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 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 5 dB below ADC overload.

**Analog demodulation mode** = Measurements with AM, PM, and FM demodulation capabilities.

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

**RBW** = Resolution bandwidth.

**Scalar mode** = Measurements with only frequency-domain analysis available. Frequency spans up to 10 MHz.

**SNR** = Signal to noise ratio.

**Vector mode** = Measurements with frequency- and time-domain capabilities. Frequency spans up to 10 MHz.

**Zoom time** = Time-domain measurements selected by setting frequency parameters using center frequency and span values.
Standard Features

**Frequency**
dc to 10 MHz
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)
Analog demodulation (AM/FM/PM)

**Sweep types**
Continuous
Manual
Single

**Triggering**
Free run
Input channel
External arm
IF channel
Programmable polarity and level
Internal source
Pre and post delay
HP-IB

**Averaging**
Video
Peak hold
Video exponential
Simultaneous display of instantaneous and average spectrum
Time
Time exponential

**Source types**
CW
Periodic chirp
Random noise
Arbitrary (up to 8192 points)

**Input**
One channel
Second 10 MHz input channel (optional)
Auto-ranging
Overload indicators
50/75/1M Ω BNC

**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
Time capture
PSD
Frequency response, coherence, cross spectrum, and cross correlation (with second 10 MHz input)
Main time
Gate time
Math function
Data register
Auto correlation
Instantaneous spectrum

**Data format**
Log magnitude
Imaginary part
Linear magnitude
Group delay
Phase (wrap or unwrap)
Log/linear x-axis
Real part

**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 HP-IB disk
Disk format and file delete, rename, and copy
Nonvolatile clock with time/date
Save/recall of: Trace data, instrument states, trace math functions, HP Instrument BASIC programs, time-capture buffers

**Hard copy output**
HP-IB/HPGL plotters
HP-IB/RS-232/parallel printers
Plot to file
Time stamp
Single-plot spooling

**Interfaces**
HP-IB (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 HP-IB (optional)

**Standard data format utilities**

**Optional features**
HP Instrument BASIC (option 1C2)
Vector modulation analysis (option AYA)
Digital video modulation analysis (option AYH)
Waterfall and spectrogram (option AYB)
Extended RAM and additional I/O (option UFG)
Advanced LAN support (option UG7)
Adaptive Equalization (option AYH or AYJ)
**Frequency**

**Frequency tuning** (characteristic only)
- Frequency range: dc to 10 MHz
- Frequency span: 1 Hz to 10 MHz
- Center frequency tuning: 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: ± 10 ppm
  - With precision: ± 0.2 ppm
- Aging: ± 0.5 ppm/month
  - With precision: ± 0.25 ppm/month

**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 1/2 resolution bandwidth of peak
- Unspecified for uniform window and resolution bandwidth < 5 Hz

**Stability (spectral purity)**
Absolute and residual phase noise, $F_{in} = 10$ MHz (with optional 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**
- 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.

**Frequency counter basic accuracy**

---

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HP 89410A Technical Data
Standard Features

**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

A/D overload level > 5.0 dB above range
(typical)

**Auto-ranging** (characteristic only)
Up-only, up-down, single, off

**Input port**
Input channels: 1 (second 10 MHz input channel optional)

Return loss
- 50 Ω input: > 25 dB
- 75 Ω input: > 20 dB

Coupling: dc/ac (ac coupling attenuation < 3 dB at 3 Hz)

Input Impedance: 50/75 Ω, 1 MΩ ± 2%
(< 80 pF shunt capacitance)

Connector: BNC

**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 (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

**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 (50 Ω input)
- 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 MHz: < -144 dBm/Hz
- (< -148 dBm/Hz typical)

Crosstalk (source-to-input or channel-to-channel, 50 Ω terminations) < -85 dBfs
**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 = (number of frequency points − 1) ÷ span (Hz) [second]; for resolution bandwidth in arbitrary and auto-coupled mode.

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

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 (time-domain calibrations on, both channels on the same range) < 1 ns

**Phase** (vector mode)

Phase specifications apply with flat-top window selected.

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

**Analog demodulation**

Demodulation specifications apply with demodulation mode selected and time-domain calibration on.

AM, PM, or FM demodulation. Auto carrier locking is available with PM or FM demodulators and the carrier value determined is a displayable marker function.

