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
- Pre and post delay

**Averaging**
- Video
- Video exponential
- Time
- Time exponential

**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
- 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)
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: 0.001 Hz resolution
- 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

**Stability (spectral purity)**
(with standard high-precision frequency reference or equivalent with ≥ 5 dBm level)

Phase noise (absolute and residual)
- \( F_n \leq 200 \) MHz
  - 100 Hz offset: \(-103 \) dBc/Hz
  - 1 kHz offset: \(-112 \) dBc/Hz
  - ≥ 10 kHz offset: \(-116 \) dBc/Hz
- \( 200 \) MHz ≤ \( F_n \leq 1 \) GHz
  - 100 Hz offset: \(-96 \) dBc/Hz
  - 1 kHz offset: \(-104 \) dBc/Hz
  - ≥ 10 kHz offset: \(-116 \) dBc/Hz
- \( 1 \) GHz ≤ \( F_n \leq 2650 \) 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:
  - \( f_n \leq 2 \) GHz: \(-70 \) dBc
  - \( f_n > 2 \) GHz: \(-68 \) dBc

**Spectral purity at 1 GHz**

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**Frequency counter basic accuracy**

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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.

<table>
<thead>
<tr>
<th>Window</th>
<th>Selectivity*</th>
<th>Passband flatness</th>
<th>Sideband level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat-top</td>
<td>2.45:1</td>
<td>+ 0, –0.01 dB</td>
<td>–95 dBc</td>
</tr>
<tr>
<td>Gaussian-top</td>
<td>4.0:1</td>
<td>+ 0, –0.68 dB</td>
<td>–125 dBc</td>
</tr>
<tr>
<td>Hanning</td>
<td>9.1:1</td>
<td>+ 0, –1.5 dB</td>
<td>–32 dBc</td>
</tr>
<tr>
<td>Uniform</td>
<td>716:1</td>
<td>+ 0, –4 dB</td>
<td>–13 dBc</td>
</tr>
</tbody>
</table>

* 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)

<table>
<thead>
<tr>
<th>20° - 30°C</th>
<th>0° - 55°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ –25 dBm range</td>
<td>± 1 dB</td>
</tr>
<tr>
<td>≤ –30 dBm range</td>
<td>± 1.5 dB</td>
</tr>
</tbody>
</table>
(0.5 dB typical)

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 ± 0.4 dB (relative to the center frequency)

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)

<table>
<thead>
<tr>
<th>20° - 30°C</th>
<th>0° - 55°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ –25 dBm range</td>
<td>&lt; –75 dBc</td>
</tr>
<tr>
<td>≤ –30 dBm range</td>
<td>&lt; –54 dBc</td>
</tr>
</tbody>
</table>

Third-order intermodulation < –75 dBc

Distortion (with two input tones at 6 dB below full scale and ≥ 10 MHz)

General spurious (with input signal level equal to range and input frequency ≤ 2650 MHz)

For spans ≤ 1.5 MHz and for offset < 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)**

<table>
<thead>
<tr>
<th>20° - 30°C</th>
<th>0° - 55°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ –25 dBm range</td>
<td>&lt; –115 dBs/Hz</td>
</tr>
<tr>
<td>≤ –30 dBm range</td>
<td>&lt; –110 dBs/Hz</td>
</tr>
</tbody>
</table>

Sensitivity**

<table>
<thead>
<tr>
<th>20° - 30°C</th>
<th>0° - 55°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>±50 dBm range</td>
<td>&lt; –160 dBm/Hz</td>
</tr>
</tbody>
</table>

*< –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: 10^-x times/sample
5% full scale

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 32 Ksamples
second 10 MHz input, Option AY7)
Post-trigger delay range
(see time specifications for sample resolution)
2 Gsample

