

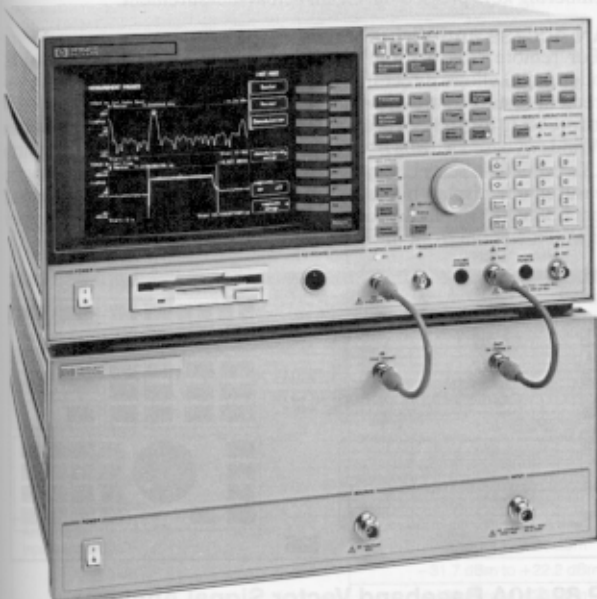
SIGNAL ANALYZERS

(b) (7)(C) Vector Signal Analyzers, DC to 10 MHz, DC to 1.8 GHz, and DC to 2.65 GHz

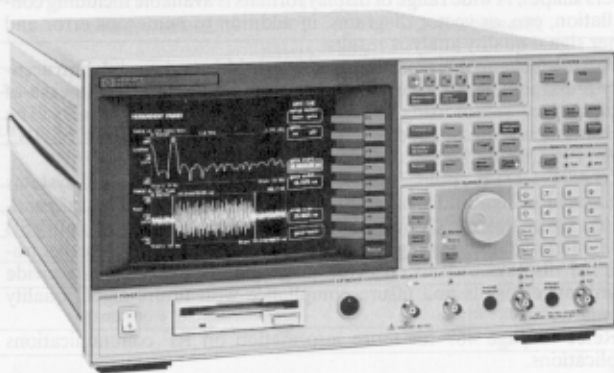
HP 89410A, 89440A, 89441A, 89411A, 89450A, 89451A

- High-performance spectrum analysis
- Advanced, optimized time-gated spectrum analysis
- Vector modulation analysis (optional)

- Precision digital AM, FM, PM demodulation
- Flexible internal RF signal source (optional)
- Narrowband spectrum speed to 60 updates/s
- Simultaneous time and frequency measurement
- 1 MSample time capture with postprocessing (optional)
- High-resolution, high-accuracy time domain
- Second 10-MHz input channel (optional)



HP 89441A DC to 2.65 GHz Vector Signal Analyzer
HP 89440A DC to 1.8 GHz Vector Signal Analyzer



HP 89410A DC to 10 MHz Vector Signal Analyzer



HP 89400 Series Vector Signal Analyzers

Advanced Measurements on Complex Signals

Hewlett-Packard's Vector Signal Analyzers integrate frequency-domain and time-domain analysis to provide the most advanced measurements of complex and time-varying signals. Using state-of-the-art digitizing and signal processing technology, these analyzers offer complex signal analysis, such as digital modulation analysis and AM/FM/PM demodulation, vector spectrum analysis, and time-gated spectrum analysis. Simultaneous time- and frequency-domain measurements and displays improve productivity and enhance ease of use.

Complex and time-varying signals include burst, pulsed, transient, hopping, and analog- and digital-modulated signals. Signals such as these are common in RF communications, video broadcast, satellite, radar, sonar and ultrasound imaging systems and must be characterized in the design, manufacture and monitoring of these systems. Vector signal analyzers are ideally suited to making the needed power, frequency, and modulation measurements on these complex signals.

The HP 89410A covers baseband frequencies from dc to 10 MHz with one or two full-bandwidth input channels. The HP 89440A and 89441A cover baseband through RF frequencies of dc to 1.8 GHz and dc to 2.65 GHz, respectively, with a single RF input and an (optional) dc to 10 MHz second baseband channel.

