Agilent 89441V

dc to 2.65 GHz VSB/QAM Signal Analyzer

Data Sheet

Agilent Technologies 89441V

Specifications describe warranted performance over the temperature range of 0° to 55°C (except where noted) and include a 30-minute warm-up from ambient conditions, automatic calibrations enabled, auto-zero on, time domain calibration off, and anti-alias filter in, unless noted otherwise. Supplemental characteristics, identified as "typical" or "characteristic," provide useful information by giving non-warranted performance parameters. Typical performance is applicable from 20° to 30°C.

When enabled, automatic calibrations are periodically performed to compensate for the effects of temperature and time sensitivities. During the calibration, no signals >0 dBm should be connected to the front panel inputs.

Definitions

Baseband: dc to 10 MHz measurements.

Baseband time: Time-domain measurements selected by setting start frequency to exactly 0 Hz or choosing full span in 0 to 10 MHz measurements.

dBc: dB relative to input signal level.

dBfs: dB relative to full scale amplitude range setting. Full scale is approximately 2 dB below ADC overload.

FS or fs: Full scale; synonymous with amplitude range or input range.

RBW: Resolution bandwidth.

RF: 2 MHz to 2.65 GHz measurements.

Scalar mode: Measurements with only frequency-domain analysis available. Frequency spans up to 2648 MHz.

SNR: Signal to noise ratio.

Vector mode: Measurements with frequency- and time-domain capabilities. Frequency spans up to 10 MHz in baseband, and 8 MHz for RF analysis.

Zoom time: Time-domain measurements selected by setting frequency parameters using center frequency and span values.

Agilent 89441V Technical Data—Standard Features

Frequency
dc to 2.650 GHz
51 to 3201 points
Center frequency signal-tracking
Instrument modes
Scalar (frequency-domain only)
Vector (amplitude and phase information in frequency- and time-domain and also time-gating)
Sweep types
Continuous, Manual, Single
Triggering
Free run
Input channel
IF channel
GPIB
Trigger holdoff
External
External arm
Programmable polarity and level
Pre and post delay
Averaging
Video
Video exponential
Time
Time exponential
Peak hold
Simultaneous display of instantaneous and average spectrum
Source Types
CW, Random noise
Input
One channel
Second 10 MHz input channel (optional)
Auto-ranging (baseband only)
Overload indicators
50/75/1M Ω BNC (dc to 10 MHz)
50 Ω Type-N, 75 Ω with minimum-loss pad (2 MHz to 2650 MHz)
Resolution/window shapes
1-3-10 bandwidth steps
Arbitrary RBW
Windows: Flat-top (high amplitude accuracy), Gaussian-top (high dynamic range), Hanning (high frequency resolution), Uniform
Detectors: normal, positive peak, sample
Measurement data
Spectrum
PSD
Main time
Gate time
Math function
Data register
Auto correlation
Time capture
Frequency response, coherence, cross spectrum, and cross correlation (with second 10 MHz input channel)
Instantaneous spectrum
Additional data formats for video demodulation
Data format
Log magnitude
Linear magnitude
Phase (wrap or unwrap)
Real part
Imaginary part
Group delay
Log/linear x-axis
Trace math
Display
1, 2, or 4 grids
1 to 4 traces displayed (single or overlay)
Auto-scaling
Color (user definable)
User trace title and information
Graticule on/off
Data label blanking
X-axis scaling
Instrument/Measurement state displays
External monitor
Markers
Marker search: Peak, next peak, next peak right, next peak left, minimum
Marker to: Center frequency, reference level, start frequency, stop frequency
Offset markers
Couple markers between traces
Marker functions: Peak track, frequency counter, band power (frequency, time, or demodulation results)
peak/average statistics
Memory and data-storage
Disk devices
Nonvolatile RAM disk (100 Kbyte)
Volatile RAM disk (up to 1 Mbyte)
90 mm (3.5-inch) 1.44 Mbyte flexible disk (HP LIF or MS-DOS® formats)
External GPIB disk
Disk format and file delete, rename, and copy
Nonvolatile clock with time/date
Save/recall of: Trace data, instrument states, trace math functions, Instrument BASIC programs, time-capture buffers
Online help
Hard copy output
GPIB/HPGL plotters
GPIB/RS-232/parallel printers
Plot to file
Time stamp
Single-plot spooling
Interfaces
GPIB (IEEE 488.1 and 488.2)
External reference in/out
External PC-style keyboard
Active probe power
RS-232 (one port)
Centronics
LAN and second GPIB
Standard data format utilities
Optional features
Instrument BASIC (Option 1C2)
Advanced LAN support (Option UG7)

Agilent 89441V Technical Data—RF

RF specifications apply with the receiver mode set to "RF section (2-2650 MHz)."