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

<table>
<thead>
<tr>
<th>Source (requires internal RF source Option AY8)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source types</strong></td>
<td></td>
</tr>
<tr>
<td>(vector mode and video demodulation)</td>
<td>CW (fixed sine), random noise</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>2 MHz to 2650 MHz</td>
</tr>
<tr>
<td>Maximum offset from center frequency</td>
<td>3.5 MHz</td>
</tr>
<tr>
<td><strong>Amplitude (fixed sine source type)</strong></td>
<td></td>
</tr>
<tr>
<td>Amplitude range</td>
<td>–40 dBm to +13 dBm</td>
</tr>
<tr>
<td>Typical maximum amplitude</td>
<td>+17 dBm</td>
</tr>
<tr>
<td>(overdrive is available using direct numeric entry)</td>
<td></td>
</tr>
<tr>
<td>Amplitude resolution</td>
<td>0.1 dB</td>
</tr>
<tr>
<td><strong>Amplitude accuracy (source level ≤ 13 dBm)</strong></td>
<td></td>
</tr>
<tr>
<td>Source amplitude accuracy is the sum of absolute accuracy at the center frequency (zero offset frequency) and the IF flatness.</td>
<td></td>
</tr>
<tr>
<td>20° - 30°C</td>
<td>0° - 55°C</td>
</tr>
<tr>
<td>Absolute accuracy at the center frequency</td>
<td>± 1.2 dB</td>
</tr>
<tr>
<td>IF flatness (relative to center frequency)</td>
<td>± 1 dB</td>
</tr>
<tr>
<td>IF Flatness with</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dynamic range (source level ≤ dBm)</strong></td>
<td></td>
</tr>
<tr>
<td>Harmonic distortion</td>
<td>&lt; –40 dBc</td>
</tr>
<tr>
<td>Non-harmonic spurious (within measurement bandwidth)</td>
<td>&lt; –40 dBc</td>
</tr>
<tr>
<td>Average noise level</td>
<td>&lt; –120 dBc/Hz</td>
</tr>
<tr>
<td>(for offsets &gt; 1 MHz from the carrier and carrier frequency &gt;100 MHz. For offsets &lt; 1 MHz, add the LO phase noise.)</td>
<td></td>
</tr>
<tr>
<td><strong>Crosstalk (source-to-receiver, source level ≤ 0 dBm)</strong></td>
<td></td>
</tr>
<tr>
<td>&lt; –80 dBfs</td>
<td></td>
</tr>
<tr>
<td><strong>Source port</strong></td>
<td></td>
</tr>
<tr>
<td>VSWR</td>
<td>Level ≤ –10 dBm</td>
</tr>
<tr>
<td>Impedance</td>
<td>50 Ω (75 Ω with optional minimum-loss pad)</td>
</tr>
<tr>
<td>Connector</td>
<td>Type-N</td>
</tr>
</tbody>
</table>
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, $F_n = 10$ 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 $20 \log_{10} \left| \frac{F_{in}}{10 \text{ MHz}} \right| dB$

**Resolution bandwidth**
Same as the RF specifications.

<table>
<thead>
<tr>
<th>Amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input range (characteristic only) (2 dB steps)</td>
</tr>
<tr>
<td>50 $\Omega$ input</td>
</tr>
<tr>
<td>75 $\Omega$ input</td>
</tr>
<tr>
<td>1 M$\Omega$ input</td>
</tr>
<tr>
<td>(referenced to 50 $\Omega$)</td>
</tr>
</tbody>
</table>

Maximum safe input power
- 50 $\Omega$/75 $\Omega$ input: $+27$ dBm
- 1 M$\Omega$ input: 20 V Peak

<table>
<thead>
<tr>
<th>Auto-ranging (characteristic only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up-only, up-down, single, off</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input port</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input channels: 1 (second 10 MHz input channel optional)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Return loss (IF section only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 $\Omega$ input: $&gt;25$ dB</td>
</tr>
<tr>
<td>75 $\Omega$ input: $&gt;20$ dB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Coupling</th>
</tr>
</thead>
<tbody>
<tr>
<td>dc/ac (ac coupling attenuation $&lt;3$ dB at 3 Hz)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input Impedance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(IF section only)</td>
</tr>
<tr>
<td>50/75 $\Omega$, 1 M$\Omega \pm 2%$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>(IF section only)</td>
</tr>
<tr>
<td>(&lt;80 pF shunt capacitance)</td>
</tr>
<tr>
<td>BNC (RF section: Type-N)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Amplitude accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy specifications apply with flat-top window selected.</td>
</tr>
<tr>
<td>Amplitude accuracy is the sum of absolute full-scale accuracy and amplitude linearity.</td>
</tr>
</tbody>
</table>

| Absolute full-scale accuracy $\pm 0.5$ dB |
| (IF section only, with signal level equal to range) |

<table>
<thead>
<tr>
<th>Amplitude linearity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to $-30$ dBfs: $&lt;0.10$ dB</td>
</tr>
<tr>
<td>$-30$ to $-50$ dBfs: $&lt;0.15$ dB</td>
</tr>
<tr>
<td>$-50$ to $-70$ dBfs: $&lt;0.20$ dB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Residual dc (50 $\Omega$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&lt;-25$ dBfs</td>
</tr>
</tbody>
</table>
**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: $<-75 \text{ dBc}$ ($-80 \text{ dBc}$ typical)
- 3rd, 4th, 5th: $<-75 \text{ dBc}$ ($-85 \text{ dBc}$ typical)

**Intermodulation distortion**
(with two input tones at 6 dB below full scale)
- Second-order: $<-75 \text{ dBc}$ ($-80 \text{ dBc}$ typical)
- Third-order: $<-75 \text{ dBc}$ ($-85 \text{ dBc}$ typical)

**Typical harmonic and intermodulation distortion**
Residual (spurious) responses (IF section only)
(50 $\Omega$ input and front panel connections to RF section disconnected)
- Frequencies $< 1 \text{ MHz}$: $< -75 \text{ dBfs}$ or $< -100 \text{ dBm}$ whichever is greater
- Frequencies $\geq 1 \text{ MHz}$: $<-80 \text{ dBfs}$

