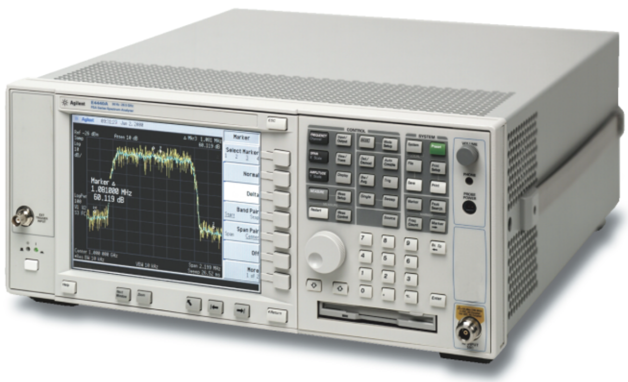
# Agilent PSA Performance Spectrum Analyzer Series

# Measurement Innovations and Benefits

Product Note



The Agilent performance spectrum analyzer (PSA) series (model E4440A) is the first in a new generation of spectrum analyzers designed for exceptional performance and speed in RF and microwave measurements. World-class performance of the PSA series is combined with ease-of-use improvements, both are the result of numerous technology innovations.

The technological innovations of the PSA series provide measurement benefits primarily in the measurement accuracy, dynamic range and measurement speed areas. This product note begins with a summary of these benefits and innovations, and other product notes for the PSA series describe them in more detail. These product notes are listed as references at the end of this document. In most applications, multiple PSA innovations work together and reinforce each other to enhance their benefits. The PSA series make the toughest measurements easier and the slowest measurements faster, bringing reliability and repeatability to measurements with the highest accuracy and dynamic range.

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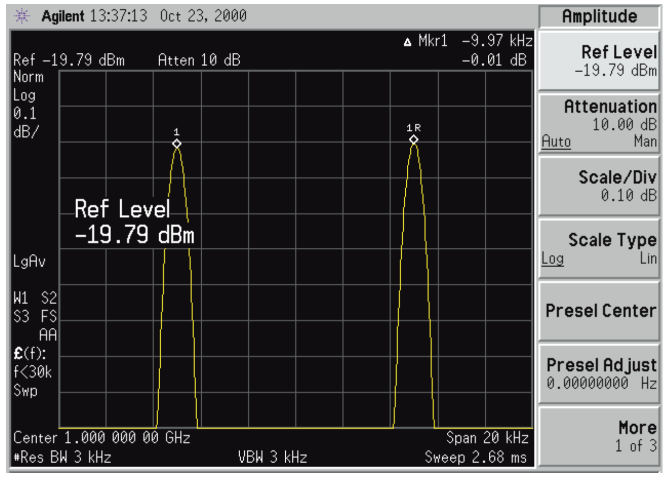
## Measurement Benefits of the PSA Series

### Exceptional Amplitude Accuracy and Resolution

Most amplitude accuracy specifications of the PSA series are approximately 10 times tighter than preceding high-performance spectrum analyzers, such as the Agilent Technologies 8563E. The accuracy improvements apply to continuous wave (CW) signals, signals with both analog and digital modulation, and noise or noise sidebands. Using the Agilent PSA series can eliminate the need for a separate power meter and filters because they combine the frequency selectivity of a spectrum analyzer with accuracy approaching that of a power meter.




**The accuracy and resolution of measurements with the PSA series can eliminate the need for a separate power meter. In this illustration, a two-tone measurement is made at 0.1 dB/div. with a reference level resolution of 0.01 dB.**

Accurate amplitude measurements challenge the entire analysis chain, including the input section, downconversion, signal processing, and detection. Innovations in the PSA series that contribute to accuracy include:

- Highly accurate, built-in 50 MHz calibrator, matching the calibration frequency of many power meters.
- New and more effective calibration/correction algorithms.
- All-digital implementation of a swept spectrum analyzer IF section—allowing many error sources to be reduced or eliminated. These include RBW/ENBW (resolution bandwidth/equivalent noise bandwidth) uncertainty, log amplifier inaccuracy, RBW filter sweep effects, RBW switching uncertainty, and IF gain uncertainty.
- Improved input design, including attenuator accuracy and flatness and accurate input impedance to reduce mismatch error.
- Switchable analog-to-digital converter (ADC) dither to optimize low-level log fidelity or noise floor.

In some applications, relative power accuracy and resolution are the most important. For these measurements the PSA series' 0.1 dB/div. display resolution, 0.01 dB reference level resolution, and 3-digit marker readout provide an extremely detailed view of signal characteristics and trends.

