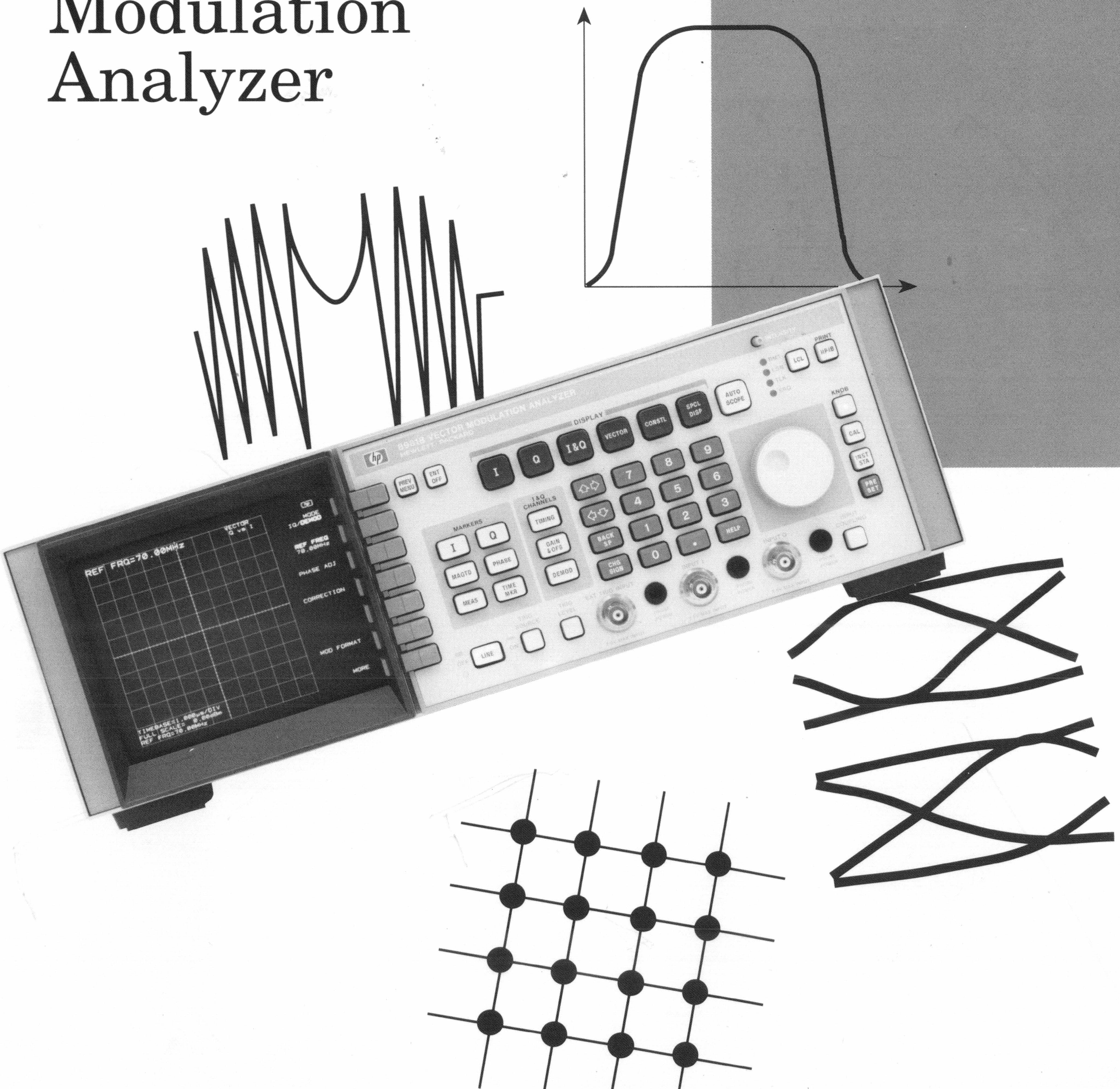
HEWLETT PACKARD

# HP 8981B Vector Modulation Analyzer

**50 – 200 MHz**

**Off-the-shelf standard for I/Q demodulator and modulator test now with magnitude and phase vs. time display**



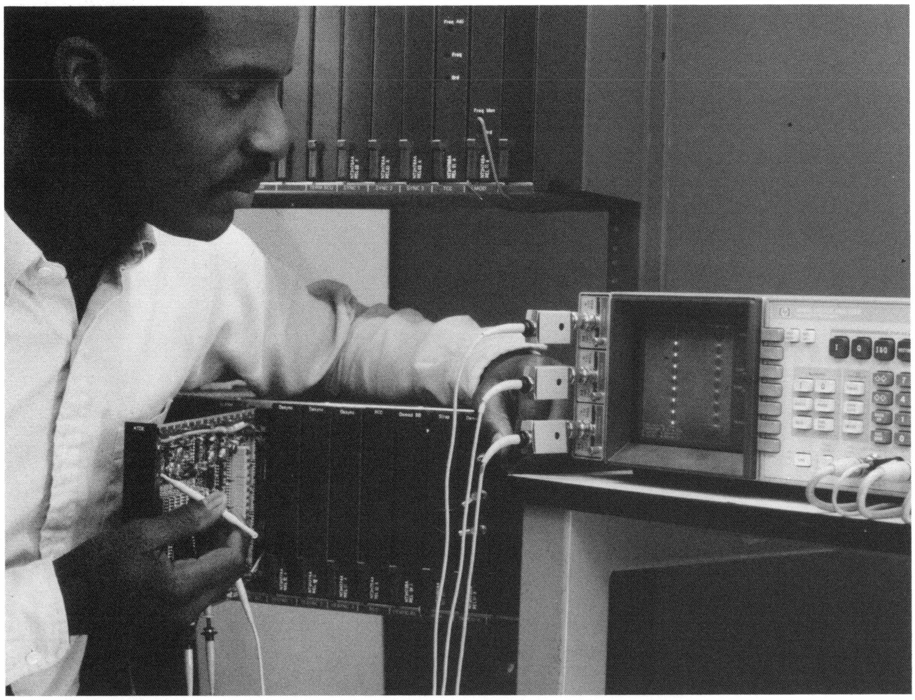
# New analysis tools for modern microwave systems that put productivity first

## *Digital Communications:*

### Quantitatively Measure Modulation Impairments with Constellation Analysis

Communications advances, such as spectrally efficient, digital microwave radios dictate new standards of performance and new ways of looking at signals. The HP 8981B Vector Analyzers meet your test equipment needs for high-rate digitally-modulated systems.

Built-in analysis software quantitatively measures modulation impairments such as quadrature error, lock angle error and closure. Modulator errors can be isolated from demodulator errors with the HP 8981B Vector Modulation Analyzer. It independently analyzes the outputs of both your modulator and your demodulator. These instruments save you troubleshooting time in R&D, in production and in the field.



*Use the HP 8981B Vector Modulation Analyzer to quantitatively measure modulator or demodulator quadrature error without disturbing traffic. The HP 8981B simplifies troubleshooting by isolating modulator from demodulator errors.*

## *Radar / EW:*

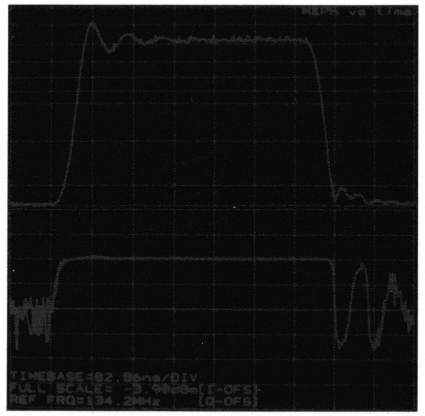
### Accurately Calibrate I/Q Demodulators

Evaluating a modern radar receiver can involve time consuming digitizing and data manipulation. The HP 8981B Vector Analyzer provides a real-time visual display of phase and magnitude, thus adding valuable information for design and troubleshooting of I/Q demodulators.

