Speeding Up Spectrum Analyzer Measurements

Choose and optimize your spectrum analyzer to meet *your* needs.

The measurement speed of a spectrum analyzer can significantly affect the time it takes to complete a project. Consider the following examples:

A manufacturing test engineer wants to optimize for speed to achieve the highest throughput on the assembly line. He has made all measurements, but waits for the results to move through the GPIB to the computer.

A field technician needs to travel to a service location to make some measurements and adjustments, archive the results, and travel to the next job site. But she must wait from 30 minutes to 2 hours for the spectrum analyzer to warm up prior to making calibrated measurements.

R&D finally receives the new project prototypes back from Manufacturing. Tests reveal a problem with low-level harmonic and nonharmonic spurious signals. To find and examine these low-level spurs, a spectrum analyzer sweep time of 100 seconds or longer is needed due to the narrow resolution bandwidth (RBW) filters required to drive the noise floor down.

Having speed where it matters most can help solve all three of these problems. For example, spectrum analyzers offering quick warmups, such as the Agilent Technologies ESA-E series (5 minutes), solve the problem of waiting a long time to use the analyzer. Fast warmup is critical when a battery is supplying the operating power. Speed in other areas can reduce the delays described in the other two examples.

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In each of these examples, data must be printed or displayed in a usable form as quickly as possible. But spectrum analyzers have to perform several steps to produce data in usable form, and spectrum analyzers differ in which areas they emphasize speed. Some provide fast display updates and others offer rapid GPIB updates. Knowing how quickly different analyzers perform these internal steps can help you understand the holdups you may be experiencing now, and also help you choose the spectrum analyzer that best suits your needs.

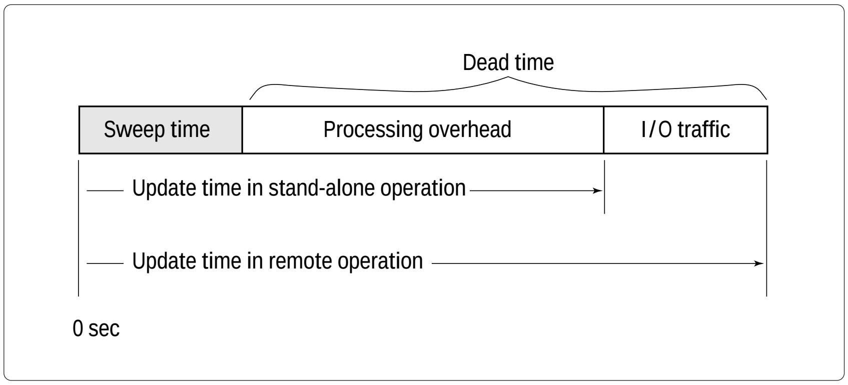

Figure 1. The components of measurement update time

What are the components of spectrum analyzer speed?

One element of spectrum analyzer speed is warmup time, as described above. Once a spectrum analyzer is warmed up and ready to perform, speed is determined by the time required for each measurement update to the analyzer's display or to an external computer. There are two main components of measurement update time: the actual measurement time ("sweep time"), and the time between sweeps ("dead time"), which consists of processing overhead and I/O traffic time **(figure 1)**.

RF and microwave spectrum analyzers can make full-span calibrated measurements with sweep times ranging from 1 millisecond to several thousand seconds, and zero-span sweeps in microseconds. Sweep time is dependent on the resolution bandwidth (RBW) filter, frequency span, and the design of the spectrum analyzer.

Processing overhead is the time it takes the spectrum analyzer to perform its "housekeeping" tasks. These include formatting the acquired data for display, preparing the data for export to an external computer, setting up for the next sweep, and many others. Currently, engineers want spectrum analyzers to provide more analysis on the acquired data, including markers, averaging, signal tracking, and adjacent channel power (ACP). Although these features add greatly to the user's convenience, they also increase the processing overhead by as much as eight times, reducing spectrum analyzer speed.

At present, I/O traffic time (in remote-control operation) is an insignificant part of the measurement update time, so improving computer and interface speeds will not noticeably affect measurement speed. However, as reductions in processing overhead are achieved, I/O traffic time may take up a larger portion of measurement time.