Demodulator bandwidth (determined by selected measurement span)
- Maximum bandwidth 10 MHz (typical)

AM demodulation (typical performance)
- Accuracy ± 1%
- Dynamic range 60 dB (100%) for a pure AM signal
- Cross demodulation < 0.3% AM on an FM signal with 10 kHz modulation, 200 kHz deviation

PM demodulation (typical performance)
- Accuracy ± 3 degrees
- Dynamic range 60 dB (rad) for a pure PM signal
- Cross demodulation < 1 degree PM on an AM signal with 80% modulation

FM demodulation (typical performance)
- Accuracy ± 1% of span
- Dynamic range 60 dB (Hz) for a pure FM signal
- Cross demodulation < 0.5% of span FM on an AM signal with 80% modulation
### 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.

Channel match $\pm 0.25 \text{ dB}, \pm 2.0 \text{ deg}$

(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

<table>
<thead>
<tr>
<th>Trigger Types</th>
<th>Free run, input channel, internal source, HP-IB, external (each measurement step requires a separate trigger)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scalar mode</td>
<td>Free run, input channel, IF channel, internal source, HP-IB, external</td>
</tr>
<tr>
<td>Vector mode</td>
<td>Free run, input channel, IF channel, internal source, HP-IB, external</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>One channel</th>
<th>64 Ksamples (1 Msample with extended time capture, option AY9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two channels</td>
<td>32 Ksamples (0.5 Msample with extended time capture, option AY9)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>IF trigger (characteristics only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used to trigger only on in-band energy, where the trigger bandwidth is determined by the measurement span (rounded to the next higher $10^{7/2n}[\text{Hz}]$).</td>
</tr>
</tbody>
</table>

External trigger (positive and negative slope)

<table>
<thead>
<tr>
<th>Level accuracy</th>
<th>± 0.5 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>± 5 V</td>
</tr>
<tr>
<td>Input impedance</td>
<td>10 kΩ (typical)</td>
</tr>
</tbody>
</table>

External Arm

<table>
<thead>
<tr>
<th>Level accuracy</th>
<th>± 0.5 V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>± 5 V</td>
</tr>
<tr>
<td>Input impedance</td>
<td>10 kΩ (typical)</td>
</tr>
</tbody>
</table>

Input channel trigger (positive and negative slope)

<table>
<thead>
<tr>
<th>Level accuracy</th>
<th>± 10% full scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>± 110% full scale</td>
</tr>
<tr>
<td>Resolution</td>
<td>Full scale/116 (typical)</td>
</tr>
</tbody>
</table>
### Source (with output filter on)

#### Source types
- **Scalar mode**: CW (fixed sine), arbitrary
- **Vector mode**: CW, random noise, periodic chirp, arbitrary
- **Random noise source % of energy in-band** (Span = 10 MHz/2^N, N = 1 to 24): > 70%
- **Periodic chirp source % of energy in-band**: > 85%

#### 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
  - Periodic chirp and arbitrary: –110 dBm to +19.542 dBm (50 Ω), 3.0 Vpk maximum
- **DC offset**: ±3.42 V maximum
- **Amplitude accuracy (50 Ω, fixed sine)**
  - –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**: > 20 dB
- **Source impedance**: 50/75 Ω

---

### Arbitrary source characteristics
The arbitrary source repetitively outputs data stored in a data register. The data register may contain a single time record or, with option AYB, a trace buffer. The time length of the register depends on the time-sample resolution for the span entered when the data register was saved or created. See time specifications for time-sample resolution details.

#### Arbitrary source length
- **Single time record**: Up to 4096 complex or 8192 real points.
- **Trace buffer (requires option AYB)**: Up to 16,384 real or complex points. Some configurations allow up to 32,768 real or complex points (see the Operator's Guide for details)
HP 89410A Technical Data

General

Safety and environmental

<table>
<thead>
<tr>
<th>Safety standards</th>
<th>CSA Certified for Electronic Test and Measurement Equipment per CSA C22.2, No. 231</th>
</tr>
</thead>
<tbody>
<tr>
<td>This product is designed for compliance to</td>
<td>UL1244 and IEC348, 1978</td>
</tr>
<tr>
<td>Acoustics</td>
<td>LpA &lt; 55 dB typical at 25°C ambient (Temperature controlled fan to reduce noise output)</td>
</tr>
</tbody>
</table>
| Temperature | Operating 0° to 55°C  
Internal disk operations 4° to 40°C  
Storage -20° to 65°C |
| Humidity, non-condensing | Operating 10% to 90% at 40°C  
Internal disk operations 20% to 80% at 30°C  
Storage 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))  
Storage 4600 m (15,000 ft) |
| Calibration interval | 1 year |
| Warm-up time | 30 minutes |
| Power requirements | 115 VAC operation 90 - 140 Vrms, 47 - 440 Hz  
230 VAC operation 198 - 264 Vrms, 47 - 63 Hz |
| Maximum power dissipation | 750 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, and 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 | 78.125 kHz, 80 updates/second  
(log magnitude spectrum measurement data, 1601 frequency points, channel 2 off, averaging off) |
| Two-channel vector mode | 39.0625 kHz, 80 updates/second  
(requires second 10 MHz input channel, option AY7) (Log magnitude frequency response measurement data, 801 frequency points, averaging off) |