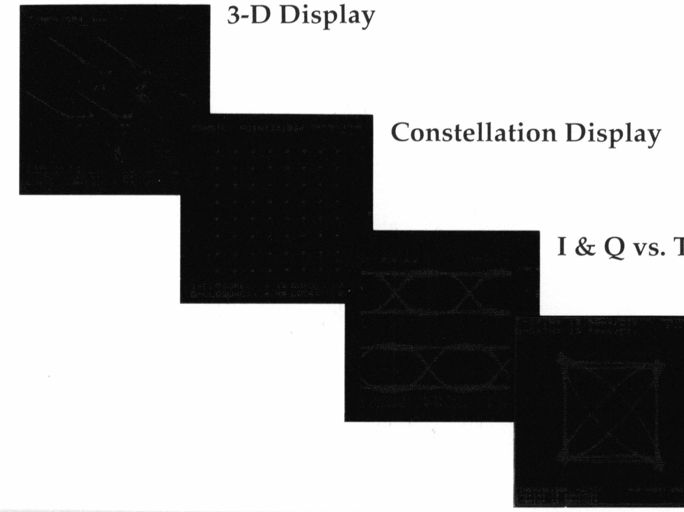
The 12-bit data capture combined with external software can measure a demodulator's I/Q gain imbalance, quadrature error and image rejection. The HP 8981B provides accuracy you can count on for receiver alignment and signal processing.

*Courtesy McDonnell-Douglas Corporation*

# Designed for systems using I/Q modulation/demodulation techniques



New Magnitude and Phase vs. Time Display



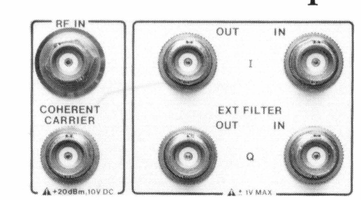
3-D Display

Constellation Display

I & Q vs. Time Display

Vector Display


HP 8981B Rear Panel Demodulator Inputs




# HP 8981B Vector Modulation Analyzer

- 350 MHz Baseband I/Q Inputs
- 5 mV/Div to 1 V/Div Input Sensitivity
- 1% I and Q Measurement Accuracy
- 12 Bits A/D Resolution on Repetitive Signals
- Quadrature Error Measurement
- Phase, Magnitude, Time, I and Q Measurement Markers
- TDMA Gate Input
- 50/75 Ohm Inputs
- HP 2225A Thinkjet™ Printer Output
- Built-in I/Q Demodulator
- 50 — 200 MHz Modulated IF Input Frequency Range
- Optional demodulators in bands to 1400 MHz.
- –5 dBm to –20 dBm Modulated IF Input Level
- +10 dB to –20 dBm Coherent Carrer Input Level
- 100 MHz Baseband Bandwidth Available with External I/Q Filters
- 35 MHz Baseband Bandwidth with Internal I/Q Filters

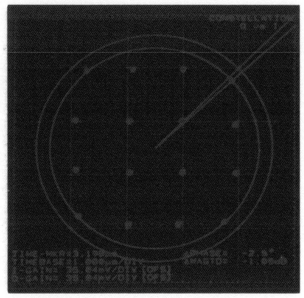
DESIGNED FOR HP-IB SYSTEMS — HP's implementation of IEEE-488

# The vector display simplifies complex modulation analysis

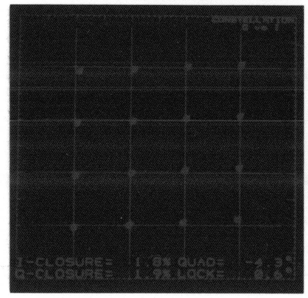
## *Locate Radio Impairments by Sight*

Traditionally, designers of terrestrial digital radio and satellite systems used oscilloscopes to determine the effects of noise, intersymbol interference (ISI), and timing problems on radio performance. But an oscilloscope only tells part of the story.

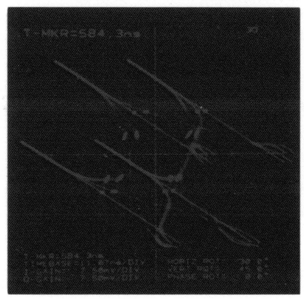
The HP 8981B Vector Analyzer adds 350 MHz X-Y (vector) bandwidth, excellent I/Q channel matching, and circuitry that samples at the clock instant and diplays the constellation pattern. Now you can visually examine, as well as quantitatively measure, quadrature error or nonlinear distortions. At the push of a button you can either check out the alignment of a 256QAM constellation or look at the eye diagram.



*Phase and magnitude markers combine to improve the speed and accuracy of nonlinear distortion measurements, such as AM-AM or AM-PM distortion shown on a 16QAM signal.*



*Assess system performance at the clock instant by quantitatively measuring quandrature error with the HP 8981B statistical analysis firmware.*

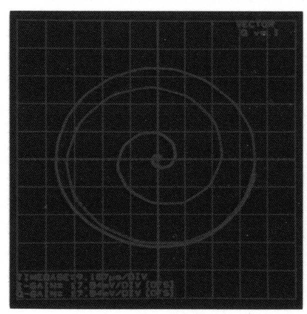


*3-D display of a QPSK signal at the transition point. Rotate the signal about any of the three axis: Q vs. I vs. Time. Improves your intuitive understanding of the signal.*

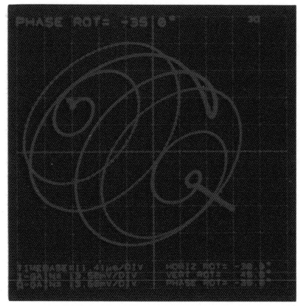
## *See Pulse Transients*

The key to transient analysis of pulsed signals is a wide bandwidth demodulator and an X-Y display. Unlike most general-purpose oscilloscopes or network analyzers, the HP 8981B Vector Modulation Analyzer has a 70 MHz modulation bandwidth and excellent I/Q channel matching.

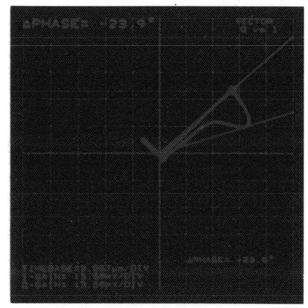
The HP 8981B Vector Modulation Analyzer reveals phase and magnitude transients, such as a UMOP (Unintentional-Modulation-on-Pulse). The time, phase, and magnitude markers characterize these transients during the rise and fall times.



*The HP 8981B Vector Modulation Analyzer conveniently displays vector demodulated SAW chirp signals. The spiraling phase response indicates the changing chirp frequency and amplitude.*



*A 3-D view of a radar chirp signal. Aids your intuition by showing Q vs. I vs. Time.*



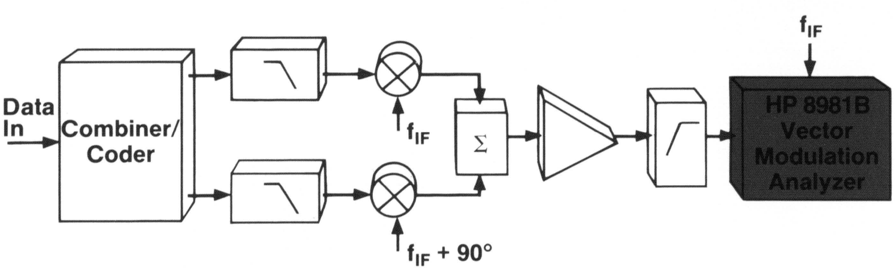
*Identify UMOP (Unintentional-Modulation-on-Pulse) by quantitatively measuring the phase transients on a radar pulse with the delta-phase measurement marker.*

# Digital Communications — visual and quantitative analysis of terrestrial and satellite system performance

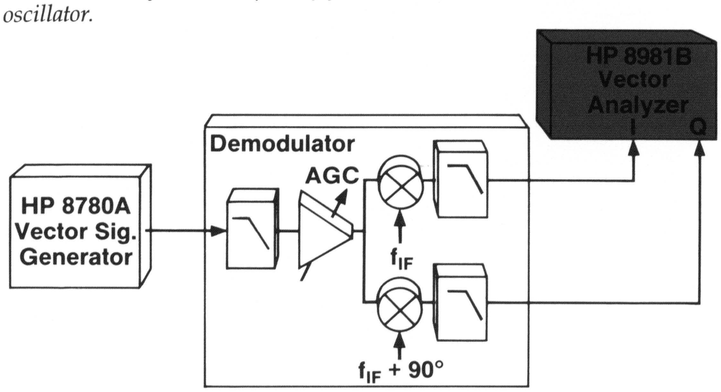
## Isolate Sources of High BER with Off-the-Shelf Standards

Designers of terrestrial digital radios and satellite systems use BER measurements to determine the effects of noise, intersymbol interference (ISI), and timing problems on radio performance.