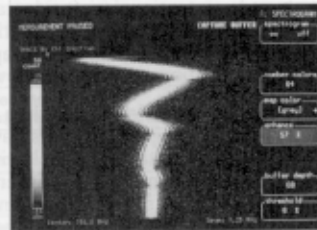
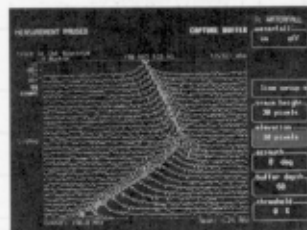
These analyzers provide unprecedented speed and power. Complex time and spectrum measurements are made and displayed up to 60 times each second. Deep time-capture RAM is available with flexible post-processing in time and frequency domains. A variety of display types are available, including log frequency, polar, and (optionally), eye and constellation diagrams.

High-Speed, Narrow-Resolution Vector Spectrum

Using high-speed signal processing, these analyzers can measure both the magnitude and phase (in the frequency domain) of CW and non-stationary or burst signals. Multiple signal processors and microprocessors display signal and circuit behavior in real time, and produce fast averaged measurements with enhanced signal-to-noise ratio.

High measurement speed is preserved even in narrowband measurements, with display updates orders of magnitude faster than traditional analyzers performing equivalent measurements. Resolution is also better, with resolution bandwidths less than 0.001 Hz over the entire frequency range.

Optional waterfall and spectrogram display formats take full advantage of the high-measurement and display-update speed. Waterfalls display up to 300 successive spectra and scroll them through the display, while spectrograms use colors to indicate signal amplitudes. Both formats make it easy to monitor signal trends of short or long duration.



High-Resolution, High-Dynamic Range Time Domain

All measurements are made with a state-of-the-art A/D subsystem and proprietary signal processing. All frequency spans are image and alias protected, offering band-limited time-domain analysis not available in traditional oscilloscopes and waveform analyzers.

These products feature a deep-data memory of up to one million samples (optional). This memory can be used for long duration time capture where the time-capture data can be selectively postprocessed (internally) or transferred via HP-IB to an external computer for further analysis.

SIGNAL ANALYZERS

Vector Signal Analyzers, DC to 10 MHz, DC to 1.8 GHz, and DC to 2.65 GHz (cont'd)

HP 89410A, 89440A, 89441A, 89411A, 89450A, 89451A

Advanced Time-Selective Spectrum Analysis

For burst or time-varying signals, it may be necessary to examine only a selected part of the waveform. Time-selective spectrum analysis in the HP 89400 series vector signal analyzers allows the entire time-domain signal to be viewed and a specific portion selected for frequency-domain analysis. The selected data is identified clearly with gate markers and all of its traditional frequency-domain parameters (including noise or signal/noise) can then be measured. In addition, this time-selective analysis does not require a repetitive signal.

Digital Modulation Analysis

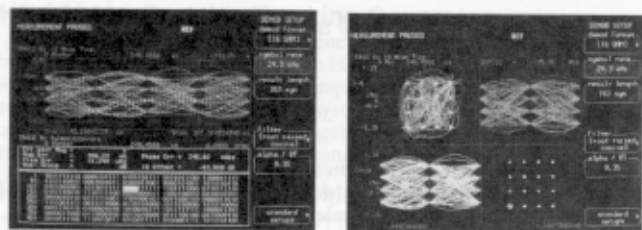
A vector signal analyzer with optional vector modulation analysis provides all the tools necessary to test throughout a system block diagram and to measure the quality of digitally modulated signals. Measurements are easy since no external filters, coherent carriers or symbol timing signals are required.

Measurements are made on baseband, IF, or RF signals with a selection of modulation formats, variable number of symbols, and a variety of filters shapes. A wide range of display formats is available including constellation, eye, or vector diagrams, in addition to numerous error and other signal quality analysis results.

Adjacent channel power, occupied bandwidth, and modulation accuracy are among the measurements that can be made with the ease of "one-button" setups using the HP 89451A Radio Test Personality. The measurements can be made on burst or continuous signals of NADC, PDC, PHS, or user-defined systems.

In ATV/HDTV applications, designers of components and systems can speed design and troubleshooting with precise analysis of modulated signal quality. Option AYH characterizes both QAM and VSB modulated signals, showing results with eye, constellation, and other traditional displays. Advanced error magnitude measurements provide quantitative results and insure compliance with future signal quality standards.