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 |

Demodulation

| Single-channel analog demodulation mode (log magnitude spectrum measurement data, 1601 frequency points, time cal off, channel 2 off, averaging off) | AM demodulation 19.53125 kHz  
FM or PM demodulation 9.765625 kHz |
**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)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of averages</td>
<td>1 to 99,999</td>
</tr>
<tr>
<td>Overlap averaging</td>
<td>0% to 99.99%</td>
</tr>
<tr>
<td>Average types</td>
<td></td>
</tr>
<tr>
<td>Scalar mode</td>
<td>rms (video), rms (video) exponential, peak hold</td>
</tr>
<tr>
<td>Vector mode</td>
<td>rms (video), rms (video) exponential, time, time exponential, peak hold</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Gate length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>Main time length</td>
</tr>
<tr>
<td>Minimum</td>
<td>Approximately window shape ÷ (0.3 × 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):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>Window (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/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/No 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 time (AYA), IQ reference time (AYA), 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.

<table>
<thead>
<tr>
<th>Displayed Results</th>
<th>average power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>peak power</td>
</tr>
<tr>
<td></td>
<td>peak/average ratio</td>
</tr>
<tr>
<td></td>
<td>number of samples</td>
</tr>
</tbody>
</table>

| Peak Percent            | 90% – 99.99%. Setting can be changed at any time during or after the measurement. |

**Signal characteristics**

<table>
<thead>
<tr>
<th>Peak power range</th>
<th>+ 13 dB relative to average power of the first time record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average power range</td>
<td>± 3 dB relative to average power of the first time record</td>
</tr>
</tbody>
</table>

**Display (characteristic only)**

<table>
<thead>
<tr>
<th>Trace formats</th>
<th>One to four traces on one, two, or four grids or a quad display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other displays</td>
<td>On-line help text, view state</td>
</tr>
<tr>
<td>Number of colors</td>
<td>User-definable palette</td>
</tr>
<tr>
<td>Display points/trace</td>
<td>401</td>
</tr>
<tr>
<td>User-definable trace titles and information</td>
<td>Allows expanded views of portions of the trace information</td>
</tr>
<tr>
<td>X-axis scaling</td>
<td>Data or full display</td>
</tr>
<tr>
<td>Display blanking</td>
<td>± 5 mm referenced to bezel opening</td>
</tr>
<tr>
<td>Graticule on/off</td>
<td></td>
</tr>
<tr>
<td>Center</td>
<td></td>
</tr>
</tbody>
</table>

**Dimensions**

<table>
<thead>
<tr>
<th>Height</th>
<th>105 ± 5 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>147 ± 5 mm</td>
</tr>
<tr>
<td>Diagonal</td>
<td>180.6 mm (7.1 in)</td>
</tr>
</tbody>
</table>

**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 HP active probes |
| Sync out           | Active low TTL level signal synchronous with source output of periodic chirps and arbitrary blocks up to 8192 samples. |

**External reference in/out**

| External reference input | Locks to a 1, 2, 5, or 10 MHz reference input (± 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. |

**HP-IB**
Implementation of IEEE Std 488.1 and 488.2
SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C1, C2, C3, C12, E2

**Benchmark characteristics** (typical transfer rate of 401 frequency-point traces)

<table>
<thead>
<tr>
<th>Scalar</th>
<th>25 traces/second</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vector</td>
<td>20 traces/second</td>
</tr>
<tr>
<td>RS-232</td>
<td>Serial port (9-pin) for connection to printer</td>
</tr>
<tr>
<td>Centronics</td>
<td>Parallel port for connection to a printer</td>
</tr>
</tbody>
</table>
External monitor output