A BER test is a go/no-go test. It measures how much degradation exists, but it does not locate the source. The HP Vector Modulation Analyzer picks up where the BER tester leaves off, providing the troubleshooting power that the system designers need to isolate IF, RF and baseband error sources.




*Identify modulator errors, such as quadrature error, gain imbalance, and offsets with the HP 8981B Vector Modulation Analyzer. It connects directly to the outputs of your modulator and coherent local oscillator.*




*Isolate demodulator errors. The HP 8780A Vector Signal Generator is the ideal source for calibrated digital communication signals. It eliminates transmitter impairments. However, for margin testing, the HP 8780A can simulate impairments, such as clock skew, dropouts, and I or Q signal imbalance. The HP 8981B performs constellation analysis on the I and Q outputs to measure the demodulator's performance.*

## Don't Depend on Indirect Methods. Measure Quadrature Error Directly

With modern digital systems pushing the limits of speed, modulation complexity and bandwidth, designers need to specify radio performance to increasingly narrower limits.

The HP 3709B Constellation Display and the HP 8981B are the first commercial instruments available that provide quantitative measurements of quadrature error.

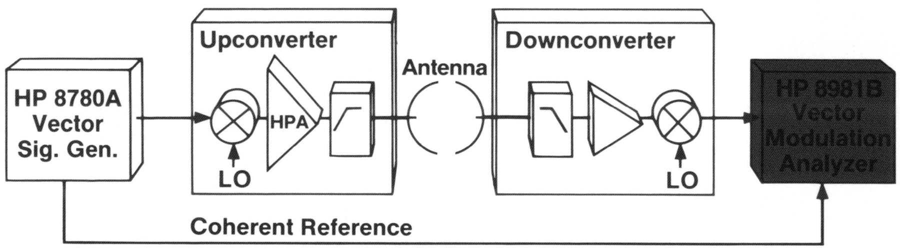
Other methods, such as the SSB image rejection technique shown on the next page, do not test your modulator or demodulator under real-life conditions. The advantage of the vector modulation analyzer is that it performs statistical analysis on live or simulated traffic to measure quadrature error.

Courtesy of Loral Corporation

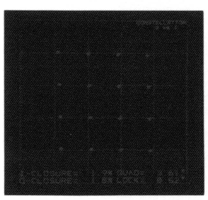
## Measure AM/AM and AM/PM Due to Power Amp Distortions

Nonlinearities in the transmitter high power amplifiers of microwave digital radios cause compression of the transmitted signal, increasing the bit error rate. An oscilloscope eye diagram can't quantitatively measure high power amplifier signal distortions. But the HP 8981B Vector Modulation Analyzer can! An example test set-up is shown below.

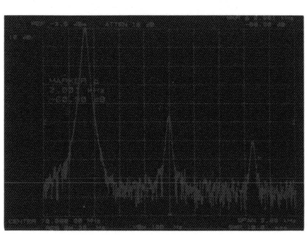
The HP 8981B high bandwidth constellation display shows the AM/AM and AM/PM conversion accurately. The delta-phase and delta-magnitude markers measure the changes in power and phase at a specified level due to nonlinearities, as shown in the HP 8981B screen shots below. These markers can typically measure AM/AM to within 0.15 dB and AM/PM to within 1°.



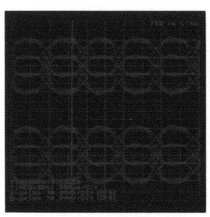

*High Power Amplifier (HPA) Test*



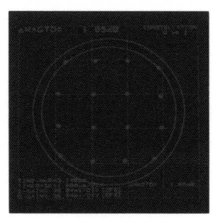

*It's simple to get direct, repeatable quadrature error measurements: all you need to do is select the appropriate constellation format and sample size, align the constellation pattern on the grid and push the measurement softkey. The vector analyzer firmware will do all the rest. The results are displayed on-screen or transmitted via HP-IB.*



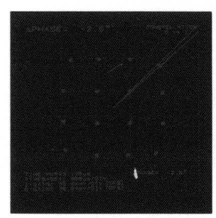
*Modulator quadrature error can be measured with a spectrum analyzer by observing the single sideband image rejection. The drawbacks of this technique are that it does not separate quadrature error from gain imbalance, and that it does not test the modulator under live or simulated traffic.*



*Using an oscilloscope, it is difficult to identify the source of degradations with a traditional eye diagram. However, a constellation diagram of a degraded signal, as shown in the next two photos, pinpoints the source.*



*Measure AM/AM distortion with the delta-magnitude marker. First, align the non-distorted four inner states with the 16QAM grid. Then place the magnitude marker on the outer states of the 16QAM grid. Finally, move the delta-magnitude marker to the compressed signal state to measure the compression, as shown above.*

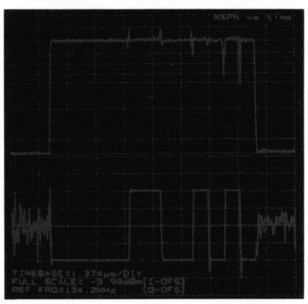


*Measure AM/PM distortion with the delta-phase marker. First, align the non-distorted four inner states with the 16QAM grid. Then set the phase marker to 45°. Finally, move the delta-phase marker so that it intersects the phase distorted signal state to measure the phase distortion, as shown above.*

# Radar/EW —
# an information packed view of radar/EW signals in I, Q, vector or phase and magnitude vs. time

## Analyze Complex Signals by Viewing Magnitude and Phase vs. Time

The HP 8981B measures the in-phase and quadrature components of complex RADAR and EW signals. In addition to displaying these vector quantities as a function of time, the HP 8981B now has the ability to display the signal's magnitude and phase as a function of time. Now you can determine the magnitude and phase transition characteristics of your signals. Measure such parameters as rise and fall time, overshoot, ringing, phase and magnitude transients and the position of phase changes. The new analysis capabilities make it easier than ever to measure and characterize complex signals.

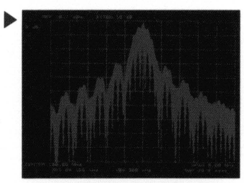


*The HP 8981B's new magnitude and phase vs. time display is an ideal tool for analyzing signal transitions. Both magnitude and phase transients can be measured on signals such as the phase-coded pulse shown here. The top trace, magnitude, shows the variations in pulse amplitude. The bottom trace, phase, shows the position and behavior of the phase transitions.*

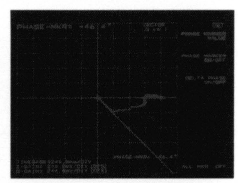
## Detect Subtle Phase Anomalies That Can't Be Seen on an Oscilloscope or a Spectrum Analyzer

Phase anomalies during the rise and fall times of a pulse can translate into frequency offsets that masquerade as Doppler offsets and false target information. A spectrum analyzer or an oscilloscope cannot measure these transients.

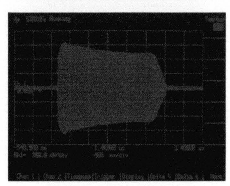
The HP 8981B Vector Modulation Analyzer can characterize the phase trajectory of a pulse during the turn-on and turn-off transition times. This measured phase response under dynamic conditions is a powerful tool for identifying UMOP (Unintentional-Modulation-on-Pulse) in EW applications or for measuring the phase slopes between states in a phase-coded radar.