Refer to page 487 for more information on RF communications applications.



Precision AM, FM, and PM Demodulation

Precision, high-resolution digitized time-series data allows for advanced signal analysis, such as AM, FM, and PM demodulation. Signals can be analyzed for instantaneous amplitude, frequency or phase versus time, and the resulting time-domain results can be translated into the frequency domain for further analysis. This is useful for characterizing phenomena such as phase noise, oscillator frequency transitions, and the amplitude or frequency behavior of transmitters at turn-on. Both deliberate and unintentional (or incidental) modulation can be characterized completely. Demodulation is selective, so that the type of modulation can be uniquely determined and separated from other types. FM and PM demodulation are made easier with an auto-carrier function.

Powerful, Flexible Triggering

These vector signal analyzers have extremely flexible triggering to make the most of their time-selective analysis and demodulation features. Measurements can be triggered from the analyzer's own signal source, an external source, HP-IB, an input channel (HP 89410A), or the analyzer's own band-limited IF. The IF trigger allows the analyzer to establish a trigger from a selected frequency band of the input signal, ensuring that the trigger event can always be seen. Both analyzers also provide pre- and post-trigger delays, along with manual, external, or automatic arming with programmable delay.

Advanced Data Analysis

The high-resolution time-domain data of the HP 89400 analyzers allows for advanced data analysis functions. The built-in math functions can be used for scalar arithmetic and complex operations. Other advanced analysis capabilities include correlation functions, such as auto-correlation. This statistical function compares a signal with a delayed version of itself, useful in uncovering hidden periodic signals and analyzing multipath or other signal delays.

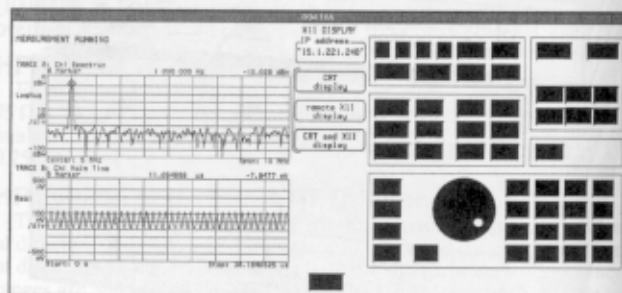
Measurement Automation and Convenience

Features

Optional HP Instrument BASIC (a subset of HP BASIC) runs inside the analyzers to make repetitive measurements, to create custom displays and test sequences, and even to control other instruments in a test system. Automatic program generation is available with the "keystroke recording" feature, which creates complete executable programs by remembering keys pressed during an actual measurement.

LAN Access and Virtual Front Panel

For remote control from across the building or across the world, Option UFG allows direct transfer of instrument commands and measurement results to a LAN-equipped PC or workstation. Option UG7 adds access to instrument memory and file storage via FTP, along with an X-Windows based "virtual front panel". This display, which can be sent to an X-compatible server anywhere on your network, shows not only the measurement display but also the complete instrument front panel. Press keys with your mouse or pointing device, and operate the analyzer just as if it were in front of you.



HP 89410A Baseband Vector Signal Analyzer

The HP 89410A covers a frequency range of dc to 10 MHz and offers an optional second channel. The second channel makes it possible to measure frequency response or perform vector network analysis, and the built-in math functions facilitate measurement calibration and correction.

Two-channel statistical measurements such as cross-correlation and coherence can also be made. Cross-correlation is similar to autocorrelation, but instead of comparing a signal with itself to see time delays or repetitions, one signal is compared with another. If the same repetitive signal is present in both waveforms it will be discovered in the cross-correlation measurement. This technique is also useful in analyzing multipath distortions.

Coherence is a measure of the power in the output signal related to the power in the input. It is useful for troubleshooting noise or signal propagation through a circuit or system. Coherence is also a good indication of the quality of a network measurement in a noisy environment.

Flexible Source

The HP 89410A provides a flexible source for circuit stimulation. Sinewaves, periodic chirps (sinewave sweeps), and pseudo-random noise are available, along with user-definable arbitrary waveforms. The arbitrary waveforms operate on a block of up to 4096 complex points.

Any of these signals can be used as a stimulus while spectrum measurements are made elsewhere in the circuit. Source level and dc offset of the pattern are all controllable by the user.