Frequency

Frequency tuning

Frequency range	2 MHz to 2650 MHz
Frequency span	
Scalar mode	1 Hz to 2648 MHz
Vector mode	1 Hz to 8 MHz
Center frequency tuning resolution	0.001 Hz
Number of frequency points/span	51 to 3201

Signal track (when enabled) keeps the largest measured signal at the center frequency.

Frequency accuracy

(with standard high-precision frequency reference)

Frequency accuracy is the sum of initial accuracy, aging, and temperature drift.

Initial accuracy	± 0.1 ppm
Aging	± 0.015 ppm/month
Temperature drift	± 0.005 ppm (0° to 55°C)

Frequency counter

The frequency counter operates in scalar or vector mode.

Frequency counter accuracy:

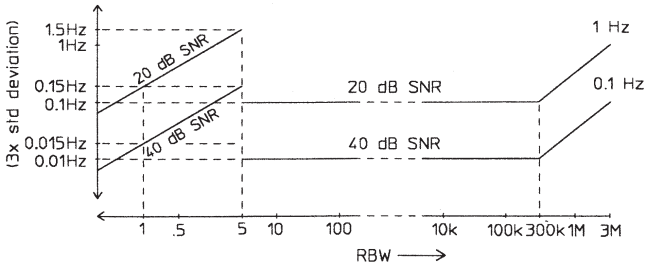
Total accuracy is the sum of the frequency counter's basic accuracy and the instrument's frequency accuracy.

Conditions/Exceptions:

Signal-to-noise ratio within resolution bandwidth, 20 dB minimum

Marker within ½ resolution bandwidth of peak

Unspecified for uniform window and resolution bandwidth < 5 Hz



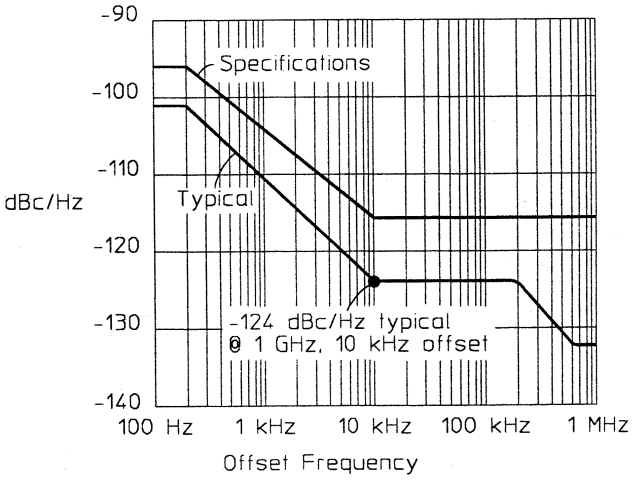
Frequency counter basic accuracy

Stability (spectral purity)

(with standard high-precision frequency reference or equivalent with ≥ 5 dBm level)

Phase noise (absolute and residual)

$F_{in} \leq 200$ MHz	
100 Hz offset	< –103 dBc/Hz
1 kHz offset	< –112 dBc/Hz
≥ 10 kHz offset	< –116 dBc/Hz
200 MHz ≤ $F_{in} \leq$ 1 GHz	
100 Hz offset	< –96 dBc/Hz
1 kHz offset	< –104 dBc/Hz
≥ 10 kHz offset	< –116 dBc/Hz
1 GHz ≤ $F_{in} \leq$ 2650 MHz	
100 Hz offset	< –87 dBc/Hz
1 kHz offset	< –97 dBc/Hz
≥ 10 kHz offset	< –116 dBc/Hz
LO spurious sidebands	
Offset > 1 kHz	< –75 dBc
Offset ≤ 1 kHz	
$f_{in} \leq$ 2 GHz	< –70 dBc
f_{in} > 2 GHz	< –68 dBc



Spectral purity at 1 GHz

Agilent 89441V Technical Data—RF, continued

Resolution bandwidth
Range 312.5 µHz to 3 MHz in 1, 3, 10 sequence or arbitrary user-definable bandwidth

Note: In scalar mode, the minimum resolution bandwidth is 312.5 µHz and the maximum resolution bandwidth is a function of span. In vector mode, the minimum resolution bandwidth is a function of span and the number of frequency points, and the maximum resolution bandwidth is a function of span only.

Window	Selectivity*	Passband flatness	Sideband level
Flat-top	2.45:1	+ 0, –0.01 dB	–95 dBc
Gaussian-top	4.0:1	+ 0, –0.68 dB	–125 dBc
Hanning	9.1:1	+ 0, –1.5 dB	–32 dBc
Uniform	716:1	+ 0,–4 dB	–13 dBc

* Shape factor or ratio of –60 dB to –3 dB bandwidths.