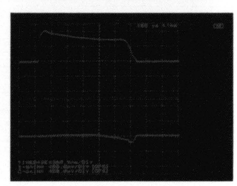
*Spectrum analyzer ▶ display of a pulsed RF waveform. Spectrum analyzers are excellent for spurious content checks but they cannot show the phase information of the pulse.*



*◀Q vs. I display of the vector demodulated signals from a pulsed RF signal. The incidental phase modulation is seen as curved lines connecting the "off" to the "on" states on the I axis. The delta phase marker measures the incidental phase modulation.*



*▲ Pulsed RF waveform as a function of time. Digital oscilloscopes are excellent for measuring pulse rise and fall times but they can't detect phase transients.*



*▲ Time domain displays of the I and Q signals from a vector demodulated pulsed RF signal. The top trace, the I channel, shows the modulated pulse signal. The bottom trace, the Q channel, shows the incidental phase modulation on the RF pulse.*

## Measure Demodulator Image Rejection

Image rejection (IR) is a measure of I/Q demodulator performance. Also known as doppler image suppression, it is a measure of the balance and quadrature between the I and Q channels of a demodulator. Measuring image rejection is especially important for radar receivers because an image might be mistaken for a target.

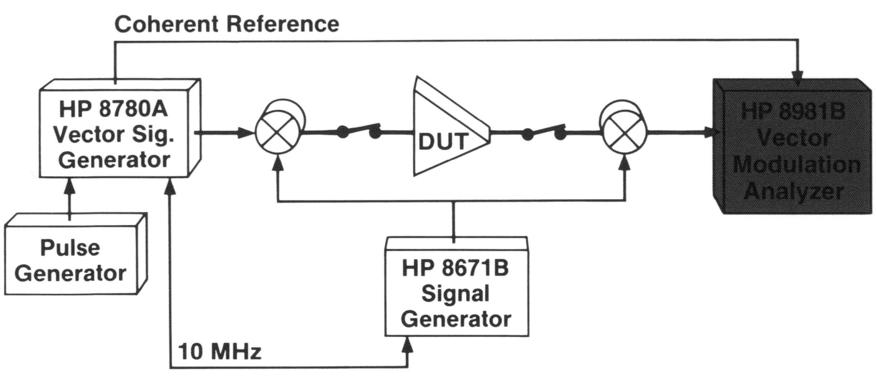
## Gain and Phase Match Pulsed Amplifiers

A modern radar may contain many amplifier modules which must be matched in gain and phase. Network analyzers are the first choice for measuring gain and phase through a two port device. However, it is often necessary to test components under wideband pulsed conditions precluding the use of a network analyzer. When this is the case, the HP 8981B offers another solution.

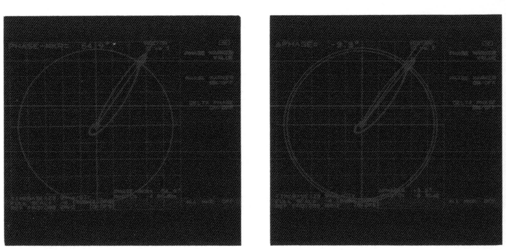
The block diagram for measuring the gain and phase of RF-pulsed devices is shown below. The pulsed IF signal is supplied by the HP 8780A Vector Signal Generator. The generator was selected because it supplies the necessary coherent reference to the demodulator and has negligible unwanted phase modulation. The standard HP 8981B has a built-in demodulator that operates at frequencies between 50 and 200 MHz. If your system requires higher frequencies, a number of special options are available for banded operation up to 1400 MHz.

The HP 8981B Vector Modulation Analyzer measures phase shift and gain of a pulsed signal. By comparing the response with and without the device under test (DUT), unwanted modulation such as AM, FM and PM can be analyzed. By comparing the response with different DUTs, it is easy to match devices as shown in the screen shots below.

*Courtesy of McDonnell-Douglas Corporation*




*Pulsed amplifier test set-up*



*The photo on the left shows the measurements on a RF amplifier. The amplifier is being pulsed at a 1 MHz rate with a 16% duty cycle. In this photo you can see phase transients, but observe what happens when the original amplifer is replace d with another of the same model as shown in photo on the right. Notice that the dot has moved slightly because the second amplifier has different gain and phase characteristics. The delta-markers show that the phase differs from the original device by 3.2 degrees and that the magnitude differs by 0.32 dB. Now the second device can be adjusted to match the first or passed as is. A large number of devices can be tested this way and "matched" to the original reference. For more information, see Application Note 343-2, "Measuring Pulsed RF Performance."*

# A product concept that meets your measurement requirements

## What's a Vector Modulation Analyzer?

The HP 8981B Vector Modulation Analyzer operates in two different modes. In the I/Q mode, it is a calibrated baseband analyzer which connects to the I and Q's output of your receiver's demodulator. In the demod mode, it adds a vector demodulator for IF measurements as well. It connects to the IF output of your transmitter and the coherent reference. The HP 8981B measures signal magnitude and phase and performs constellation analysis of quatrature error, lock angle error and closure to give your reliable, repeatable measurements.

## Powerful Measurement Aids

**Markers:** phase, magnitude, time, I or Q. Delta or absolute measurements.

**Continuous or Single Constellation Analysis:** Statistical analysis that measures I or Q Closure, Lock Angle Error, and Quadrature Error values. The number of points used in the analysis is selectable. Available for QPSK, 9PRS, 16QAM, 25QAM, 64QAM, 256QAM, 49QPR and 81QPR signals.

**Continous or Single I, Q, Phase and Magnitude Measurements:** displays digitized I and Q values measured at the time marker instant as well as calculated phase and magnitude.

**Quadrature Adjust (I/Q Mode only):** allows the user to remove any quadrature error from the signal under consideration, and not have it included in the signal being viewed or in the measurement functions. Range is between –20 and +20 degrees.

**Phase Adjust:** allows the user to subtract out a phase offset error, and not have it included in the signal being viewed or in the measurement functions. Adjustment range is between +360 and –360 degrees.

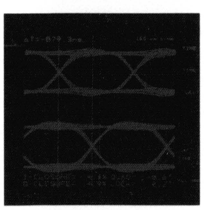
**Print:** Hardcopy output. Screen information is sent to an HP 2225A Thinkjet™ printer.

**Optional Demodulator:** The new optional demodulators for the HP 8981B can be ordered in place of the standard 50 to 250 MHz demodulator. The new modulators are offered in a wide variety of modulation bandwidths and frequency ranges up to 1400 MHz. Most of these demodulators rely on the 8981B demodulator correction routines to provide precise modulation analysis over wide operating ranges. Option H32 is calibrated to operate at 321.4 MHz to accept the IF output of many spectrum analyzers and provide calibrated analog I and Q outputs in addition to precise modulation analysis. The spectrum analyzer can be used as a down-converting receiver whose 321.4 MHz IF output can then be analyzed by the HP 8981B. A 321.4 MHz local oscillator is also required in this application.

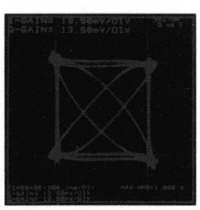
**Optional Demodulators**

| HP 8981B | Freq. Range | RF BW | Calib. Mod. Anal | Calib. I/Q Output |
|---|---|---|---|---|
| Option H20 | 50 – 200 MHz | 70 MHz | Yes | No |
| Option H32 | 200 – 350 MHz | 100 MHz | Yes | No |
| Option H35 | 321.4 MHz | 200 MHz | Yes | Yes |
| Option H36 | 350 – 500 MHz | 150 MHz | Yes | No |
| Option H50 | 360 – 550 MHz | 200 MHz | Yes | No |
| Option H75 | 750 – 1250 MHz | 500 MHz | Yes | No |
| Option H85 | 850 – 1400 MHz | 500 MHz | Yes | No |

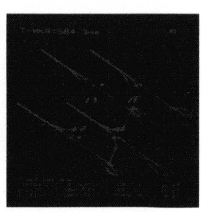
## Display modes:



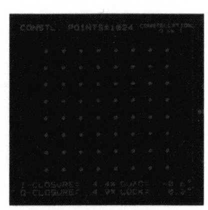
*I & Q Display: each I and Q channel is displayed vs. time on a separate grid, one above the other.*



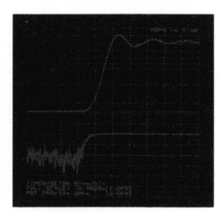
*Vector Display: displays Q vs. I over the time interval specified by the timing controls. Excel-lent for analyzing phase transitions.*



*3D Display: useful for visual or intuitive analysis of Q vs. I vs. time waveforms. Signal can be rotated about any of three axes for optimal viewing.*



*Constellation Display: displays Q vs. I at the time instant defined by the time marker. Useful for constellation analysis of QPSK, 9PRS, 16QAM, 25QAM, 64QAM, 256QAM, 49QPR and 81QPR signals.*



*Magnitude and Phase Display: Magnitude and Phase are displayed vs. time. This display is ideal for analyzing changes in magnitude and phase such as those seen in this pulse transition.*

## Easy-to-Use Set-Up Aids

**Demod Correction (HP 8981A only):** Powerful analysis routine to measure and correct for demodulator quadrature error, I/Q gain imbalance and dc offsets. Available for an external, as well as the built-in, demodulator.