<table>
<thead>
<tr>
<th>Format</th>
<th>Analog plug-compatible with 25.5 kHz multi-sync monitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impedance</td>
<td>75 Ω</td>
</tr>
<tr>
<td>Level</td>
<td>0 to 0.7 V</td>
</tr>
<tr>
<td>Display rate</td>
<td>60 Hz</td>
</tr>
<tr>
<td>Horizontal refresh rate</td>
<td>25.5 kHz</td>
</tr>
<tr>
<td>Horizontal lines</td>
<td>400</td>
</tr>
</tbody>
</table>

Optional interfaces
Option UFG includes the following interfaces

- Second HP-IB: Implementation of IEEE Std 488.1 and 488.2
- LAN: ThinLAN BNC

Peripheral

Plot/print
Direct plotting and black-and-white printing to parallel (Centronics), serial (RS-232), and HP-IB 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 Kbyte
- Volatile RAM disk: 1 Mbyte that can be partitioned between measurement, HP Instrument BASIC program space and RAM. Volatile RAM also supports memory of waterfalls and spectrograms with option AYB.

Internal 90 mm (3.5-inch) flexible disk (HP LIF or MS-DOS® formats)

- 1.44 Mbyte

External disk
HP-IB 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, HP 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 |

Optional extended RAM
Option UFG includes 4 Mbyte additional RAM for expanding the volatile RAM capabilities listed earlier.

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 ACSII formats.
**Options**

### Vector Modulation Analysis — Option AYA

#### Supported modulation formats

The vector modulation analysis option supports both single modulated carriers and separate baseband I-Q signals. The optional second 10 MHz input channel is required for baseband I and Q analysis.

- **Carrier types**: Continuous and pulsed/burst (such as TDMA)
- **Modulation formats**:
  - 2 level FSK (including GFSK)
  - 4 level FSK
  - MSK (including GMSK)
  - QAM implementations of: BPSK, QPSK, OQPSK, DQPSK, π/4DQPSK, 8PSK, 16QAM, 32QAM

**Default parameter settings †**

- NADC, PDC (JDC), GSM, PHS, DECT, CDPD, TETRA
- CDMA Base, CDMA Mobile

#### Filtering

All filters are computed to 20 symbols in length

- **Filter types**:
  - Raised cosine
  - Square-root raised cosine
  - IS-95 compatible
  - Gaussian
  - None
  - Rectangular
  - Low pass

- **User-selectable filter parameters**
  - Alpha/BT continuously adjustable from 0.05 to 10

- **User-defined filters**
  - User-defined impulse response, fixed
  - 20 points/symbol
  - Maximum 20 symbols in length or 401 points

#### Symbol Rate

**Symbol Rate** is limited only by the information bandwidth

\[
Symbol \ Rate = \frac{Bits/Second}{\frac{Bits/Symbol}{1 + \alpha}}
\]

Where bits/symbol is determined by the modulation type. Example: For the raised-cosine filter

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

#### Measurement results (formats other than FSK)

- **Display update rate**
  - Conditions: NADC preset, 50 kHz span, result length 150 symbols, 1 point/symbol. IQ envelope triggering and data synchronization off.
  - Update rate >2 per second (characteristic only)

- **I-Q measured**
  - Time, spectrum
  - (Filtered, carrier locked, symbol locked)

- **I-Q reference**
  - Time, spectrum
  - (Ideal, computed from detected symbols)

- **I-Q error vs. time**
  - Magnitude, phase
  - (I-Q measured vs. reference)

- **Error vector**
  - Time, spectrum
  - (Vector error of computed vs. reference)

- **Symbol table + error summary**
  - Error vector magnitude is computed at symbol times only

#### Measurement results (FSK)

- **FSK measured**
  - Time, spectrum

- **FSK reference**
  - Time, spectrum

- **Carrier error**
  - Magnitude

- **FSK error**
  - Time, spectrum

---

† NACD and CDMA preset settings require option UFG.

‡ Two-channel measurements such as ch1 + j*ch2 require option AY7 second 10 MHz input channel.
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 between 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 (formats other than FSK)
- Measured rms and peak values of the following:
  - Error vector magnitude
  - Magnitude error
  - Phase error
- Frequency error (carrier offset frequency)
- I-Q offset
- Amplitude droop (formats other than QAM)
- SNR (QAM formats)

Error summary (FSK)
- Measured rms and peak values of the following:
  - FSK error
  - Magnitude error
  - Carrier offset frequency
  - Deviation

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.
- For formats other than FSK and MSK, bits are user-definable for absolute states or differential transitions. Note: Synchronization words are required to resolve carrier phase ambiguity on non-differential modulation formats.