HP 89440A and 89441A RF Vector Signal Analyzers

The HP 89440A and 89441A cover baseband through RF frequencies of dc to 1.8 GHz and dc to 2.65 GHz, respectively, in scalar and vector analysis modes. The scalar RF instrument mode allows full-frequency coverage in spans to 1798 MHz in the HP 89440A, and 2648 MHz in the HP 89441A. Vector RF mode offers exceptional speed and additional signal processing for enhanced time-domain characterization and demodulation. Vector spans as wide as 7 MHz can be selected anywhere in the 1.8 GHz or 2.65 GHz frequency range. A vector baseband mode is also available to provide all of the features and functionality of the HP 89410A.

In vector RF mode, both phase and amplitude characteristics are captured in the time-series data. This information can be processed for narrow resolution spectrum analysis, AM/FM/PM demodulation, time-selective analysis, vector modulation analysis (optional), and many other types of measurements.

RF Signal Source

In vector RF mode, the HP 89440A and 89441A offer an optional flexible source with up to 7 MHz bandwidth, settable to any frequency in the 1.8 GHz or 2.65 GHz frequency range. As with the HP 89410A, sine-waves, periodic chirps (sinewave sweeps), and pseudo-random noise are available, along with user-definable arbitrary waveforms.

Microwave Measurements with Downconverter

The HP 89411A IF downconverter works with the HP 89410A to provide narrowband vector signal analysis at RF and microwave frequencies. The HP 89411A converts a 21.4 MHz IF output from an external receiver to the input frequency range of the HP 89410A. This downconverter is also compatible with the HP 89440A and 89441A.

This downconverter is designed for use with various HP microwave spectrum analyzers and other devices with compatible 21.4 MHz IF outputs. Frequency coverage is thus available over the complete frequency range of the microwave receiver or analyzer.

Specifications Summary

Refer to the HP 89410A/89440A/89441A/89411A technical data sheets for full specifications. The following specifications apply from 0 to 55°C.

	HP 89410A	HP 89440A	HP 89441A
Frequency			
Frequency range	dc to 10 MHz	2 MHz to 1800 MHz	2 MHz to 2650 MHz
Frequency span			
Scalar mode	1.0 Hz to 10 MHz	1.0 Hz to 1798 MHz	1.0 Hz to 2648 MHz
Vector mode	1.0 Hz to 10 MHz	1.0 Hz to 7 MHz	
Frequency resolution	0.001 Hz		
Accuracy-initial	±10 ppm (±0.2 ppm optional)	±0.1 ppm	
Resolution bandwidth	312.5 μHz to 3 MHz (1, 3, 10 sequence or arbitrary)		
Phase noise	(at center frequency = 10 MHz)	500 MHz ≤ center frequency ≤ 1800 MHz	1000 MHz ≤ center frequency ≤ 2650 MHz
100 Hz offset	-106 dBc/Hz	< -89 dBc/Hz	-87 dBc/Hz
1 kHz offset	-110 dBc/Hz	< -82 dBc/Hz	-97 dBc/Hz
10 kHz offset	-120 dBc/Hz	< -83 dBc/Hz	-116 dBc/Hz
100 kHz offset	-120 dBc/Hz	< -105 dBc/Hz	-116 dBc/Hz
Amplitude			
Input range 50 Ω	-30 dBm to +24 dBm	-30 dBm to +25 dBm	-50 dBm to +25 dBm
75 Ω	-31.7 dBm to +22.2 dBm		
1 MΩ (referenced to 50 Ω)	-30 dBm to +28 dBm		
Accuracy-absolute full-scale	±0.5 dB	±1.8 dB (±0.5 dB typical)	±2.0 dB (±0.5 dB typical)
Accuracy-amplitude linearity			
0 to -30 dBfs			<0.10 dB
-30 to -50 dBfs			<0.15 dB
-50 to -70 dBfs			<0.20 dB
Input noise density (50 Ω)	-114 dBfs/Hz	-112 dBfs/Hz	-112 dBfs/Hz
Sensitivity (lowest range, 50 Ω)	-144 dBm/Hz	-142 dBm/Hz	-159 dBm/Hz
Spurious responses			
General spurious	≤ -75 dBfs (≥ 1 MHz)		
Second harmonic distortion	< -75 dBc (-80 dBc typical)	< -70 dBc	< -75 dBc
Intermodulation (third order relative to two tones at -6 dBfs)	≤ -75 dBc (-85 dBc typical)	< -70 dBc	< -75 dBc
Residual responses	< -75 dBfs (< 1 MHz)		
	-80 dBfs (≥ 1 MHz)		
Analog demodulation			
Maximum bandwidth (typical)	10 MHz	7 MHz	
Demodulation accuracy - AM		±1% (typical)	
- PM		±3 degrees (typical)	
- FM		±1% of span (typical)	
Trigger			
Scalar mode	Free run, input channel, internal source, HP-IB, external	Free run, HP-IB, internal source, external	
Vector mode	Free run, input channel, IF channel, internal source, HP-IB, external	Free run, IF channel, internal source, HP-IB external	
Input Coupling	dc/ac	ac	
Source			
Scalar mode	Fixed sine, arbitrary		
Vector mode	Fixed sine, random noise, periodic chirp, arbitrary		
Arbitrary source	Up to 4096-complex or 8192-real points		
Source level (fixed sine)	-110 dBm to +23.9 dBm	-27 dBm to +13 dBm	-40 dBm to +13 dBm