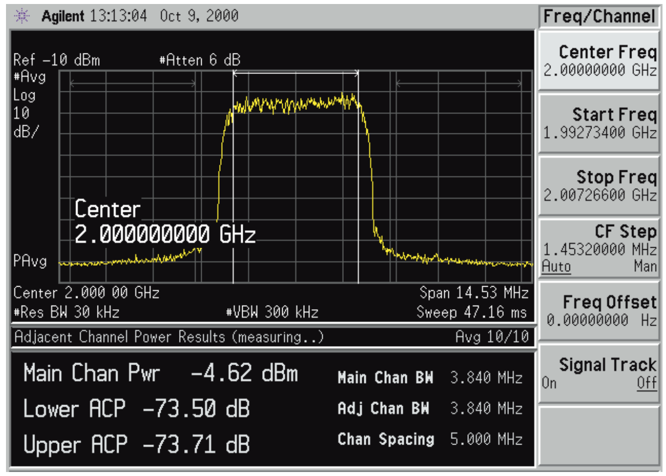
For more information on the exceptional amplitude accuracy of the PSA series and suggestions for optimizing accuracy in typical measurements see the PSA series product note entitled *Amplitude Accuracy,* literature number 5980-3080EN.

## High Dynamic Range in a Wide Variety of Measurements

Dynamic range is quantified in several different ways, depending on the application. The PSA series provide wide dynamic range as specified in the following ways:

- TOI-to-noise dynamic range—A challenging example is the ability to measure W-CDMA ACP (adjacent channel power). Typical performance for the Agilent PSA series is 73 dB.
- Phase noise dynamic range—Good specified performance at 10—100 kHz offsets (-113 to -118 dBc/Hz) is accompanied by exceptional performance at 1 MHz (-142 dBc/Hz) to 6 MHz (-146 dBc/Hz) offsets and beyond, critical for GSM systems.
- Log fidelity dynamic range—Logarithmic amplification is performed digitally, therefore it is possible to provide a log range that is limited only by the instrument noise. Signals from -10 dBm to near the noise floor at -156 dBm can be measured without changing the IF gain or the input attenuation.
- Compression-to-noise dynamic range—The PSA series input mixer can be driven with signals as large as +5 dBm and still observe sidebands accurately (less than 1 dB compression of sidebands). This performance is excellent for measuring out-of-band signals emissions in demanding applications like GSM.

**The PSA series provide measurements with exceptional dynamic range due to their careful analog design and digitally-implemented IF section.**

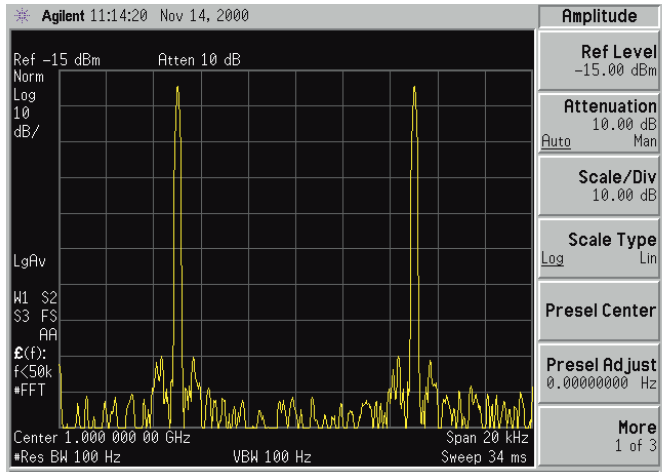



The usable dynamic range of the PSA is enhanced by a standard 2 dB step attenuator that covers the complete frequency range of the analyzer, and by the ability to switch off ADC dither to lower displayed-average noise level (DANL).

For more information on the dynamic range performance of the PSA series and suggestions for optimizing dynamic range in typical measurements see the PSA series product note entitled *Optimizing Dynamic Range for Distortion Measurements*, literature number 5980-3079EN.

## Faster Measurements for Demanding Applications

Spectrum measurements requiring high dynamic range and/or high amplitude accuracy are often slow. Slow measurement speeds are also typical for narrow frequency span measurements using traditional spectrum analyzers. In most cases, these slow measurements require the use of a narrow resolution bandwidth, either to reduce DANL or to provide appropriate frequency resolution. Measurements of noise or noise-like signals may also be time-consuming due to the need for averaging or narrow video bandwidth (VBW) to reduce the variance of the signal.