**Auto Scope:** scales voltages, offsets, timing, and trigger for optimal signal viewing. It is possible to independently control which features are Auto-Scoped.

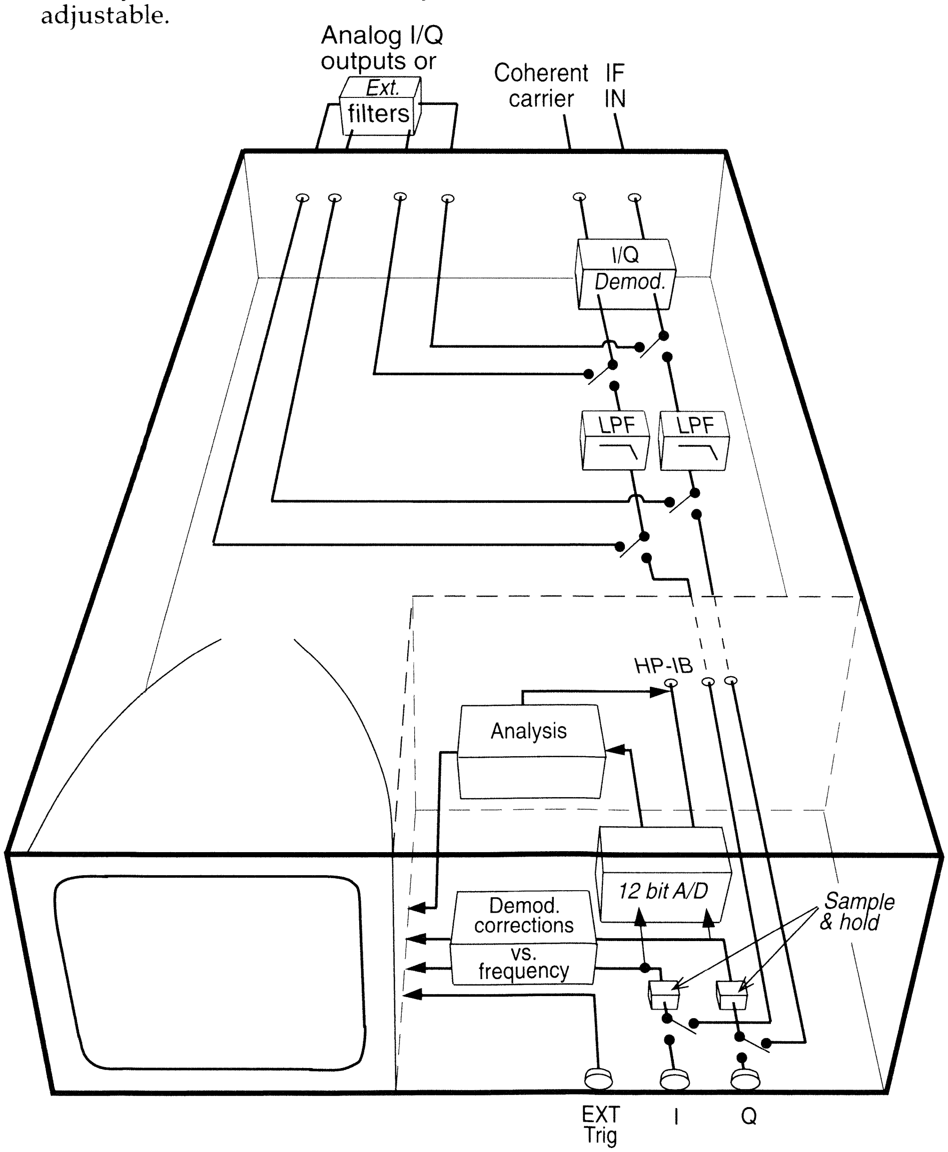
**Gains and Offsets:** I and Q gain are continuously adjustable, and can be set individually or simultaneously. Offsets are individually adjustable.

**Preset:** places the instrument into a known state.

**Save/Recall:** eight front panel settings can be stored in non-volatile memory.

**Help:** provides help messages on the screen for users who need further information about a particular function, including HP-IB mnemonics.

**Gate Input:** useful for measuring a single burst of a time division multiple access (TDMA) signal. This rear panel input disables the display of data on the CRT.




## Traceable to NBS

Hewlett-Packard is committed to the measurement integrity of your test equipment. Because we know if the accuracy is off — even slightly — it could slow or stop production. Most custom test equipment is difficult to calibrate and maintain. That's why switching to an HP Vector Analyzer is such a good idea. Each instrument is calibrated and traceable to the National Bureau of Standards before it leaves our shipping docks.

## High MTBF

If your test equipment goes down, it affects your business. Delays are costly. The HP 8981B Vector Analyzer has a proven track record of a high Mean-Time-Between-Failure (MTBF) of over 17,000 hours. That means greater uptime on your production floor.

## Flexible Service

The Vector Analyzers were designed with serviceability in mind. Standard cal-lab test equipment is all that's required to calibrate and maintain your instrument. If it needs repair, extensive built-in error reporting reduces repair time. You can choose from on-site or return-to-HP service agreements.

*In the I/Q mode, the HP 8981B Vector Modulation Analyzer routes the I and Q input signals to the 1 MHz sample-and-hold circuits that drive the analog CRT. Two 12-bit A/D's operating at a 3 kHz rate digitize these inputs for use in constellation analysis or for off-line processing via HP-IB. In the demod mode, the HP 8981B adds a vector demodulator. The demodulator breaks down the modulated IF signal into its in-phase (I) and quadrature-phase (Q) components. These signals are then switched into the sample-and-hold circuits. Firmware makes IF signal analysis easy.*

# HP 8981B Vector Modulation Analyzer (Demodulator Mode) Specifications

SPECIFICATIONS describe the instruments's warranted performance over the 0°C to 55°C range of operating temperatures. *SUPPLEMENTAL CHARACTERISTICS are intended to provide information useful in applying the instrument by giving typical, but nonwarranted, performance standards at 25°C.* The following conditions apply to all specifications: 1) after a minimum half-hour warm-up, 2) within 5°C of the temperature during internal self-calibration, and 3) when operating from a 50Ω source and using 50Ω input connectors.

"Uncorrected" specifications refer to instrument performance without the internal correction algorithm. "Corrected" performance is achieved after the internal correction algorithm has been run. Either an 8PSK signal or a CW signal offset-in-frequency from the coherent reference is required at the IF input to run the internal correction algorithm.