Optimizing Sweep Time

Selecting the optimum RBW filter is critical for minimizing sweep time. For near-Gaussian-shaped analog RBW filters:

Sweep time = k(span)/RBW^2,
where k = constant of proportionality.

Notice that when the RBW filter is reduced by a factor of 10, the sweep time goes up by a factor of 100 due to the squaring of the RBW filter value.

The key specifications an engineer must consider when choosing the RBW filter are width (usually specified at the -3-dB points) and selectivity (shape factor). RBW selectivity is the ratio of the filter width at -60 dB to the width at -3 dB **(figure 2)**. A sharper filter has a smaller selectivity.

Consider the example of a manufacturing engineer who must verify the presence of two CW signals to prove that his device under test, a bandpass filter, passes the test specification. The first signal is at 1 GHz and is 20 dB lower than the second signal. The second signal is approximately 240 Hz higher in frequency. **Figure 3a** shows the output of the bandpass filter using a 300-Hz analog RBW filter. Only the largest signal can be identified due to the width

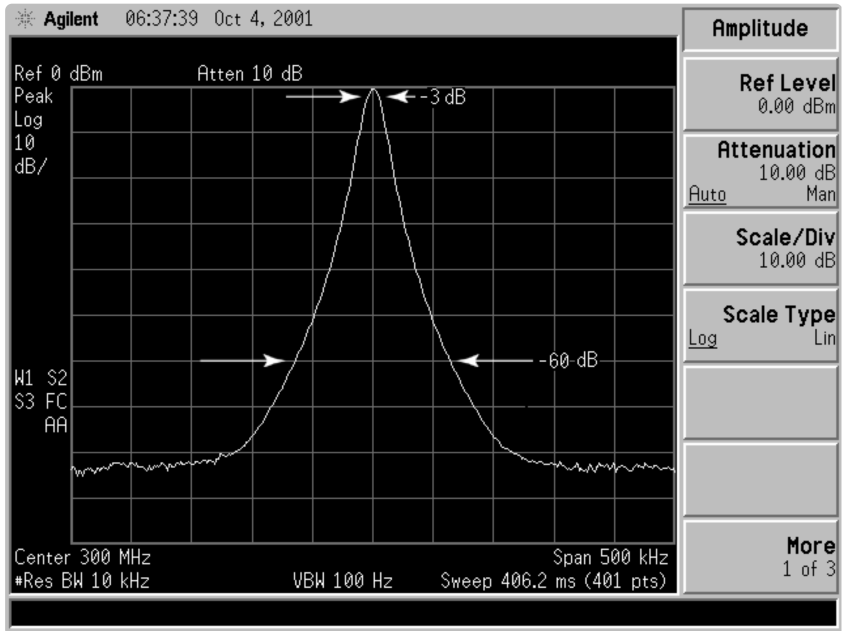

Figure 2. RBW selectivity is the ratio of the width at –60 dB to the width at –3 dB.

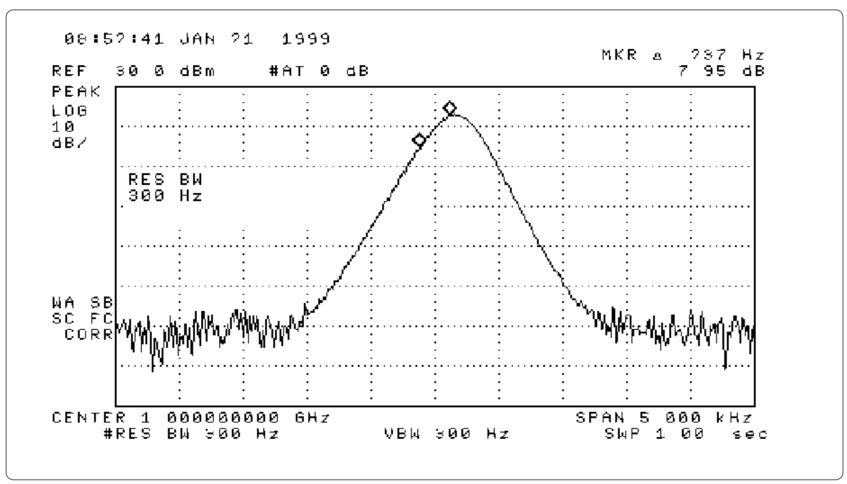

Figure 3a. 300-Hz analog RBW filter

of the selected filter. The RBW filter must be at least as narrow as the two signals are close together to resolve the signals.