Amplitude

Input range –50 dBm to + 25 dBm (5 dB steps)

Maximum safe input power
Average continuous power + 25 dBm (300 mW)
DC voltage 25 V
A/D overload level (typical) > 1.5 dB above range

Input port
Input channels 1
VSWR
Range ≥ –20 dBm 1.6:1 (12.7 dB return loss)
Range ≤ –25 dBm 1.8:1 (11 dB return loss)
Impedance 50 Ω (75 Ω with minimum-loss pad Option 1D7)
Connector Type-N

Amplitude accuracy
Accuracy specifications apply with flat-top window selected.
Amplitude accuracy is the sum of absolute full-scale accuracy and amplitude linearity.
Absolute full-scale accuracy (with signal level equal to range)

	20° - 30°C	0° - 55°C
≥ –25 dBm range	± 1 dB (0.5 dB typical)	± 2 dB
≤ –30 dBm range	± 1.5 dB (0.5 dB typical)	± 3 dB

Amplitude linearity
0 to –30 dBfs < 0.10 dB
–30 to –50 dBfs < 0.15 dB
–50 to –70 dBfs < 0.20 dB

In vector mode, relative level accuracy within a single span is the sum of vector mode frequency response and amplitude linearity.

Vector mode frequency response (relative to the center frequency) ± 0.4 dB

Dynamic range
Dynamic range indicates the amplitude range that is free of erroneous signals within the measurement bandwidth.

Harmonic distortion (with a single full scale signal at the input)
≥ –25 dBm range < –75 dBc
≤ –30 dBm range < –54 dBc
Third-order intermodulation distortion (with two input tones at 6 dB below full scale and ≥ 10 MHz) < –75 dBc

General spurious (with input signal level equal to range and input frequency ≤ 2650 MHz)
For spans ≤ 1.5 MHz and for offset frequencies ≤ 1.5 MHz from input signal < 75 dBc
For all spans and offsets < –70 dBc*
Residual responses (50 Ω input) < – 80 dBfs

Input noise density (50 Ω input, vector mode or scalar mode with sample detector)**

	20° - 30°C	0° - 55°C
≥ –25 dBm range	< –115 dBfs/Hz	< –112 dBfs/Hz
≤ –30 dBm range	< –110 dBfs/Hz	< –109 dBfs/Hz

Sensitivity**
–50 dBm range < –160 dBm/Hz < –159 dBm/Hz/Hz

*< –60 dBc for RF (2-2650 MHz)-wide
** Add 4 dB for RF (2-2650 MHz)-wide

Phase (vector mode)

Phase specifications apply with flat-top window selected.

Deviation from linear phase ± 5 deg
(relative to best fit line with peak signal level within 6 dB of full scale)

Time (vector mode)

Time-sample resolution = 1/(k*span(Hz)) [second]; where k = 1.28 for zoom time.

Main time length = (number of frequency points – 1) ÷ span (Hz) [second]; for resolution bandwidth in arbitrary and auto-coupled mode.

Amplitude accuracy (for a sine wave in the measurement passband, time-domain calibrations on, range ≥ –25 dBm)

20° - 30°C	± 12% full scale (± 6% typical)
0° - 55°C	± 26% full scale

Sample error rate for zoom time (typical)

Error threshold: 5% full scale	10^{-8} times/sample

Sample error rate reflects the probability of an error greater than the error threshold occurring in one time sample.

Trigger

Trigger types

Scalar mode	Free run, GPIB, external (each measurement step requires a separate trigger)
Vector mode	Free run, IF channel, GPIB, external

Pre-trigger delay range
(see time specifications for sample resolution)

One channel	64 Ksamples (1 Msample with extended time capture, Option AY9)
Two channels (requires second 10 MHz input, Option AY7)	32 Ksamples (0.5 Msample with extended time capture, Option AY9)

Post-trigger delay range 2 Gsample
(see time specifications for sample resolution)

Trigger holdoff
When enabled, each measurement requires two trigger events. The first event starts a holdoff timer. After the specified holdoff time, a subsequent trigger event will initiate a measurement.

Holdoff resolution	2.5 µs
Holdoff range	2.5 µs to 41 s

IF trigger (characteristics only)
Used to trigger only on in-band energy, where the trigger bandwidth is determined by the measurement span (rounded to the next higher $10^7/2^n$ [Hz]).

Amplitude resolution	< 1 dB
Amplitude ranges	+1 to –70 dBfs. Useable range will become limited by the total integrated noise in the measurement span.
IF trigger hysteresis	< 4 dB

External trigger (positive and negative slope)

Level accuracy	± 0.5 V
Range	± 5 V
Input impedance	10 kΩ (typical)

External arm

Level accuracy	± 0.5 V
Range	± 5 V
Input impedance	10 kΩ (typical)

Agilent 89441V Technical Data—RF, continued

Source (requires internal RF source Option AY8)

Source types

(vector mode and video demodulation)	CW (fixed sine), random noise

Frequency

Range	2 MHz to 2650 MHz
Maximum offset from center frequency	3.5 MHz

Amplitude (fixed sine source type)

Amplitude range	–40 dBm to +13 dBm
Typical maximum amplitude (overdrive is available using direct numeric entry)	+17 dBm
Amplitude resolution	0.1 dB

Amplitude accuracy (source level ≤ 13 dBm)

Source amplitude accuracy is the sum of absolute accuracy at the center frequency (zero offset frequency) and the IF flatness.