**Innovations such as digital filters and flexible FFT processing provide narrowband measurements that are much faster than those of traditional swept analyzers. This two-tone measurement is performed in FFT mode in only 0.034 seconds on the PSA, while a traditional swept analyzer would require 4 seconds.**

Innovations in the PSA series improve measurement speeds for slow measurements. These improvements are typically larger for the slowest measurements. The speed improvements are the result of PSA technologies including:

- Digital IF filters—Digital filters offer better selectivity (shape factor) for a given bandwidth, can be swept faster than analog filters, and provide finer RBW settings to optimize speed/resolution trade-offs.
- FFT analysis—Fast Fourier Transform (FFT) processing provides the greatest speed improvements for narrowband analysis. The PSA series' FFT implementation includes variable block size, variable number of FFTs/span, and ADC autoranging to provide increased accuracy and dynamic range.
- Low inherent noise level—The excellent noise figure of the PSA series decreases the need for narrow (slow-sweeping) RBWs that would otherwise be needed to reduce DANL.
- Averaging techniques—The PSA series' flexible detector modes, innovative averaging, and digital VBW filtering can be used alone or in combination to reduce noise variance quickly.

User interface features also contribute to effective measurement speed. When display updates are slow, it can be difficult to adjust center frequency or frequency span to bring the desired signals on screen. The PSA series implement a feature called "panning", where existing measurement data is reformatted instantly in response to user adjustments of span or center frequency. This prevents visual loss of the signal and reduces operator adjustment time.

For more information on the use of FFT and swept measurements in the PSA series, and suggestions for optimizing measurement techniques for speed, accuracy and dynamic range, see the PSA series product note entitled *Swept and FFT Analysis*, literature number 5980-3081EN.

## Technology Innovations of the PSA Series

### Digital Implementation of a Swept Spectrum Analyzer IF Section

The Agilent PSA series perform traditional swept spectrum analysis with all-digital resolution bandwidth (RBW) filters. Implementing these filters with digital technology provides several benefits.

- Filter shape factor—Using digital technology, it is possible to build filters with a better shape factor (ratio of 3 dB to 60 dB bandwidth). The shape factor of the filters in the Agilent PSA series is 4.1:1 versus approximately 12:1 for traditional analog filters. This increased resolving power for unequal-level signals means that a wider RBW can often be used in a given measurement, providing faster sweep speeds.
- Variable bandwidth RBW filters—High-speed digital signal processing (DSP) replaces traditional analog filters; RBW can now be set in fine (10%) steps instead of the typical 1-3-10 arrangement. This allows the RBW to be set in a measurement to optimize speed, dynamic range, and resolving power in any combination.
- Exact and predictable RBW—When measuring noise and noise-like signals, it is important to know the precise bandwidth (usually expressed as equivalent noise bandwidth or ENBW) of the RBW filter. The characteristics of digital filters are stable and highly predictable, leading to greater amplitude accuracy when the PSA series are used to measure noise or noise-like digitally modulated signals in communications applications.
- RBW switching uncertainty—Once again, the predictable characteristics (insertion loss in this case) of digital RBW filters increase amplitude accuracy by dramatically reducing one of the error terms in amplitude measurements. This improves repeatability and measurement confidence.
- Oversweeping RBW filters—The sweep rate for analog filters has typically been set to approximately $RBW^2/2$ [Hz/s] in a compromise between measurement speed and amplitude/frequency errors due to fast sweeping. However this formula is not a natural law, and the effects of faster sweeps can be precisely corrected when predictable, linear phase digital RBW filters are used. In the Agilent PSA series, these filters sweep about twice as fast as analog filters and with greater accuracy.

The all-digital IF section in the PSA series includes other innovations, which add flexibility and power to a variety of spectrum measurements.

- Multiple detector modes include normal, peak, minimum, sample, and average (RMS). Today's digitally modulated signals often behave more like noise (whose characteristics must be statistically measured) than the discrete, deterministic signals that traditional swept analyzers were designed for. For optimum speed, accuracy (without cumbersome corrections), and repeatability, it is vital to select the best detector type to accurately and quickly measure a variety of signal types.
- Digital logarithmic amplification—Performing logarithmic amplification as a mathematical operation significantly improves the linearity error term in amplitude measurements. The reference level of a measurement can be set independently of the signal level, eliminating the need to move part of a signal out of the display range before an accurate measurement can be made. Signals from -10 dBm to near the noise floor at -156 dBm can be measured without changing the IF gain or the input attenuation.
- Increased display resolution—Digital manipulation of display data makes it easy to see small signal differences or changes. The PSA series provides 0.1 dB/div. display resolution, 0.01 dB reference-level resolution, and 3-digit marker readout.