Accuracy (formats other than FSK and IS-95 CDMA)
Conditions: Specifications apply from 20° to 30°C, for a full-scale signal fully contained in the selected measurement span, random data sequence, instrument receiver mode of 0-10 MHz, start frequency ≥ 15% of span, alpha/BT ≥ 0.3†; and symbol rate ≥ 1 kHz. For symbol rates less than 1 kHz, accuracy may be limited by phase noise.

Residual errors (result length = 150 symbols, averages = 10)
- Error vector magnitude
  - Freq span ≤ 100 kHz
  - Freq span ≤ 1 MHz
  - Freq span > 1 MHz
- Magnitude error
  - Freq span ≤ 100 kHz
  - Freq span ≤ 1 MHz
  - Freq span > 1 MHz
- Phase error (For modulation formats with equal symbol amplitudes)
  - Freq span ≤ 100 kHz
  - Freq span ≤ 1 MHz
  - Freq span > 1 MHz

 Accuracy (2 FSK and 4 FSK)
Residual errors, typical
4 FSK or 2 FSK, symbol rate = 3.2 kHz, deviation = 4.8 kHz, instrument receiver mode of 0-10 MHz, 50 kHz span, full-scale signal, result length = 150, averages = 10, tenth-order Bessel filtering with 3 dB bandwidth = 3.9 kHz. †

- FSK error
- Magnitude error
- Carrier frequency offset
- Deviation

DECT preset (2 FSK, symbol rate = 1.152 MHz, BT = 0.5) 288 kHz deviation, instrument receiver mode of 0-10 MHz, 4 MHz span, full-scale signal, result length = 150, averages = 10.

- FSK error
- Magnitude error
- Carrier frequency offset
- Deviation

† 0.3 ≤ alpha ≤ 0.7 for Offset QPSK.
Accuracy (IS-95 CDMA)
CDMA Base or CDMA Mobile preset, instrument mode of Input (0 – 10 MHz), 2.6 MHz span, full scale signal, result length=200, averages=10.

Residual Errors
- Error vector magnitude: 1% rms
- Magnitude error: 1% rms
- Phase error: 0.57° rms
- Frequency error: 10 Hz
  (Added to frequency accuracy if applicable.)
- Origin I/Q offset: – 60 dB

Signal Acquisition
Note: Signal acquisition does not require an external carrier or symbol clock

Data block length
- Adjustable up to 1024 samples (4096 samples with extended RAM option UFG).
- Examples (with option UFG):
  - 4096 symbols at 1 point/symbol;
  - 409 samples at 10 points/symbol.

Symbol clock
- Internally generated

Carrier lock
- Internally locked

Triggering
- Single/continuous
- External
- Internal source
- Pulse search (searches data block for beginning of TDMA burst, and performs analysis over selected burst length)

Data synchronization
- User-selected synchronization words
- Arbitrary bit patterns up to 30 symbols long, at any position in a continuous or TDMA burst and measurement result. Up to 6 words can be defined.

Arbitrary waveform source
- RAM-based arbitrary waveforms
  - Waveform registers: Maximum 6
  - Waveform length: 4096 complex points each (16,384 with option AYB)

Residual accuracy, typical
- Examples
  - π/4DQPSK, 24.3 ksymbols/second, α = 0.35
    - EVM ≤ 0.7% rms
  - GMSK, 270.833 ksymbols/second, BT= 0.30
    - EVM ≤ 1.0% rms

Digital Video Modulation Analysis — Option AYH (requires option AYA)
This option extends the capabilities of the vector modulation analysis option AYA by adding modulation formats used for digital video transmission. Except where noted, all of the standard capabilities of option AYA are provided for the new modulation formats.

Supported modulation formats
- Additional modulation formats
  - 8 and 16VSB
  - 16, 32, 64 and 256QAM
    - (differentially encoded per DVB standard)

Maximum symbol rate
Option AYH 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:

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

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

Receiver mode
- ch1 + j*ch2
- 0 - 10 MHz
- External

Information bandwidth
- ≤ 20 MHz ‡
- ≤ 10 MHz
- ≤ 10 MHz ‡

Example: For a 64QAM signal (α = 0.2), the maximum symbol rate in 0-10 MHz mode is 10 MHz/(1.2) = 8.33 Msymbols/second.

† For error analysis, a Gaussian reference filter with BT = 1.22 is used to approximate the tenth-order Bessel filter.