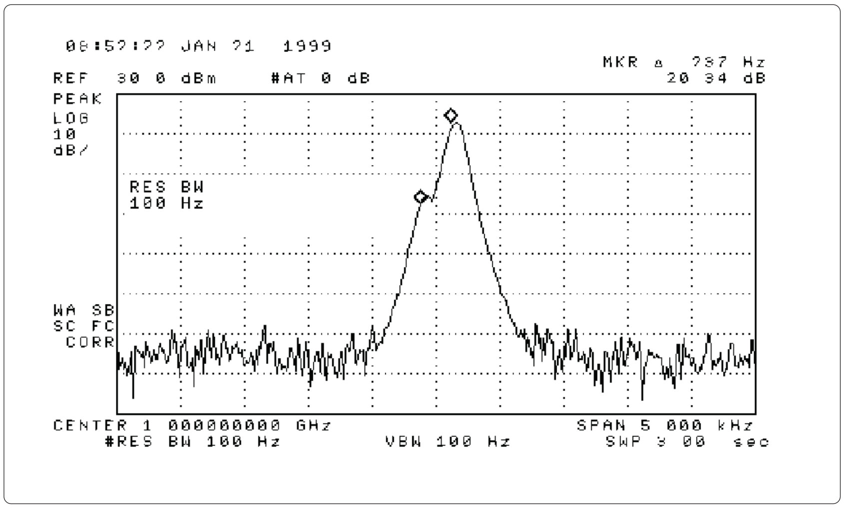

Figure 3b. 100-Hz analog RBW filter

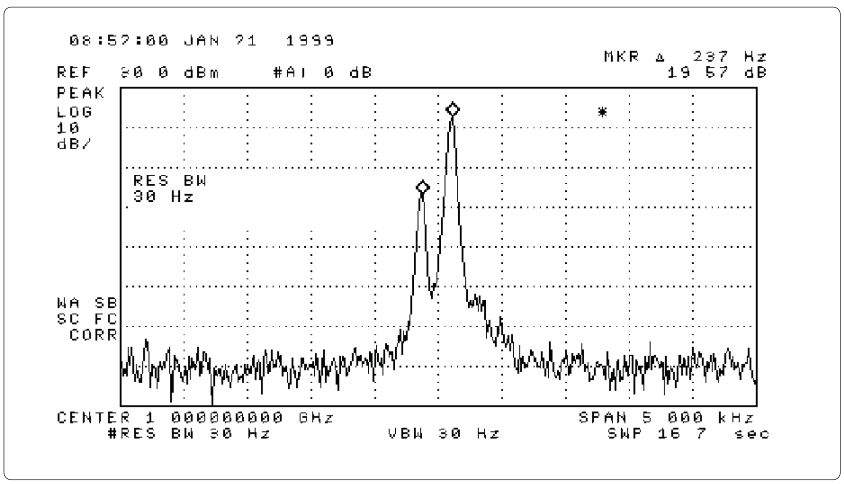

Figure 3c. 30-Hz analog RBW filter

Figure 3b shows the bandpass filter output using a 100-Hz analog RBW filter. Although the selected RBW filter is narrow enough to resolve a signal 240 Hz away from another signal, the 15:1 selectivity of the analog RBW filter is too large. The smaller 1-GHz signal still cannot be viewed, as it is hidden below the skirt of the larger signal. Therefore, an even narrower RBW filter is needed.

Figure 3c shows that the 30-Hz RBW filter will resolve the two signals with at least the 10-dB margin needed, but with a penalty in sweep time: In this example, it will take 16.7 seconds to make the measurement.