	20° - 30°C	**0° - 55°C**
Absolute accuracy at the center frequency	± 1.2 dB	± 3.5 dB
IF flatness (relative to center frequency)	± 1 dB	± 1.5 dB
IF Flatness with |offset frequency| ≤ 500 kHz		± 0.3 dB

Dynamic range (source level ≤ dBm)

Harmonic distortion	< –40 dBc
Non-harmonic spurious (within measurement bandwidth)	< –40 dBc
Average noise level (for offsets > 1 MHz from the carrier and carrier frequency >100 MHz. For offsets < 1 MHz, add the LO phase noise.)	< –120 dBc/Hz

Crosstalk (source-to-receiver, source level ≤ 0 dBm)	< –80 dBfs

Source port

VSWR	
Level ≤ –10 dBm	1.8:1 (11 dB return loss)
Impedance	50 Ω (75 Ω with optional minimum-loss pad)
Connector	Type-N

Agilent 89441V Technical Data—Baseband

Baseband specifications apply with the receiver mode set to "IF section (0-10 MHz)" or "RF section (0-10 MHz)" unless noted otherwise. Specifications noted as "IF section only" apply with the receiver mode set to "IF section (0-10 MHz)" and the input signal connected directly to the IF section's channel 1 or channel 2 input.

Frequency

Frequency tuning (characteristic only)

Frequency range	dc to 10 MHz
Frequency span	1.0 Hz to 10 MHz
Center frequency tuning resolution	0.001 Hz
Number of frequency points/span	51 to 3201

Signal track (when enabled) keeps the largest measured signal at the center frequency.

Frequency accuracy

Same as the RF specifications.

Frequency counter

Same as the RF specifications.

Stability (spectral purity)

Absolute and residual phase noise, F_{in} = 10 MHz (with standard high precision frequency reference or equivalent)

100 Hz offset	< –106 dBc/Hz
1 kHz offset	< –110 dBc/Hz
≥ 10 kHz offset	< –120 dBc/Hz

Phase noise decreases with decreasing input frequency by $20 \log_{10} \left| \frac{Fin}{10\ \text{MHz}} \right| dB$

Resolution bandwidth

Same as the RF specifications.

Amplitude

Input range (characteristic only) (2 dB steps)

50 Ω input	–30 dBm to + 24 dBm
75 Ω input	–31.761 dBm to +22.239 dBm
1 MΩ input	–30 dBm to + 28 dBm

(referenced to 50 Ω)

Maximum safe input power

50 Ω/75 Ω input	+27 dBm
1 MΩ input	20 V Peak

Auto-ranging (characteristic only)

Up-only, up-down, single, off

Input port

Input channels	1 (second 10 MHz input channel optional)
Return loss (IF section only)	
50 Ω input	> 25 dB
75 Ω input	> 20 dB
Coupling	dc/ac (ac coupling attenuation < 3 dB at 3 Hz)
Input Impedance (IF section only)	50/75 Ω, 1 MΩ ± 2% (< 80 pF shunt capacitance)
Connector	BNC (RF section: Type-N)

Amplitude accuracy

Accuracy specifications apply with flat-top window selected.

Amplitude accuracy is the sum of absolute full-scale accuracy and amplitude linearity.

Absolute full-scale accuracy (IF section only, with signal level equal to range)	± 0.5 dB
Amplitude linearity	
0 to –30 dBfs	< 0.10 dB
–30 to –50 dBfs	< 0.15 dB
–50 to –70 dBfs	< 0.20 dB
Residual dc (50 Ω)	< –25 dBfs

Agilent 89441V Technical Data—Baseband, continued

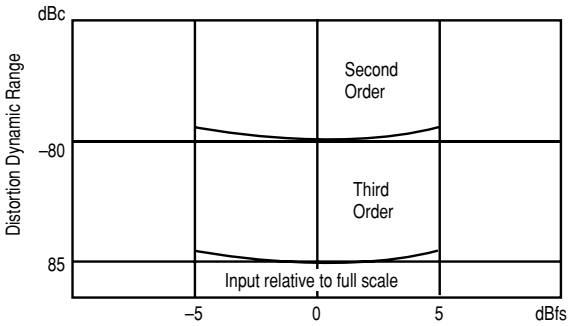
Dynamic range
Dynamic range indicates the amplitude range that is free of erroneous signals within the measurement bandwidth.