‡ Downconverter dependent.
Measurement results and display formats

Identical to option AYA measurement results and display formats except for the following changes to the error summary display:

- VSB pilot level is shown, in dB relative to nominal.
- For VSB formats, SNR is calculated only from the real part of the error vector.
- For DVB formats, EVM is calculated without removing IQ offset.

Accuracy

Residual errors (typical)

8VSB or 16VSB, symbol rate = 10.762 MHz, \( \alpha = 0.115 \), instrument receiver mode of 0-10 MHz, 7 MHz span, full-scale signal, result length = 800, averages = 10.

Residual EVM \( \leq 1.5\% \) (SNR \( \geq 36 \) dB)

16, 32, 64 or 256 QAM, symbol rate = 6.9 MHz, \( \alpha = 0.15 \), instrument receiver mode of 0-10 MHz, 8 MHz span, full-scale signal, result length = 800, averages = 10.

Residual EVM \( \leq 1.0\% \) (SNR \( \geq 40 \) dB)

Filtering

All option AYA filter types are supported except user-defined filters for VSB analysis. Filters are calculated to 40 symbols in length.

Triggering and Synchronization

All option AYA signal acquisition features are supported except pulse and sync word search for VSB analysis.

Adaptive Equalization — Option AYH or Option AYJ

(AYJ adds adaptive equalization to option AYA)

This option 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 3–99 symbols, adjustable

Filter taps 1,2,4,5,10, or 20 taps/symbol

Measurement results

Equalizer impulse response

Channel frequency response

Supported modulation formats

MSK, BPSK, QPSK, OQPSK, DQPSK, \( \pi/4 \)DQPSK, 8 PSK, 16 QAM, 32 QAM, 64 QAM, 256 QAM, 8 VSB, 16 VSB
### Waterfall and Spectrogram — Option AYB

<table>
<thead>
<tr>
<th>Waterfall</th>
<th>Spectrogram</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Types</strong></td>
<td><strong>Types</strong></td>
</tr>
<tr>
<td>Vertical and skewed — Azimuth adjustable 0 to ±45 Normal and hidden line With or without baseline</td>
<td>Color, normal and reversed Monochrome, normal and reversed User color maps (2 total)</td>
</tr>
<tr>
<td><strong>Adjustable parameters</strong></td>
<td><strong>Adjustable parameters</strong></td>
</tr>
<tr>
<td>Trace height</td>
<td>Number of colors</td>
</tr>
<tr>
<td>Buffer depth</td>
<td>Enhancement</td>
</tr>
<tr>
<td>Elevation</td>
<td>(color-amplitude weighting)</td>
</tr>
<tr>
<td>Threshold</td>
<td>Threshold</td>
</tr>
</tbody>
</table>

**Trace select**

When a waterfall or spectrogram measurement is paused or completed, any trace in the trace buffer can be selected by trace number or by z-axis value. The marker values and marker functions apply to the selected trace.

**Z-axis value**

The z-axis value is the time the trace data was acquired relative to the start of the measurement. The z-axis value of the selected trace is displayed as part of the marker readout.

**Display update rate**

30 to 60/second, typical

**System memory**

Note: In standard configuration, the analyzer has approximately 1-2 Mbytes free memory for these displays. Option UFG adds 4 Mbytes free memory.

**Memory required**

Displays occupy memory at the rate of 175 traces/MByte (for traces of 401 frequency points). A full screen of 307 traces will require 2.25 Mbytes of free memory. With option UFG, the analyzer will typically accommodate more than 1000 traces in memory.

### 4 Mbytes Extended RAM and Additional I/O — Option UFG

**Extended RAM**

Extended memory type: 4 Mbytes dynamic RAM Available memory with option UFG installed: 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: HP 28685B (10base-T) or HP 28683A (FDDI) Program interface: Send and receive HP-IB programming codes, status bytes and measurement results in ASCII and/or binary format.

**HP-IB I/O**

Secondary HP-IB port: Per IEEE 488.1 and 488.2 Functions: Controller-only; accessible from IBASIC program or front panel commands. Note: Option UFG is strongly recommended for use with option AYA Vector Modulation Analysis and option AYB Waterfall and Spectrogram.

**Advanced LAN Support — Option UG7**

**Remote X11 display** (characteristic only)

Update rate: > 20 per second, depending on workstation performance and LAN activity. X11 R4 compatible X-terminals, UNIX workstations, PC with X-server software Display: 640 × 480 pixel minimum resolution required; 1024 × 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 Note: Option UG7 requires option UFG.