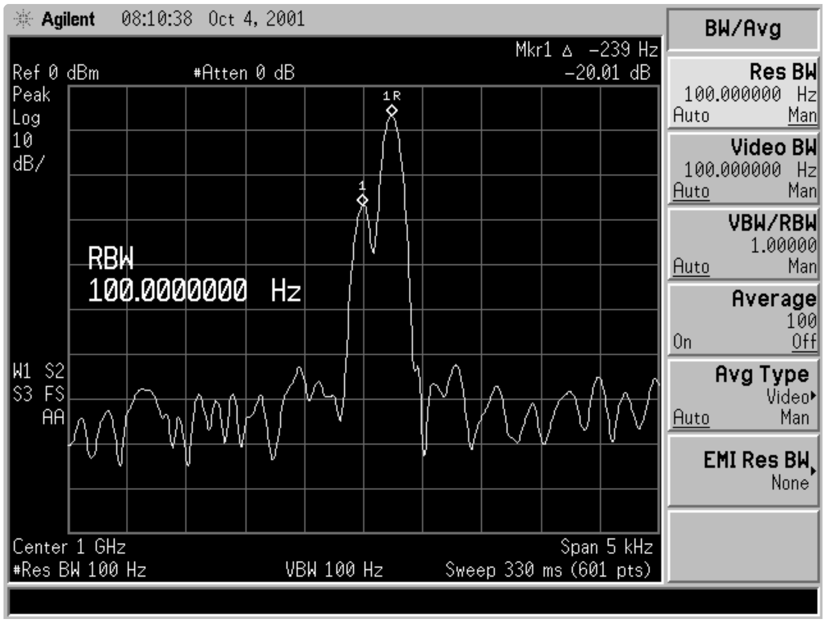

Figure 4a. 100-Hz digital RBW filter

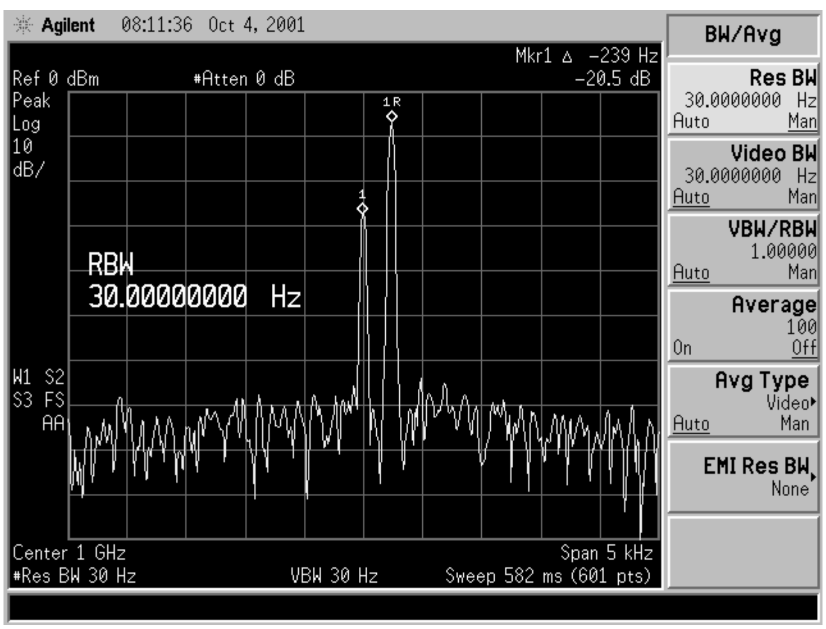

Figure 4b. 30-Hz digital RBW filter

Figures 4a and 4b show the same measurement using a digital RBW filter with <5:1 selectivity (at 100 and 30 Hz). The <5:1 selectivity allows the manufacturing engineer to use the 100-Hz RBW filter and still clearly identify the smaller 1-GHz signal. A spectrum analyzer with digital RBW filters allows you to make measurements in 330 ms, or more than 50 times faster, eliminating a potential manufacturing bottleneck.

As mentioned above, modern spectrum analyzers employ various digital techniques to decrease sweep time. The most effective technique is the FFT (Fast Fourier Transform), used in place of swept analysis. The FFT calculates the spectrum using time samples of the signal. The use of fast analog-to-digital converters to sample the last intermediate frequency (IF) makes this possible. The FFT is used with digital RBW filters in the narrowest RBW settings (usually less than 1 kHz) to minimize sweep times.