Harmonic distortion
(with a single full scale signal at the input)

2nd	< –75 dBc (–80 dBc typical)
3rd, 4th, 5th	< –75 dBc (–85 dBc typical)

Intermodulation distortion
(with two input tones at 6 dB below full scale)

Second-order	< –75 dBc (–80 dBc typical)
Third-order	< –75 dBc (–85 dBc typical)



Typical harmonic and intermodulation distortion

Residual (spurious) responses (IF section only)
(50 Ω input and front panel connections to RF section disconnected)

Frequencies < 1 MHz	< –75 dBfs or < –100 dBm whichever is greater
Frequencies ≥ 1 MHz	< –80 dBfs

Alias responses (for a single out-of-band tone at full scale)	< –80 dBfs

Input noise density (50 Ω input, vector mode or scalar mode with sample detector)

1 kHz to 40 kHz	< –101 dBfs/Hz
40 kHz to 10 MHz	< –114 dBfs/Hz (–118 dBfs/Hz typical)

Sensitivity (–30 dBm range, 50 Ω input, vector mode or scalar mode with sample detector)

1 kHz to 40 kHz	< –131 dBm/Hz
40 kHz to 10 Hz	< –144 dBm/Hz (–148 dBm/Hz typical)
Crosstalk (source-to-input or channel-to-channel, 50 Ω terminations)	< –85 dBfs

Phase (vector mode)
Phase specifications apply with flat-top window selected.

Deviation from linear phase (relative to best fit line with peak signal level within 6 dB of full scale)	± 5 deg

Time (vector mode)
Time-sample resolution = 1/(k*span(Hz)) [second]; where k = 1.28 for zoom time, 2.56 for baseband time measurements.

Main time length = (number of frequency points – 1) ÷ span (Hz) [second]; for resolution bandwidth in arbitrary and auto-coupled mode.

Amplitude accuracy (IF section only) (for a sine wave in the measurement passband, time-domain calibrations on)	± 5% full scale

Sample error rate for zoom time (typical)
Error threshold: 10^{-8} times/sample
5% full scale

Sample error rate reflects the probability of an error greater than the error threshold occurring in one time sample.

Analog channel-to-channel time skew (IF section only) (time-domain calibrations on, both channels on the same range)	< 1 ns

Two-channel

The second 10 MHz input channel (Option AY7) provides additional measurements, including frequency response, coherence, cross spectrum, and cross correlation. These measurements are made by comparing a signal on channel two to a signal on channel one or to a demodulated signal on the RF input.

Channel match	± 0.25 dB, ± 2.0 deg

(IF section only, at the center of the frequency bins, dc coupled, 16 rms averages, frequency response, full scale inputs, both inputs on the same range. Exclude the first 5 bins of the dc response.)

Trigger

Same as RF trigger specifications with the following additional specifications.

Input channel trigger (positive and negative slope)

Level accuracy	± 10% full scale
Range	± 110% full scale
Resolution	Full scale/116 (typical)

Source

Source types

Scalar mode	CW (fixed sine),
Vector mode and video demodulation mode	CW, random noise
Random noise source % of energy in-band (Span = 10 MHz/2^N, N = 1 to 24)	> 70%

Frequency

Frequency range	dc to 10 MHz
Frequency resolution	25 µHz

Amplitude

Source level

CW and random noise	–110 dBm to +23.979 dBm (50 Ω) 5.0 Vpk maximum
DC offset	± 3.42 V maximum (resolution and range of programmable dc offset is dependent on source amplitude)

Amplitude accuracy (50 Ω, fixed sine)
(IF section only)

–46 dBm to +24 dBm	± 1.0 dB
–56 dBm to –46 dBm	± 2.0 dB

Harmonic and other spurious products
(fixed sine, 0 V dc offset)

dc to 10 kHz	< –55 dBc
10 kHz to 5 MHz	< –40 dBc
5 MHz to 10 MHz	< –33 dBc

Source port

Return loss (IF section only)	> 20 dB
Source impedance	50/75 Ω

Agilent 89441V Technical Data—General

Safety and environmental

Safety standards	CSA Certified for Electronic Test and Measurement Equipment per CSA C22.2, No. 231
This product is designed for compliance to:	UL1244 and IEC348, 1978
Acoustics	LpA < 55 dB typical at 25°C ambient (Temperature controlled fan to reduce noise output)
Temperature	
Operating	0° to 55°C
Internal disk operations	4° to 40°C
Storage (no disk in drive)	–20° to 65°C
Humidity, non-condensing	
Operating	10% to 90% at 40°C
Internal disk operations	20% to 80% at 30°C
Storage (no disk in drive)	10% to 90% at 40°C
Altitude	
Operating (above 2285 m (7,500 ft), derate operating temperature by –3.6°C/1000 m (–1.1°C/1000 ft))	4600 m (15,000 ft)
Storage	4600 m (15,000 ft)
Calibration interval	1 year
Warm-up time	30 minutes
Power requirements	
115 VAC operation	
IF section	90 - 140 Vrms, 47 - 440 Hz
RF section	90 - 140 Vrms, 47 - 63 Hz
230 VAC operation	198 - 264 Vrms, 47 - 63 Hz
Maximum power dissipation	
IF section	750 VA
RF section	275 VA

IEC 801-3 (Radiated Immunity) Performance degradation may occur at Severity Level 2.