## *Modulated IF Input*

**Input carrier frequency range:** 50 MHz to 200 MHz
**Input level range:** −5 dBm to −20 dBm

*SUPPLEMENTAL CHARACTERISTICS*

***Minimum input frequency:*** *20 MHz*

***AM-AM conversion (−5 dBm input power):*** *< 0.1 dB/dB*

***AM-PM conversion (−5 dBm input power):*** *< 0.5°/dB*

***Signal-Noise ratio with internal filters:*** *> 40 dB*

***VSWR (50Ω input):*** *< 1.4:1*

***Input Impedance:*** *50Ω nominal (75Ω with interchangeable adapter)*

## *Coherent Reference Input*

**Input frequency range:** 50 MHz to 200 MHz

**Input level range:** +10 dBm to −20 dBm

*SUPPLEMENTAL CHARACTERISTICS*

***Reference phase vs. level sensitivity:***
*70 MHz Coherent Reference input: < 1°/dB*
*140 MHz Coherent Reference input: < 1.6°/dB*

***VSWR:*** *< 2:1*

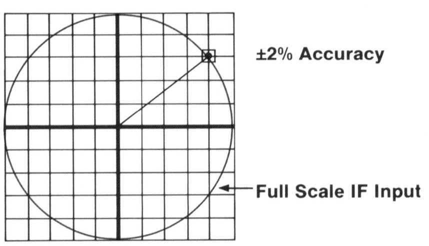
***Input Impedance:*** *50Ω nominal*

## *Demodulated I and Q*

**Baseband bandwidth with external filters (3 dB):** > 100 MHz

**I vs. Q Timing Accuracy:** ±1.5 ns or 1% of full-scale I or Q input, whichever is greater; I Delay, Q Delay = 0.

**Corrected Vector dc accuracy at 70 MHz:** (typical from 50 to 200 MHz) <±2% of full scale IF input



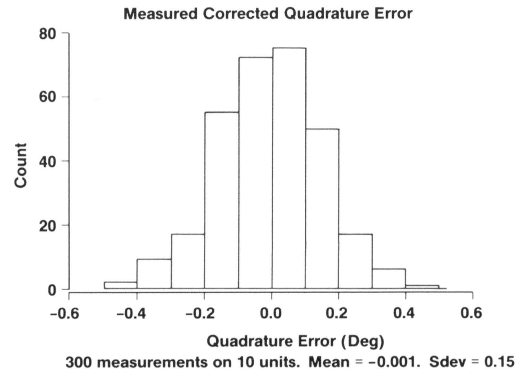

## *Demodulated I and Q (cont'd)*

*SUPPLEMENTAL CHARACTERISTICS*

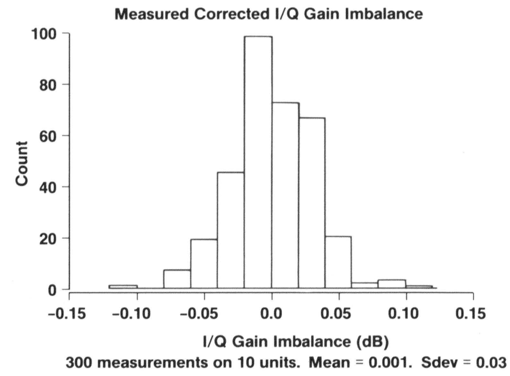
***Baseband bandwidth with internal filters (3 dB):*** 35 MHz

***Uncorrected Vector dc Accuracy:*** *< ±2.5% of full scale IF input*

***Quadrature Error:***
*Corrected: < ±0.5°   Uncorrected: < ±1°*



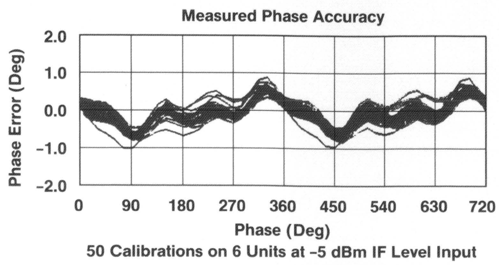

***I/Q Gain Imbalance (dc to 10 kHz):***
*Corrected: < ±0.1 dB   Uncorrected: < ±0.25 dB*



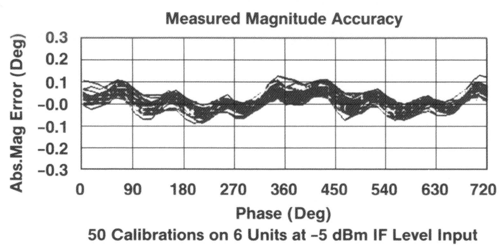

***Residual dc offsets (% of full scale IF input):***
*Corrected: < ±1%   Uncorrected: < ±4%*

## *Demodulated I and Q (cont'd)*

***Phase Accuracy:*** *Corrected:* $< \pm 1.6°$




***Magnitude Accuracy:*** *Corrected:* $< \pm 0.24$ *dB*




***I and Q amplitude flatness (dc to 20 MHz with internal filters):*** $< \pm 0.3$ *dB*

***I and Q amplitude flatness matching (dc to 20 MHz with internal filters):*** *< 0.2 dB*

***Crosstalk between I and Q at:***
*70 MHz carrier (40 MHz IF bandwidth): < 0.6%*
*140 MHz carrier (80 MHz IF bandwidth): < 0.6%*

***Absolute level accuracy:*** *< 1.2 dB*

## *Spurious Signals*

*SUPPLEMENTAL CHARACTERISTICS*

***Harmonics of baseband tones dc to 10 kHz (< −5 dBm IF input power):*** *< −40 dBc*

***Internal Filters***
***Isolation from Modulated IF input to I/Q:***
***dc to 50 MHz:*** *> 24 dB*
***> 50 MHz:*** *> 60 dB*

***Isolation from Coherent Reference input to I/Q at −20 dBm IF input:*** *> 40 dB*

***External Filters***
***Isolation from Modulated IF input to external filter I/Q outputs:*** *> 24 dB*

***Isolation from Coherent Reference input to external filter I/Q outputs at −20 dBm IF input:*** *> 10 dB*

***Isolation from external filter output to external filter input:*** *> 45 dB*

## *External Filter I and Q Ports*

*SUPPLEMENTAL CHARACTERISTICS*

***Signal level for −20 dBm inputs:*** *> 50 mV p-p*

***VSWR (dc to 40 MHz):*** *< 1.3:1*

***Impedance:*** *50Ω nominal*

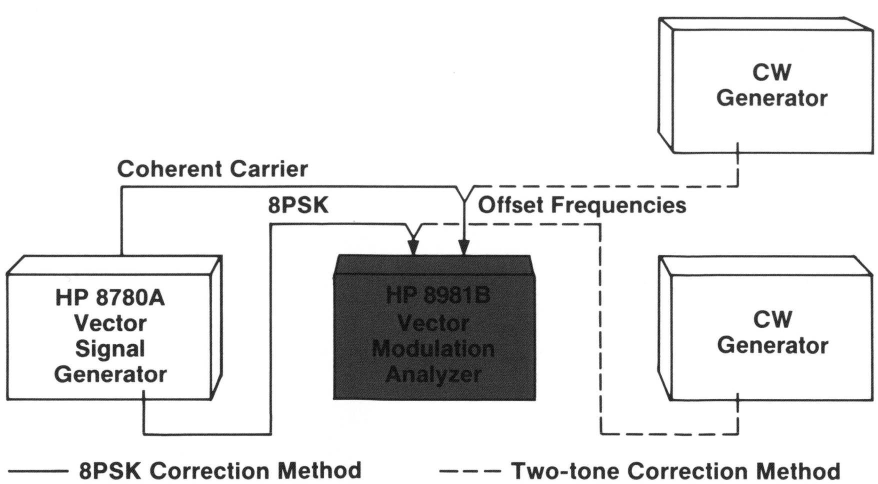
***Quadrature error:*** $< \pm 8°$

***Residual dc offsets (at −20 dBm IF input):*** *< 20% of full scale IF input*

***I/Q gain imbalance (dc to 10 kHz):*** $< \pm 0.5$ *dB*

***I and Q amplitude flatness (dc to 40 MHz):*** $< \pm 0.3$ *dB*

***I and Q amplitude flatness matching (dc to 40 MHz):*** *< 0.2 dB*




*Easy-to-run internal correction algorithm provides "corrected" specification performance. Choose between two alternative signal sources: 1) an 8PSK modulated signal and a coherent carrier, or 2) two CW tones offset in frequency by approximately 100 kHz.*

# HP 8981B Vector Modulation Analyzer (I/Q Mode) Specifications

SPECIFICATIONS describe the instruments's warranted performance over the 0°C to 55°C range of operating temperatures. *SUPPLEMENTAL CHARACTERISTICS are intended to provide information useful in applying the instrument by giving typical, but nonwarranted, performance standards at 25°C.* The following conditions apply to all specifications: 1) after a minimum half-hour warm-up, 2) within 5°C of the temperature during internal self-calibration, and 3) when operating from a 50Ω source and using 50Ω input connectors.