Table 1 compares the sweep times of two analyzers: an Agilent 8566B Option 002 (turbo option) with analog RBW filters and an Agilent ESA-E series spectrum analyzer with digital RBW filters. In this example, the spectrum analyzer with digital RBW filters is up to 114 times faster when making the same measurement.

RBW	8566B Opt. 002 (analog filters)	ESA-E series (analog / digital filters)
1 kHz	300 milliseconds	85 milliseconds (analog)
10 Hz	300 seconds	2.629 seconds (FFT / digital)

Table 1. Sweep-time comparison (span = 10 kHz @ 1 GHz)

Optimizing Processing Overhead

Minimizing sweep time is important for speeding up your measurement updates, but processing overhead is also a large portion of throughput and must be optimized. Determining how you will use the spectrum analyzer (either standalone operation or remote operation) will help you understand how to make your measurements faster.

Standalone operation

Standalone operation is typically used when the operator is either analyzing one or more signals, or adjusting a component to a specified value. In this manual operation mode, instantaneous response is desired. To achieve instantaneous response, the update rate should be between 25 and 30 continuous measurements per second, or the refresh rate of the display.

Center frequency = 1GHz Frequency span = 300 MHz RBW filter = 3 MHz	8566B Opt. 002 spectrum analyzer	ESA-E series spectrum analyzers
Sweep time	20 ms	1 ms (101 points)
Processing overhead	23 ms	24 ms (101 points)
Measurement update rate	~23 updates / sec	~40 updates / sec (101 points)

Table 2. Measurement update rates (standalone operation)

This minimizes any time delay between a manual adjustment and the updated spectrum analyzer display. The latest RF and microwave spectrum analyzers can achieve this flicker-free performance by minimizing processing overhead and sweep times. The Agilent 8566B with turbo option, now discontinued, has been the spectrum analyzer speed benchmark since its introduction in 1991, and will be used for comparison.

In standalone operation (no data transfer to a computer or printer), the following equation provides the number of measurement updates per second:

Measurement update rate = 1 /(sweep time + time between sweeps)

Table 2 compares the measurement update rates for the Agilent 8566B and Agilent ESA-E series spectrum analyzers. It shows that the processing overhead is greater for the newer analyzers, but sweep times are faster because of recent advances, resulting in faster overall update rates.

Remote Operation

Under the computer control of remote operation, the spectrum analyzer performs most if not all of the processing required in standalone operation, and it must format the data for export. This added processing time slows down the update rate significantly. Spectrum analyzers offer amplitude data in different formats, trading off processing overhead for display scaling information. Choosing the format with the shortest processing overhead time can more than double your throughput.

The two formats a spectrum analyzer can send across the GPIB are machine units (M-units, in thousandths of a dBm) and display units (scaled to display setup). Each amplitude value represents a point in the span of the measurement sweep. Amplitude points can be 8, 16, 32, or 64 bits long, depending on the resolution required. The number of frequency points in a sweep can be 101, 201, 401, 801, 1001, or more. The number of formatted bytes sent for each measurement update can be determined by the following equation:

Bytes sent = (bytes/point) x number of points

If display annotations are required, additional processing and transmitted bytes are needed.

In ATE (automatic test equipment) environments, where speed is a priority, machine units (binary) produce the fastest results by minimizing processing overhead. Because the test conditions and instrument setups are known by the test software application, display scaling and instrument annotations are redundant. If GPIB speed is not an issue for your testing needs, display units (A-units in ASCII or binary) can be used.

Whether you are installing a new, high-speed production line, making transmitter measurements in the field, or designing a new low-noise amplifier, the speed of your spectrum analyzer will greatly affect your productivity. However, spectrum analyzer measurement speed is the sum of several time components. To select the best spectrum analyzer, you need to determine your most critical time requirements (such as rapid warmup time, high-resolution sweeps, instant feedback, or complicated analysis or display) and choose the instrument that best satisfies those requirements. With the speed that the latest generation of spectrum analyzers offers, spectrum analysis need never be a bottleneck in your testing process.

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