Physical

Weight	IF section	25 kg (55 lb)
	RF section	25 kg (55 lb)
Dimensions		
IF section	Height	230 mm (9.1 in)
	Width	426 mm (16.7 in)
	Depth	530 mm (20.9 in)
RF section	Height	173 mm (6.8 in)
	Width	419 mm (16.5 in)
	Depth	495 mm (19.5 in)

Real-time bandwidth (characteristics only)

Real-time bandwidth is the maximum frequency span that can be continually analyzed without missing any time segment of the input signal.

Frequency spans of $10^7/2^n$ Hz, arbitrary auto-coupled resolution bandwidth, markers off, one display trace with calculations off on other traces, and maximum frequency points equal to number of frequency points.

Averaging off

Single-channel vector mode (log magnitude spectrum measurement data, 1601 frequency points, channel 2 off, averaging off)	78.125 kHz, 48 updates/second
Two-channel vector mode (requires second 10 MHz input channel, Option AY7) (Log magnitude frequency response measurement data, 801 frequency points, averaging off)	39.0625 kHz, 48 updates/second

Averaging

Single-channel vector mode averaging
(log magnitude spectrum measurement data, 1601 frequency points, channel 2 off)

Fast average	78.125 kHz
Displayed	78.125 kHz, 48 updates/second

Two-channel vector mode averaging
(requires second 10 MHz input channel, Option AY7)
(Log magnitude frequency response measurement data, 801 frequency points)

Fast average	39.0625 kHz
Displayed	39.0625 kHz, 48 updates/second

Measurement speed

Display update speed (vector mode with full span, one or two channels, 401 frequency points, no averaging, markers off, single trace with calculations off on other traces, log magnitude spectrum, frequency spans of $10^7/2^n$ Hz): 60/second

Averaging (characteristics only)

Number of averages	1 to 99,999
Overlap averaging	0% to 99.99%
Average types	
Scalar mode	rms (video), rms (video) exponential, peak hold
Vector mode	rms (video), rms (video) exponential, time, time exponential, peak hold

Fast averaging allows averaging a user-defined number of measurements without updating the displayed result. This provides faster averaging results for most measurements.

Gating (characteristics only)

Time-selective, frequency-domain analysis can be performed on any input or analog demodulated time-domain data. When gating is enabled, markers appear on the time data; gate length and delay can be set directly. Independent gate delays can be set for each input channel. See time specifications for main time length and time resolution details.

Gate length

Maximum: Main time length
Minimum: Approximately window shape ÷ (0.3 x span (Hz)) [seconds]; where window shape (ws) and minimum gate length for a 10 MHz zoom time span are (for 10 MHz baseband time spans subtract 39.0625 ns):

Window	ws	Minimum gate length
Flat-top	3.819	1.328125 µs
Gaussian-top	2.215	781.25 ns
Hanning	1.5	546.875 ns
Uniform	1.0	390.625 ns

Time-capture (characteristics only)

Direct capture of input waveforms can be accomplished with spans of 10 MHz/2^n Hz. See time specifications for time-sample resolution details.

Time capture memory: 64 Ksample; 1 Msample (Option AY9)

Benchmarks: For a one-channel, zoom time measurement (for baseband time, halve the time), 64 Ksample captures from 5.12 ms in a 10 MHz span to over 11.9 hours in a 1.19 Hz span. The optional 1 Msample captures from 81.92 ms in a 10 MHz span to over 190 hours in a 1.19 Hz span. Memory is shared if two channels are enabled, therefore length of capture is half as long.

Band power marker (characteristics only)

Markers can be placed on any time, frequency, or demodulated trace for direct computation of band power, rms square root (of power), C/N, and C/N_o within the selected portion of the data.

Peak/Average statistics

Peak and peak-to-average statistics can be enabled on main time, gate time, IQ measured timed, IQ reference time, and math functions involving these trace types. Average power and peak statistics are computed using all samples in the active trace. Each successive trace adds additional samples to the calculations.

Displayed results	average power peak power peak/average ratio number of samples
Peak percent	90% - 99.99%. Setting can be changed at any time during or after the measurement
Signal characteristics	
Peak power range	+ 13 dB relative to average power of the first time record
Average power range	+ 3 dB relative to average power of the first time record

Agilent 89441V Technical Data—General, continued

Display (characteristic only)

Trace formats	One to four traces on one, two, or four grids or a quad display
Other displays	On-line help text, view state
Number of colors	User-definable palette
Display points/trace	401

User-definable trace titles and information

X-axis scaling	Allows expanded views of portions of the trace information
Display blanking	Data or full display
Graticule on/off	
Center	± 5 mm referenced to bezel opening
Dimensions	
Height	105 ± 5mm
Width	147± 5 mm
Diagonal	180.6 mm (7.1 in)

Status indicators

Overload, half range, external trigger, source on/off, trigger, pause, active trace, remote, talk, listen, SRQ.

