to the 89601A VSA software
5. Option B72 is standard if the serial prefix number is equal to or greater than US4144 or MY4144

Modulation analysis specifications and characteristics

All specifications apply over 0 °C to +55 °C (unless stated otherwise). The analyzer will meet its specifications 5 minutes after it is turned on, when the following conditions are met: the analyzer has been calibrated within the last 12 months, the analyzer has been stored within its operating temperature range for at least 2 hours, Auto Align All is selected, and an Align Now All performed within the last 24 hours. A wideband calibration is also required.

Characteristics provide useful, but non-warranted, information about the functions and performance of the instrument. Supplemental information, typical performance, or nominal values at room temperature are shown in italics. For spectrum analyzer specifications, see ESA-E Series Data Sheet.

General characteristics

Unless otherwise noted these characteristics are with default measurement settings, standard format symbol rates and filters, using the internal frequency reference[1].

EVM and frequency error
(Requires Options B7D, B7E, and 1D5)

Operating range at RF input
 +30 to –40 dBm nominal (+30 to –60 dBm nominal with preamp Option 1DS)

Residual EVM (rms)[2,3]
Measured with a single channel, -20 dBm input level, 25 measurement averages

cdmaOne BTS	*1.9% nominal*
cdmaOne MS	*1.2% nominal*
cdma2000 BTS	*1.6% nominal*
W-CDMA BTS	*1.1% nominal*
EDGE BTS	*0.8% nominal*
NADC, PDC and TETRA BTS	*1.2% nominal*

Residual Phase Error (rms)[2,3]
Measured with a single channel, -20 dBm input level, 25 measurement averages

GSM BTS	*0.7deg nominal*

Frequency error (±Hz)[2,3]
(Excludes frequency reference error)
Measured with a single channel, -20 dBm input level, 25 measurement averages
All formats ±15 Hz nominal

Average mode
Exponential, repeat

Trigger source
RF burst, external, free run

Burst synch
Training sequence,[4] none, RF amplitude

Spurious Performance
Measurements may be affected by spurious responses caused by out-of-span signals (ie. where demodulation analysis span can be determined by equation
Symbol Rate x (1 + Filter Alpha)).
Of particular importance are out-of-span signals within ±16MHz of the analyzer's center frequency that may affect multi-carrier modulation analysis measurements. To avoid these spurious responses the input signal should be band limited to the analysis span.

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1. Use either the internal frequency reference or external 10 MHz REF IN frequency reference port for best residual EVM and phase error results. Use the variable external frequency input ports EXT REF IN and 10 MHz OUT when your reference frequency is between 1 MHz and 30 MHz, although EVM and phase error performance may be degraded for lower symbol rate signals like NADC, PDC and TETRA, due to degraded close-in phase noise at < 600Hz offsets.
2. Nominal values for residual EVM, residual phase error and frequency error apply between 30 MHz and 3 GHz frequency range
3. Frequency drift can occur within the EVM measurement when "Auto Align" is set to ALL (default) on the ESA. This is especially true at lower Symbol Rates and using longer time records (large Measurement Intervals). This can result in degraded EVM for digital demodulation analysis. A workaround is to turn the "Auto Align" parameter on the ESA to OFF and perform the following steps as needed: 1) ALIGN NOW, ALL, 2) WIDEBAND CAL NOW. See the "Specifications and Characteristics" chapter of the ESA-E Series Spectrum Analyzer Specifications Guide for more information on how often to perform an ALIGN NOW, ALL when the auto alignment is off. Use this information to determine how often to perform the above steps.
4. Only available for GSM and EDGE demodulation format.

Additional recommended options and accessories

Agilent ESA-E series spectrum analyzer product and application information

Option A5D 12 Vdc power cable
Option AXT Hard transit case
Option AYT Soft carrying/operating case (gray)
Option AYU Soft carrying/operating case (yellow)
Option AYZ External mixing
Option UK9 Front panel cover
Option A4H GPIB and parallel printer interfaces
Option 1AX RS-232 and parallel printer interfaces
Option 1CP Rackmount handle kit with slides
Option B7K Distance to fault accessory kit
E1779A Battery pack
8498A Coaxial fixed attenuator
11970/74 Series harmonic mixers

Product literature

ESA-E Series Spectrum Analyzers, Brochure,
literature number 5968-3278E
ESA-E Series Spectrum Analyzers, Data Sheet,
literature number 5968-3386E
ESA/EMC Spectrum Analyzers, Configuration Guide,
literature number 5968-3412E
Select the Right Spectrum Analyzer for Your Needs, Selection
Guide, literature number 5968-3413E
ESA Snap-On Battery Pack, Product Overview,
literature number 5966-1851E
IntuiLink Software, Data Sheet, literature number 5980-3115EN
*Agilent ESA-E series Performance Guide Using the 89601A Vector
Signal Analysis Software*, Performance Guide (5988-4097EN)

Related literature

*Testing and Troubleshooting Digital RF Communications
Transmitter Designs*, Application Note 1313, Literature number
5968-3578E

*Using Vector Modulation Analysis in the Integration,
Troubleshooting and Design of Digital RF Communication
Systems*, Product Note 89400-8, literature number 5091-8687E

For the latest news, product and support information, application
literature and more visit our web page at:
http://www.agilent.com/find/esa.

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