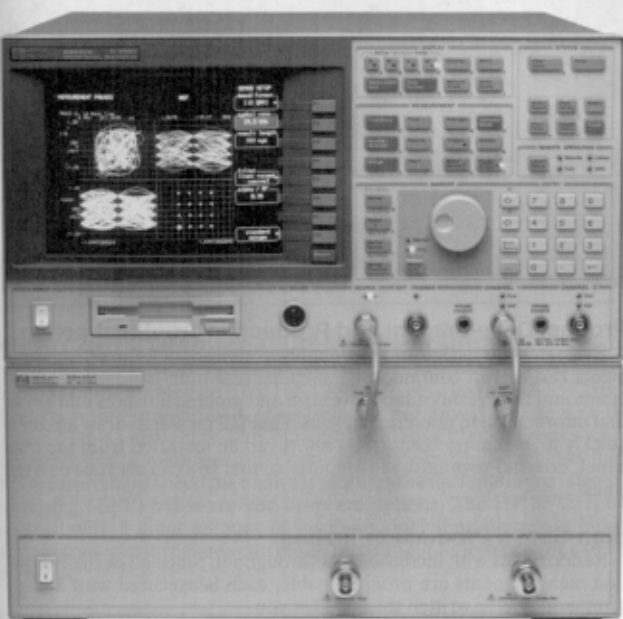
Note: specifications apply with the RF receiver selected. All HP 89410A specifications also apply for dc to 10 MHz measurements.)

MOBILE/CELLULAR RADIO INSTRUMENTS & SYSTEMS

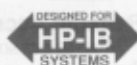
Vector Signal Analyzers, DC to Microwave

HP 89441A, 89440A, 89410A, 89411A, 89450A, 89451A

- Flexible digital modulation analysis
- Advanced time and frequency domain analysis
- Narrow resolution spectrum measurements to 60 updates/s



HP 89440A and 89441A



HP 89440A DC to 1.8 GHz Vector Signal Analyzer HP 89441A DC to 2.65 GHz Vector Signal Analyzer

A Signal Analyzer for Communications Designers

Designers of communications systems can now spend their time verifying and improving their designs rather than creating specialized testing tools for each component, new signal, or modulation type. Using vector signal analysis and advanced DSP techniques, signals that formerly required much time and effort to measure can be viewed with ease.

The HP 89400 series offers many types of measurements for characterizing performance or locating problems throughout the block diagrams of transmitters and receivers—from baseband to RF stages. Analyze burst, transient, or modulated signals with simultaneous views of time, frequency, phase, and amplitude. Using this flexibility, measurements such as LO stability, phase noise, and transient characteristics are direct, easy, and reduce the overall amount of required test equipment.

Flexible Vector Modulation Analysis

Measurements of RF or IF signals are simplified since no external filters, coherent carriers or symbol-timing signals are required. Baseband I and Q signals can also be analyzed simultaneously with the optional second 10 MHz input channel. Modulation including BPSK, QPSK, DQPSK, $\pi/4$ DQPSK, 8PSK, 16-256QAM, VSB, MSK, and 2- to 4-level FSK are supported. Various filter types with adjustable parameters and user-defined filters, in addition to burst length, symbol rate, and carrier frequency can all be selected by the user. To simplify measurements, the parameters for systems such as GSM, NADC, PDC, PHP, DECT, and CDPD can be set with a single button.