External PC-style keyboard interface

Compatible with PC-style 101-key keyboard, such as the HP C1405B with HP C1405-60015 adapter.

Interfaces (characteristics only)

Active probe power	+15 Vdc, –13 Vdc; 150 mA maximum, compatible with Agilent active probes
Sync out (not used)	Active low TTL level signal synchronous with source output of periodic chirps and arbitrary blocks up to 8192 samples.

External reference in/out IF section

External reference input	Locks to a 1, 2, 5, or 10 MHz signal (± 10 ppm) with a level > 0 dBm
External reference output	Output the same frequency as the external reference input at a level of > 0 dBm into a 50 Ω load.

External reference in/out RF section

External reference input	Locks to a 1, 2, 5, or 10 MHz signal (± 10 ppm) with a level > 0 dBm (use ≥ 5 dBm for optimum phase noise performance).
External reference output	Outputs 10 MHz at > 0 dBm (+6 dBm typical) into a 50 Ω load.

GPIB

Implementation of IEEE Std 488.1 and 488.2
SH1, AH1, T6, TE0, L4, LE0, SRI, RL1, PP0, DC1,DT1, C1, C2, C3, C12, E2

Benchmark characteristics

(typical transfer rate of 401 frequency-point traces)

Scalar	25 traces/second
Vector	20 traces/second
RS-232	Serial port (9-pin) for connection to printer
Centronics	Parallel port for connection to a printer

External monitor output

Format	Analog plug-compatible with 25.5 kHz multi-sync monitors
Impedance	75 Ω
Level	0 to 0.7 V
Display rate	60 Hz
Horizontal refresh rate	25.5 kHz
Horizontal lines	400
Second GPIB	Implementation of IEEE Std 488.1 and 488.2
LAN	ThinLAN BNC

Peripherals

Plot/print

Direct plotting and black-and-white printing to parallel (Centronics), serial (RS-232), and GPIB graphics printers and plotters. Printers supported include the HP LaserJet, HP PaintJet, HP ThinkJet, HP DeskJet, and HP QuietJet. Single-plot spooling allows instrument operation while printing or plotting a single display.

Memory and data storage

Disk devices

Nonvolatile RAM disk	100 Kbytes
Volatile RAM disk	5 Mbytes that can be partitioned between measurement, Instrument BASIC program space and RAM.
Internal 90 mm (3.5-inch) flexible disk (HP LIF or MS-DOS® formats)	1.44 Mbyte
External disk	GPIB interface

Disk format and file delete, rename, and copy

Nonvolatile clock with time/date

Save/recall can be used to store trace data, instrument states, trace math functions, Instrument BASIC programs, and time-capture buffers.

Benchmarks

(typical disk space requirements for different file types)

Trace data (401 points)	6.2 Kbyte
Instrument state	12.3 Kbyte
Trace math	2 Kbyte
Time-capture buffers (32 Ksamples)	271 Kbyte

Trace math

Operands	measurement data, data register, constant, other trace math functions, jw
Operations	+, -, *, /, cross correlation, conjugate, magnitude, phase, real, imaginary, square root, FFT, inverse FFT, natural logarithm, exponential

Trace math can be used to manipulate data on each measurement. Uses include user-units correction and normalization.

Marker functions

Peak signal track, frequency counter, band power peak/average statistics.

Standard data format utilities

Included on two 90 mm (3.5-inch) 1.44 Mbyte flexible disks and two 130 mm (5.25-inch) 1.2 Mbyte floppy disks. The utilities run in MS-DOS® 2.1 or greater on an IBM PC (AT or higher) or compatible. The utilities include conversions to standard data format (SDF), PC displays of data and instrument state information, and utilities for conversion to PC-MATLAB, MATRIX$_X$, data set 58 and ACSII formats.

Agilent 89441V Technical Data—General, continued

Digital video modulation analysis

Supported modulation formats

Modulation formats	8 and 16VSB 16, 32, 64 and 256QAM 16, 32, and 64QAM (differentially encoded per DVB standard)

Frequency span

The (2 - 2650 MHz)-wide receiver mode increases the maximum allowable vector frequency span to 8 MHz. Specifications for this mode are in the RF specification section.

Maximum symbol rate

The 89441V analyzes vector modulated signals up to a maximum symbol rate determined by the information bandwidth of the receiver mode and the excess bandwidth factor (α) of the input signal, according to:

$$\textit{Max Symbol Rate} \leq \frac{\textit{Information Bandwidth}}{1 + \alpha}$$

(Note: the maximum symbol rate is doubled for VSB signals.)