### Sophisticated Automatic Coupling of Measurement Parameters With Complete Manual Control

The PSA series spectrum analyzers default to automatic coupling of most measurement parameters. If changed, these couplings can be restored by the "Auto couple" key. These parameters can also be set manually by the user to optimize a particular measurement characteristic. In addition to the traditional couplings of RBW, VBW, and sweep time, there are other examples of measurement intelligence embedded in the Agilent PSA series features and firmware:

- The choice of FFT or swept analysis can be automatically determined by span and RBW. It can be selected by rules that optimize speed or rules that optimize dynamic range. Alternatively, the user can specifically choose FFT or swept analysis. The user can choose a near continuum of speed/dynamic range performance between FFTs and swept, where the frequency span is analyzed by a user-controlled number of FFTs. These narrower FFTs can approach the dynamic range of swept measurements, while offering faster measurement speeds.
- The local oscillator (LO) configuration can be set to optimize the close-in phase noise performance (below 50 kHz offsets) or the wideband performance (above 50 kHz offset). The LO can also be optimized for fast tuning between center frequencies.
- Dither, an additive signal that linearizes the ADC, can be set for best detection linearity (the "dither on" mode improves low-level log fidelity from about 0.5 dB to 0.07 dB) or best noise floor (the "dither off" mode has about 1.5 dB lower displayed-average noise level).
- Detector types can be chosen automatically or manually. The peak detector offers the best accuracy for CW signals, while the average detector is best for power measurements or measuring complex modulated signals. The sample detector provides a good tradeoff between accurate peak measurements and measurements of noise. The normal detector is a good choice for making signal versus noise judgments.
- Averaging scales can be automatically or manually selected. The averaging processes include trace averaging, the average detector type, VBW filtering, and the noise marker. All of these processes can be performed on a power scale for optimum speed and RMS detection in channel power measurements, a log scale for optimum CW measurements (especially near the noise floor), or a voltage scale (the best choice for observing pulsed RF transitions).

### 2 dB Step Attenuator

The PSA series provide a standard 2 dB resolution step attenuator covering the full frequency range of the analyzer. The fine amplitude resolution of this attenuator allows the user to obtain the ideal signal level at the input of the analyzer, optimizing the particular kind of dynamic range that is most important for a given measurement. This allows the analyzer's inherent high dynamic range to be realized no matter what the signal level.

### Multiple Measurement Modes Including FFT, Swept, and Combination

FFT spectrum analysis provides much faster measurements (typically 1-2 orders of magnitude faster than traditional spectrum analyzers) for narrow spans and RBWs. However, dynamic range for a single FFT analysis may be limited by the noise inherent in wide bandwidth analog-to-digital (ADC) conversion and the inability to autorange the ADC during the measurement.

Swept analysis using digital RBW filters provides the highest accuracy and dynamic range and is typically twice as fast as traditional analog spectrum analysis.

A combined analysis mode, involving a stepped-frequency LO and multiple FFT calculations for a single frequency span, provides a continuum of performance in terms of speed and dynamic range. This allows for an optimum combination of measurement speed and dynamic range.

## Multiple-Mode Local Oscillator

The flexibility of the PSA series local oscillator offers an opportunity to optimize speed and dynamic range for different frequency offsets. The dynamic behavior of this LO is selected automatically and can also be changed by the user to suit their measurement priorities.

- Close-in/wideband phase noise optimization—The already excellent phase noise of the PSA series can be further optimized for either close-in (<50 kHz offset) or wideband measurements. This can yield several dB better phase noise for a given measurement.
- Fast-switching local oscillator mode—Faster-switching LOs typically have more phase noise. The ability of the PSA series to switch modes and change the tradeoff means that some measurements covering wide frequency ranges can be made more quickly.

## Specifications

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|---|---|
| **Frequency coverage** | 3 Hz to 26.5 GHz |
| **DANL** | -153 dBm (10 MHz to 3 GHz) |
| **Absolute accuracy** | ±0.27 dB (50 MHz) |
| **Frequency response** | ±0.40 dB (3 Hz to 3 GHz) |
| **Display scale fidelity** | ±0.07 dB total (below -20 dBm) |
| **TOI** (mixer level -30 dBm) | +16 dBm (400 MHz to 2 GHz)<br>+17 dBm (2–2.7 GHz)<br>+16 dBm (2.7–3 GHz) |
| **Noise sidebands** (10 kHz offset) | -113 dBc/Hz (CF = 1 GHz) |
| **1 dB gain compression** | +3 dBm (200 MHz to 6.6 GHz) |
| **Attenuator** | 0–70 dB in 2 dB steps |

### Related Literature for the Agilent PSA Performance Spectrum Analyzer Series

*The Next Generation*
Brochure
literature number 5980-1283E

*E4440A PSA Spectrum Analyzer Series*
Technical Specifications
literature number 5980-1284E

*Optimizing Dynamic Range for Distortion Measurements*
Product Note
literature number 5980-3079EN

*Amplitude Accuracy*
Product Note
literature number 5980-3080EN

*Select the Right PSA Spectrum Analyzer for Your Needs*
Selection Guide
literature number 5968-3413E

*Self-Guided Demonstration*
Product Note
literature number 5988-0735EN

*Swept and FFT Analysis*
Product Note
literature number 5980-3081EN

### Warranty

The E4440A is supplied with a 3 year warranty.

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