Measurement results can be displayed in various formats and tables. Constellation, vector, and eye diagrams provide familiar tools for analyzing vector-modulated signals. Detected data tables display the received binary bits and show results of modulation quality including amplitude droop, I/Q gain imbalance, and quadrature error. The vector modulation analysis option also offers error measurements by generating an ideal reference signal to compare to the received signal. Results include error vector magnitude, phase error, and magnitude error.

- Accurate frequency selective power measurements
- Direct burst carrier settling analysis
- Multiple trace displays

Radio Test Personality

The HP 89451A personality adds “one-button” measurements to quickly set up and test NADC, PDC, PHS, and user-defined systems. Occupied bandwidth, adjacent channel power, modulation accuracy, and frequency tolerance are included in the suite of measurements that can be made on burst or continuous signals. Accuracy required for R&D applications, ease-of-use, and measurement speed are all provided as well as the flexibility to change any of the demodulation parameters or access any of the HP 89400 series measurement modes to troubleshoot difficult system problems.

DMCA Radio Test Personality

The HP 89450A DMCA (digital multi-channel access) personality adds “one-button” tests and modulation analysis of M16QAM signals to the HP 89400 Series Vector Signal Analyzers. These tests save time setting up DMCA approval testing or manufacturing tests and meet the measurement standards outlined in the RCR-32 DMCA radio standard.

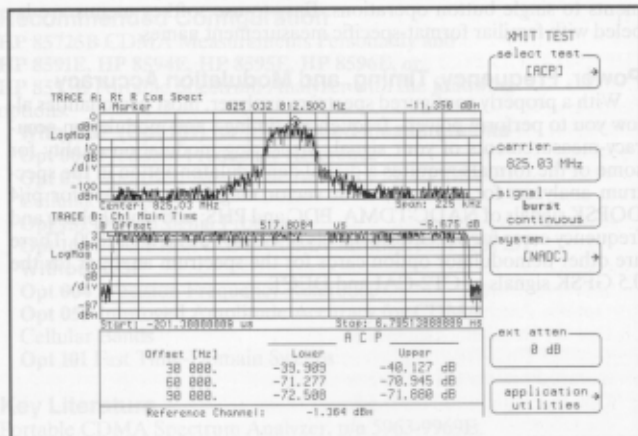
CAE Simulator Link

Testing “concurrently designed” systems typically requires waiting for an entire system to be physically prototyped and its subsystems assembled. The HP 89400 series analyzers in conjunction with OmniSys CAE System Simulator (part of HP EEsof's Communication Design Suite) reduce overall system development time by emulating signals that the hardware will actually generate—but, before the hardware exists. The built-in arbitrary source can provide this emulated signal as stimulus to subsequent sections of the system that have been completed. Also, real-world measurement results can be used in system simulations prior to prototyping. Compatible data formats in OmniSys and the HP 89400 series links theory to reality, lowering system development time barriers. See page 320 for more information on EEsof and the OmniSys solution.

Solutions for Microwave Frequency Coverage

The HP 89440A and 89441A are complete solutions for characterizing systems up to 1.8 or 2.65 GHz. To extend the vector signal analysis capabilities to higher frequencies, the HP 89410A, 89411A, plus an external spectrum analyzer provide microwave coverage.

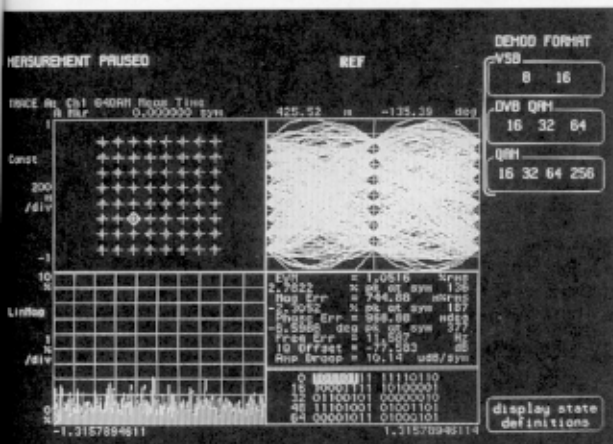
See page 249 for more detailed descriptions, specifications, and complete vector signal analyzer ordering information.