Receiver mode	Information bandwidth
ch1 + j*ch2	≤ 20 MHz *
0 - 10 MHz	≤ 10 MHz
2 - 2650 MHz - normal	≤ 7 MHz
2 - 2650 MHz - wide	≤ 8 MHz
External	≤ 10 MHz *

Example: For a 64 QAM signal (α = 0.15), the maximum symbol rate for the (2-2650 MHz)-wide receiver is 8 MHz/(1.15) = 6.96 Msymbols/second.

* Downconverter dependent.

Measurement results

I-Q measured (Filtered, carrier locked, symbol locked)	Time, spectrum
I-Q reference (Ideal, computed from detected symbols)	Time, spectrum
I-Q error vs. time (I-Q measured vs. reference)	Magnitude, phase
Error vector (Vector error of computed vs. reference)	Time, spectrum
Symbol table + error summary	Error vector magnitude is computed at symbol times only

Display formats

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

Polar diagrams
- Constellation: Samples displayed only at symbol times
- Vector: Display of trajectory only at symbol times with 1 to 20 points/symbol

I or Q vs time
- Eye diagrams: Adjustable from 0.1 to 10 symbols
- Trellis diagrams: Adjustable from 0.1 to 10 symbols

Continuous error vector magnitude vs. time

Continuous I or Q vs. time

Error summary
- Measured rms and peak values of the following:
  - Error vector magnitude
  - Magnitude error
  - Phase error
- Frequency error (carrier offset frequency)
- I-Q offset
- SNR and MER for QAM + VSB formats

VSB pilot level is shown, is dB relative to nominal.

For VSB formats, SNR is calculated from the real part of the error vector only.

For DVB formats, EVM is calculated without removing IQ offset.

Detected bits (symbol table)
- Binary bits are displayed and grouped by symbols.
- Multiple pages can be scrolled for viewing large data blocks.
- Symbol marker (current symbol shown as inverse video) is coupled to measurement trace displays to identify states with corresponding bits.
- Bits are user-definable for absolute states or differential transitions.

Accuracy

Residual errors (typical)

8VSB or 16VSB, symbol rate = 10.762 MHz, α = 0.115, instrument receiver mode of IF 0-10 MHz or RF 2 - 2650 MHz, 7 MHz span, full-scale signal, range ≥ –25 dBm, result length = 800, averages = 10.

Residual EVM	≤ 1.5% (SNR ≥ 36 dB)

16, 32, 64 or 256QAM, symbol rate = 6.9 MHz, α = 0.15, instrument receiver mode of IF 0 - 10 MHz or RF 2-2650 MHz - wide, 8 MHz span, full-scale signal, range ≥ –25 dBm, result length = 800, averages = 10.

Residual EVM	≤ 1.0% (SNR ≥ 40 dB)

Filtering
All filters are computed to 40 symbols in length

Filter types	Root Raised-Cosine
User-selectable filter parameters	Alpha continuously adjustable from 0.05 to 1.0

Adaptive equalization

The 89441V equalizes the digitally-modulated signal to remove effects of linear distortion (such as unflatness and group delay) in a modulation quality measurement.

Equalizer performance is a function of the filter design (e.g., length, convergence, taps/symbol) and the quality of the signal being equalized.

Equalizer
Decision-directed, LMS, feed-forward equalization with adjustable convergence rate.

Filter length	3 to 99 symbols, adjustable
Filter taps	1,2,4,5,10, or 20 taps/symbol

Measurement results
Equalizer impulse response
Channel frequency response

4 Mbytes Extended RAM and additional I/O

Extended RAM
Extended memory type: 4 Mbytes dynamic RAM
Approximately 6 Mbytes, user-allocatable to measurement memory, RAM disk, and IBASIC program space.

LAN I/O
LAN support: Ethernet (IEEE 802.3) TCP/IP
LAN interface: ThinLAN (BNC connector) or AUI
Recommended MAU: Agilent 28685B (I0base-T) or 28683A (FDDI)
Program interface: Send and receive GPIB programming codes, status bytes and measurement results in ASCII and/or binary format.

GPIB I/O
Secondary GPIB port: Per IEEE Std 488.1 and 488.2
Functions: Controller-only; accessible from IBASIC program or front panel commands.

Advanced LAN support—Option UG7

Remote X11 display (characteristic only)
Update rate: > 20 per second, depending on workstation performance and LAN activity.
XII R4 compatible
X-terminals, UNIX workstations, PC with X-server software
Display 640 x 480 pixel minimum resolution required; 1024 x 768 recommended.

FTP data (characteristic only)
Traces A, B, C, D
Data registers D1 - D6
Time capture buffer
Disk files (RAM, NVRAM, floppy disk)
Analyzer display plot/print

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