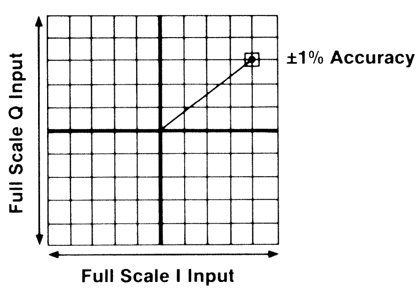
## *I and Q Channels*

**Bandwidth (−3 dB):** 350 MHz dc coupled; approximately 1 kHz to 350 MHz, ac coupled.

**Input Sensitivity:** 5 mV/div to 1 V/div, continuously adjustable.

**I or Q Offset Range:** ± 10 divisions

**DC Vector Accuracy Using Internal ADC:** ± 1% of full scale I or Q input (or 2 mV if greater) ± 1% of offset.




**I vs. Q Differential Voltage Accuracy Using Internal ADC:** ± 1% measured at 100 mV full-scale deflection, typical at all ranges.

**Maximum DC Coupled Input Voltage:** ± 5V peak.

**Maximum AC Coupled Input Voltage:** ± 25 Vdc; ± 5V peak ac.

*SUPPLEMENTAL CHARACTERISTICS*

***Transition Time (10% to 90%):*** *1 ns.*

***Deflection Factor Accuracy:*** *± 2%.*

***I or Q Vector Accuracy Using I or Q Marker:*** *± 3% of full scale I or Q input (or 2 mV if greater) ± 1% of offset.*

***I vs. Q Differential Voltage Accuracy Using I and Q Markers:*** *± 2% of full-scale I or Q input.*

***Display Offset Accuracy:*** *± 2% of full-scale I or Q input (or 2 mV if greater), for a zero volt signal and I Offset, Q Offset = 0.*

***I-Q Crosstalk:*** *−60 dB or 1% of full-scale I or Q input peak, whichever is greater, dc to 350 MHz.*

***Input Termination:*** *50Ω or 75Ω, with interchangeable adaptors.*

***Input Protection:*** *Each input is protected by a relay for overvoltages up to 30 volts peak ac + dc.*

***Input Coupling:*** *ac coupling, dc coupling, or ground (input disconnected).*

***Worst Case Phase Error Using Internal ADC:***

$\Delta\theta = \tan^{-1}(\Delta Mag/\sqrt{I^2+Q^2})$ *for* $\theta = 45°$

## *I and Q Channels (cont'd)*

***Worst Case Magnitude Error Using Internal ADC:***

$\Delta Mag = \pm\sqrt{\Delta I^2+\Delta Q^2}$, *where*
$\Delta I = .01x(\text{full-scale } I) + .01x(I \text{ offset})$, *and*
$\Delta Q = .01x(\text{full-scale } Q) + .01x(Q \text{ offset})$

## *Timing*

**Acquisition Method:** repetitive sampling

**Time per Division Range:** 500 ps/div to 2 ms/div, continuously adjustable.

**Delay I & Q Range:** 0 to 100 divisions for specified performance, 20 ms maximum.

**I Delay, Q Delay Range:** 0 to 5 divisions, 20 μs maximum.

**Delta Time Accuracy:** ± 3% specified for delta times greater than 6 ns or 2 div, whichever is larger; start times greater than 20 ns or 1 div, whichever is larger.

**I vs. Q Timing Accuracy:** ± 0.5 ns or 1% of full-scale I or Q input, whichever is greater; I Delay, Q Delay = 0.

*SUPPLEMENTAL CHARACTERISTICS*

***Time / Division Accuracy:*** *± 3%.*

***Delay Reference Accuracy:*** *Leading edge of pulse is visible (external or internal trigger); <5 ns or 2% of full-scale, whichever is greater (internal trigger only), Delay I & Q = 0.*

***Delay Accuracy:*** *± 3% + Delay Reference Accuracy.*

***Time Base Jitter:*** *2% of full-scale rms for delays less than 200 divisions.*

## *Triggering*

**Minimum External Trigger Signal:**
100 mV p-p (dc to 80 MHz)
200 mV p-p (80 MHz to 150 MHz).

**Minimum Internal Trigger Signal:**
2 divisions p-p (dc to 80 MHz)
3 divisions p-p (80 to 150 MHz).

**Maximum External Trigger Input:** ± 5V peak dc + ac, 5V p-p ac.

*SUPPLEMENTAL CHARACTERISTICS*

***Trigger Sources:*** *selectable from external, internal I, internal Q, or LINE. External trigger and internal I or Q triggers require selection of triggering levels and/or termination.*

***External Trigger Terminations:*** *50Ω or 75Ω, with interchangeable adaptors.*
*ECL: 50Ω or 75Ω to −2V.*
*GND: 50Ω or 75Ω to gnd.*

## *Triggering (cont'd)*

***External Trigger Levels:***
*ECL: triggers on ECL threshold.*
*TTL: triggers on TTL threshold.*
*VAR: adjustable trigger threshold.*
*AUTO: continuously adjusted to halfway between high and low input levels for frequencies ≈ 1 kHz input frequencies.*

***Internal I or Q Trigger Levels:*** *Internal trigger levels are adjustable within the variable trigger range specified below.*
*Note: ac triggering on dc-coupled input signals is selectable.*

***Minimum Signal Pulses:***
*External Trigger: 200 mV p-p (> 3 ns width).*
*Internal Trigger: 20% of full-scale p-p (> 3 ns width).*

***Variable Trigger:***

| | Internal I or Q Trigger | External Trigger |
|---|---|---|
| *Range* | *Anywhere on screen* | *±5V* |
| *Resolution* | *2% of full-scale* | *40 mV* |
| *Accuracy* | *±5% of full-scale* | *±100 mV* |

## *Gate*

*SUPPLEMENTAL CHARACTERISTICS*

***Gate Operation:*** *rear panel input pulse (high) blanks the display and disables measurements asynchronously with the trigger rate.*

***Gate Input Termination and Trigger Levels:***
*GND termination with TTL trigger level.*
*−2V termination with ECL trigger level.*
*GND termination with 0V trigger level.*

***Minimum Gate Pulse Width:*** *100 ns (on or off).*

***Gate Timing:*** *0 to 5 ns prior to display time instant.*

## *Digitizer*

**Resolution:** 12 bits.

**Digitizing Rate:** 3 kHz maximum.

**Measurement Noise:** 4 counts rms.

## *Remote Programming*

All functions are HP-IB programmable except the line switch.

**HP-IB Interface Functions:** SH1, AH1, T5, TE0, L3, LE0, SR1, RL1, PP1, DC1, DT0, C0, E2.

## *General*

**Warm-up:** To achieve specified performance the instrument should be recalibrated from the front panel after a ½-hour warm-up and after every 8 hours of operation or after a 5°C temperature change.

**Temperature:**
Operating: 0°C to +55°C (+32°F to +131°F).
Non-operating: −40°C to +75°C (−67°F to +167°F).

**Humidity:**
Operating: up to 95% relative humidity at +40°C (+104°F).

**Vibration:** vibrated in three orthogonal axes for 15 minutes each axis; 0.38 mm (0.015") peak-to-peak excursion; 5 to 55 Hz; 1 minute/octave sweep.

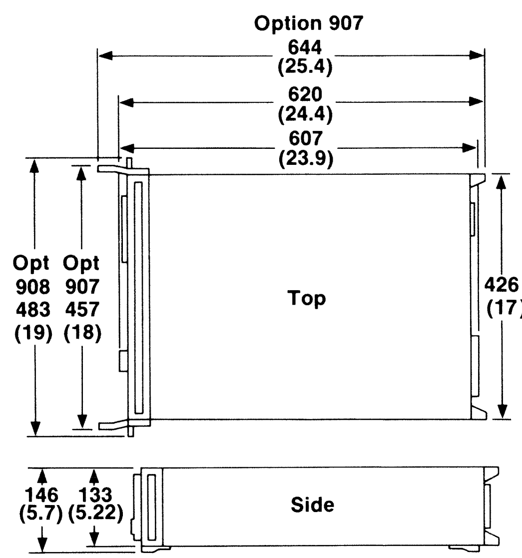
**Shock:** 1/2 sin 30 g's; 11 ms duration.