Specialized display from the HP 89451A Radio Test Personality.

Lab-quality spectrum analysis to 1.8 GHz (89440A) or 2.65 GHz (89441A)
 Constellation, eye, and error magnitude analysis for QAM, VSB, DVB, and other modulation formats (Option AYH)

- Dynamic power measurements, including: peak, average, band-integrated, and adjacent channel
- Waveform capture and analysis
- Carrier phase noise measurements to -116 dBc/Hz



Measure complex modulation formats such as 64QAM and 8VSB with precision and repeatability, and display the results in both qualitative and quantitative formats.



HP 89400 Option AYH Digital Video Signal Analyzer

Meeting the needs of both broadcast and cable system designers, HP 89400 vector signal analyzers precisely characterize RF signals in the emerging modulation formats of the digital video industry, including QAM, DVB, and VSB. Off-the-shelf, lab-quality spectrum and waveform measurements allow designers of ATV/HDTV components, equipment and systems to deliver higher quality video signals faster and for less cost than with custom-built test tools.

Signal Quality Measurements

HP 89400 vector signal analyzers measure signal power and waveforms in the time, frequency, and modulation domains, making them extremely versatile design and troubleshooting tools. Their advanced DSP architecture provides measurements that are not only fast, but exceptionally accurate and informative—even for complex, broadband ATV signals. For more information about HP 89400 signal analysis capabilities, see page 249.

Digital Modulation Analysis

Digital video analysis Option AYH equips HP 89400 analyzers to demodulate and characterize a wide variety of video-related signal formats. Results are shown via traditional eye and constellation displays, or as *error vector magnitude* measurements. EVM quantifies the instantaneous difference between the actual input signal and an ideal, internally generated reference signal containing the same data stream. It is a measurement technique now widely accepted among digital RF communications designers and international standards organizations. Expressed as a time waveform, an RMS average or an error spectrum, EVM is sensitive enough to reveal the slightest degradations in signal quality, such as those which occur between the input and output of even a single amplifier stage. Use it to troubleshoot BER or other signal problems back to their root causes.

In digital demodulation mode, carrier lock and symbol clock synchronization are automatic. This means external carrier reference or clock inputs are never required, making the HP 89400 analyzers useful even in remote or field test applications.

Specifications

Frequency Range and Bandwidth

Model number	Frequency range	Sensitivity	Maximum bandwidth
HP 89410A	dc to 10 MHz	-144 dBm/Hz	10 MHz
HP 89440A	dc to 1800 MHz	-145 dBm/Hz	8 MHz
HP 89441A	dc to 2650 MHz	-160 dBm/Hz	7 MHz

Symbol Rates (Symbols/Sec)

VSB formats: 10.77 M nominal (adjustable)

QAM formats: Rate < (Analyzer BW)/(1 + α)

Examples:

Model number	QAM $\alpha = 0.2$	DVB $\alpha = 0.15$
HP 89410A	< 8.33M	< 8.70M
HP 89440A	< 6.67M	< 6.96M
HP 89441A	< 5.83M	< 6.09M

Note: For 8 MHz bandwidth DVB signals, use only HP 89440A or HP 89441A

Maximum Measurement Size

1 sample/symbol: 4096 symbols

5 samples/symbol: 819 symbols

Modulation Formats

8, 16VSB

16, 32, 64, 256QAM

16, 32, 64QAM (DVB)

(FSK, MSK, BPSK, QPSK and other formats supported by Option AYA).

Residual Error (instrument contributed)

QAM formats: Symbol rate 5 to 7 MHz, $.15 < \alpha < .2$, full-scale signal ≥ -25 dBm:

$\leq 1.0\%$ EVM typ. (≤ 40 dB SNR)

VSB formats: Symbol rate 10.762 MHz, $\alpha = .1152$, full-scale signal ≥ -25 dBm:

$\leq 1.5\%$ EVM typ. (≤ 36 dB SNR)

Required Options

AYA (vector modulation analysis)

UFG (4 MB extended RAM)

For complete product, literature, and ordering information, see page 252.