**Alien responses**
(for a single out-of-band tone at full scale)
$<-80 \text{ dBfs}$

Input noise density (50 $\Omega$ input, vector mode or scalar mode with sample detector)
- 1 kHz to 40 kHz: $<-101 \text{ dBfs/Hz}$
- 40 kHz to 10 MHz: $<-114 \text{ dBfs/Hz}$
  ($<-118 \text{ dBfs/Hz}$ typical)

Sensitivity ($<30 \text{ dBm}$ range, 50 $\Omega$ input, vector mode or scalar mode with sample detector)
- 1 kHz to 40 kHz: $<-131 \text{ dBm/Hz}$
- 40 kHz to 10 Hz: $<-144 \text{ dBm/Hz}$
  ($<-148 \text{ dBm/Hz}$ typical)

Crosstalk
(source-to-input or channel-to-channel, 50 $\Omega$ terminations)
$<-85 \text{ dBfs}$

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

**Deviation from linear phase**
$\pm 5 \text{ deg}$
(relative to best fit line with peak signal level within 6 dB of full scale)

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

**Main time length**
$= (\text{number of frequency points} - 1)$
$\div \text{span (Hz)}$ [second]; for resolution bandwidth in arbitrary and auto-coupled mode.

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

**Sample error rate for zoom time (typical)**
Error threshold: $10^{-4}$ 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**
$< 1 \text{ ns}$

time skew (IF section only)
(time-domain calibrations on, both channels on the same range)
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 > 70% % of energy in-band (Span = 10 MHz/2^N, N = 1 to 24)

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
- LpA < 55 dB typical at 25°C ambient (Temperature controlled fan to reduce noise output)

**Acoustics**
- UL1244 and IEC348, 1978
- 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 4600 m (15,000 ft)) 
- Derate operating temperature by −3.6°C/1000 m (−1.1°C/1000 ft)
- Storage: 4600 m (15,000 ft)

**Calibration interval**
- 1 year

**Warm-up time**
- 30 minutes

### Power requirements

<table>
<thead>
<tr>
<th>115 VAC operation</th>
<th>IF section</th>
<th>90 - 140 Vrms, 47 - 440 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF section</td>
<td>90 - 140 Vrms, 47 - 63 Hz</td>
<td></td>
</tr>
<tr>
<td>230 VAC operation</td>
<td>198 - 264 Vrms, 47 - 63 Hz</td>
<td></td>
</tr>
</tbody>
</table>

**Maximum power dissipation**
- IF section: 750 VA
- RF section: 275 VA

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

### 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**
- Single-channel vector mode: 78.125 kHz, 48 updates/second
- Two-channel vector mode: 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

### 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)
Averaging (characteristics only)

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

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):

<table>
<thead>
<tr>
<th>Window</th>
<th>ws</th>
<th>Minimum gate length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat-top</td>
<td>3.819</td>
<td>1.328125 µs</td>
</tr>
<tr>
<td>Gaussian-top</td>
<td>2.215</td>
<td>781.25 ns</td>
</tr>
<tr>
<td>Hanning</td>
<td>1.5</td>
<td>546.875 ns</td>
</tr>
<tr>
<td>Uniform</td>
<td>1.0</td>
<td>390.625 ns</td>
</tr>
</tbody>
</table>

Time-capture (characteristics only)

Direct capture of input waveforms can be accomplished with spans of 10 MHz/2ⁿ 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/N₀ 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: ± 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
- **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 271 Kbyte
(32 Ksamples)

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, MATRIXx, data set 58 and ASCII formats.
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 (\(\alpha\)) of the input signal, according to:

\[
\text{Max Symbol Rate} \leq \frac{\text{Information Bandwidth}}{1 + \alpha}
\]

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

Receiver mode | Information bandwidth
---|---
ch1 + \(j^*\) ch2 | \(\leq 20\) MHz *
0 - 10 MHz | \(\leq 10\) MHz
2 - 2650 MHz - normal | \(\leq 7\) MHz
2 - 2650 MHz - wide | \(\leq 8\) MHz
External | \(\leq 10\) MHz *

Example: For a 64 QAM signal (\(\alpha = 0.15\)), 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: Time, spectrum
- I-Q reference: Time, spectrum
- I-Q error vs. time: Magnitude, phase
- Error vector: 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

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,
- \(\alpha = 0.115\), instrument receiver mode of IF 0-10 MHz or RF 2 - 2650 MHz, 7 MHz span, full-scale signal, range \(\geq -25\) dBm, result length = 800, averages = 10.
- Residual EVM \(\leq 1.5\%\) (SNR \(\geq 36\) dB)

- 16, 32, 64 or 256QAM, symbol rate = 6.9 MHz,
- \(\alpha = 0.15\), instrument receiver mode of IF 0 - 10 MHz or RF 2-2650 MHz - wide, 8 MHz span, full-scale signal, range \(\geq -25\) dBm, result length = 800, averages = 10.
- Residual EVM \(\leq 1.0\%\) (SNR \(\geq 40\) dB)
Filtering
All filters are computed to 40 symbols in length

Filter types Root Raised-Cosine
User-selectable Alpha continuously
filter parameters 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 (10base-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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Printed in USA, June 27, 2003
5966-0437E