**EMI:** Conducted and radiated interference is within the requirements of CE03, CS01, CS02, RE02, RS01 and RS03 of MIL-STD-461B. It is also within the requirements of VDE 0871/1978, Level B and CISPR publication 11 (1975).

**Power Requirements:** Voltage: 100, 120, 220, 240 Vac, −10% to +10%; 48-66 Hz, 330 VA.

**Weight:**
Net: approximately 20 kg (45 lb).
Shipping: approximately 24 kg (53 lb).

**Dimensions;** Package is 5¼" rack height, one module width, 23D HP System II cabinet. Dimensions are in millimetres and (inches).



# You've got a measurement partner

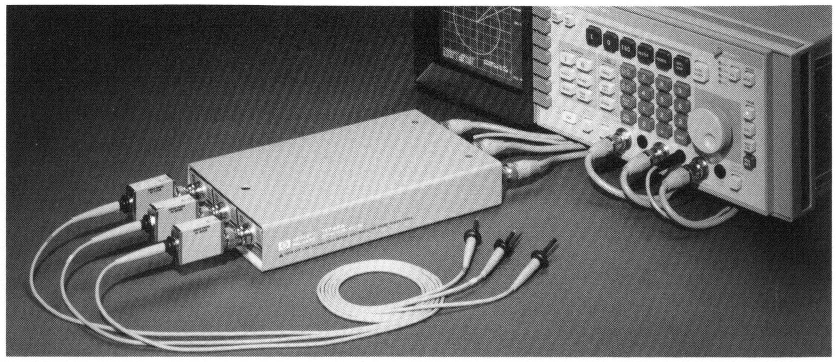
We stand behind every vector analyzer we sell with a commitment to continued customer satisfaction reflected in a variety of accessories, related products and application literature.

## *Probes*

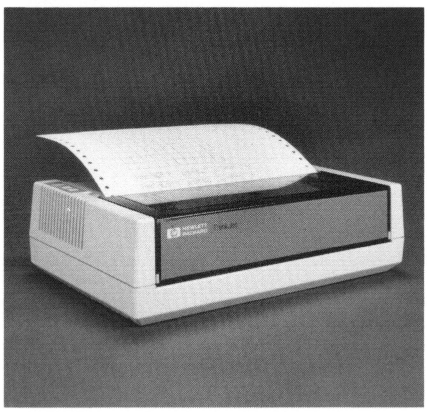
**HP 11748A Active Probe System →**

The HP 11748A Active Probe System conveniently provides three wide bandwidth (250 MHz) active probes in one package for high impedance probing of I, Q and clock signals. The HP 11748A includes an input assembly, the three probes and all necessary cables.

**Division Ratio:** 10:1
**Typical Circuit:** 1 MΩ/7.5 pF
**Bandwidth:** 250 MHz
**Output Impedance:** 50Ω



## *Computer Accessories*

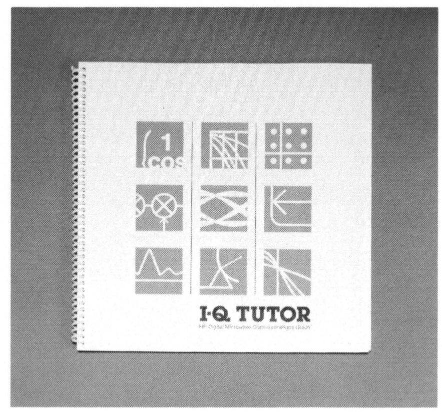


**← HP 2225A ThinkJet™ Printer**

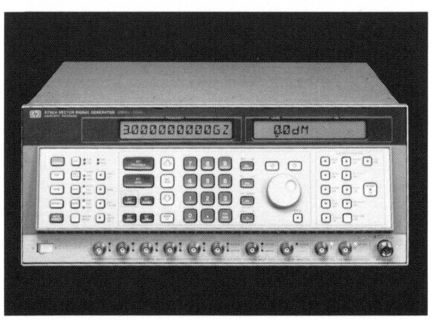
The HP 2225A ThinkJet™ Printer provides hardcopy output of the Vector Analyzer Display.

**I·Q Tutor →**

I·Q Tutor is a computer program that teaches the basics of vector modulation by simulating the operation of a digital microwave radio. For HP Vectra/IBM-PC/AT compatibles, order HP part number 11736B.




## *Related Instruments*

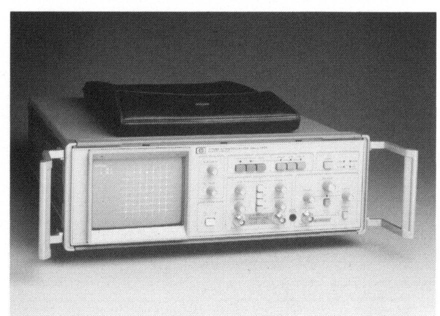


**← HP 8780A Vector Signal Generator**

A synthesized signal generator with versatile digital, pulse and vector modulations for simulating communications and radar/EW signals.

**HP 3709B Constellation Analyzer →**

Similar to the HP 8981B Vector Analyzer but designed specifically for the service and maintenance of digital microwave radios. Quantifies nonlinear distortion measurements.



**← HP 8782B Vector Signal Generator**

A lower cost synthesized signal generator that covers 1 to 250 MHz for generating IF communications signals. The HP 8782B offers digital, pulse and vector modulations. An optional 1 GHz LO output is available for mixing up to 750 to 1250 MHz for RF testing in Mobile communications applications.

## *Options*

Furnished with each HP 8981B: Power Cord, Operating Manual.

**Front Handle Kit (Option 907)**
Available separately as
HP part no. 5061-9689.

**Rack Flange Kit (Option 908)**
For rack mounting the HP 8981B without front handles attached. Available separately as
HP part no. 5061-9677.

**Rack Flange and Front Handle Kit (Option 909)**
For rack mounting the HP 8981B with front handles. The kit includes front handles. Available separately as
HP part no. 5061-9683.

**Add Service Manual (Option 915)**
Available separately as
HP part no. 08981-90019.

**Add Extra Operating Manual ((Option 916)**
Available separately as HP part no. 08981-90017.

**90-Day On-Site Warranty Conversion (Option W03)**
Converts the standard one-year return-to-HP support to a 90-day on-site support (where available).

**3-Year Extended Return-to-HP Support (Option W30)**
Adds 2 additional years of return-to-HP support to your normal one-year return-to-HP warranty. Return-to-HP support does not include annual maintenance or calibrations.

**Rack Mount Slide Kit**
This kit is not available as a factory installed option. Available separately: HP part no. 1494-0059.

These slides can be directly mounted in an HP system enclosure. If the rack mount-ing slides are to be mounted in a standard EIA rack, then an adapter (HP part no. 1494-0061) is required.

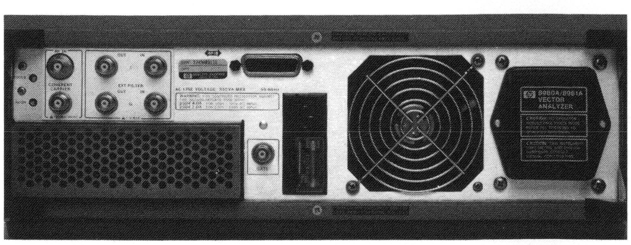
**Transit Case**
For instrument transport. Available separately as HP part no. 9211-2661.

**Optional demodulators**
There are a number of optional internal demodulators available in place of the 50 – 250 MHz standard demodulator for banded coverage to 1400 MHz.
Option H20: 50 – 200 MHz
Option H32: 321.4 MHz
Option H35: 350 – 500 MHz
Option H36: 360 – 550 MHz
Option H50: 500 – 900 MHz
Option H75: 750 – 1250 MHz
Option H85: 850 – 1400 MHz

## *Ordering Information*

The following options are available on the HP 8981B:
Option 907: Front Handle Kit
Option 908: Rack Flange Kit
Option 909: Rack Flange and Front Handle Kit
Option 915: Add Service Manual
Option 916: Add Extra Operating Manual
Option W03: 90-Day On-Site Warranty Conversion (where available)
Option W30: 2 Additional Years of Return-to-HP Service

## *Vector Modulation Analyzer Rear Panel*



**HEWLETT PACKARD**

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