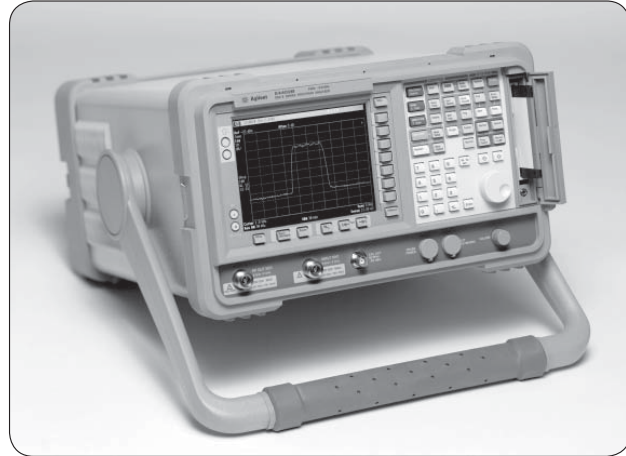


# Agilent ESA Series Spectrum Analyzers

## Demonstration Guide and Application Note



This demo guide is a tool to gain familiarity with the basic functions and features of the Agilent Technologies ESA-L series (E4411B, E4403B, E4408B) and ESA-E series (E4401B, E4402B, E4404B, E4405B, E4407B) spectrum analyzers. Almost all exercises utilize the 10 MHz reference signal from the back of the analyzer, eliminating the need for an external signal generator or DUT.

This demo requires a 4-foot BNC cable, Agilent part number 10503A. Key names surrounded by [ ] indicate hard keys located on the front panel, while key names surrounded by { } indicate the soft keys located on the right edge of the display.



**Agilent Technologies**

## Part 1. The Basics: Frequency, Span, and Amplitude

The key measurement parameters of a spectrum analyzer are:

- Frequency (what part of the frequency range you are looking at)
- Span (how closely you look at the signal)
- Amplitude (adjusting the view of the signal's amplitude)

In a typical spectrum analyzer measurement, the center frequency of the analyzer is first tuned to the signal of interest. Next, the span is adjusted to zoom in on the signal of interest. Finally, the amplitude is adjusted to give the optimum view of the signal.

In this section, you will connect a 10 MHz reference signal and zoom in on the signal. Next, you will set the reference level, which adjusts the amplitude at the top graticule line.

INSTRUCTIONS	KEYSTROKES
Connect a BNC cable from the 10 MHz reference signal on rear panel to input (50 Ω or 75 Ω) on front panel. <i>Note: leave connected throughout this demo.</i>	No keystrokes
Tune the center frequency to 60 MHz (Figure 1).	[FREQUENCY] [60] {MHz}
Adjust span so signal fills screen (Figure 2).	[SPAN] [110] {MHz}
Set reference level so that signal peak is at the top graticule line. <i>This is always good practice, since the top graticule lines of the display give the most accurate results.</i>	[AMPLITUDE] Rotate KNOB, [↑], or [↓]

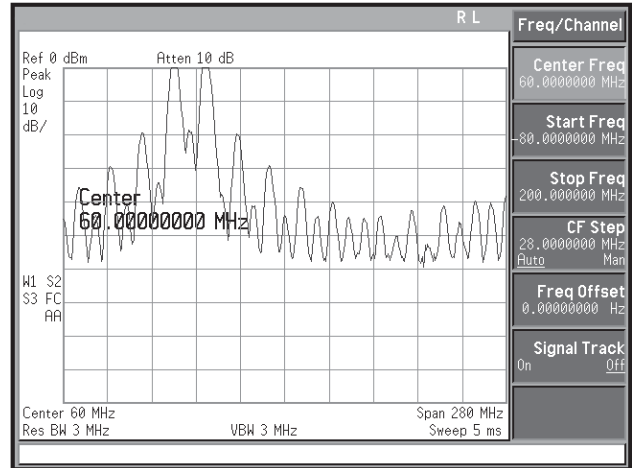


Figure 1. 10 MHz reference

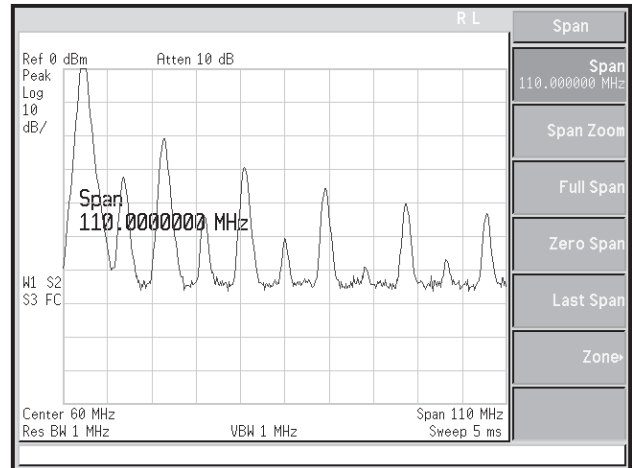


Figure 2. Adjust span

## Part 2. Save Your Work: The File System

A key feature of the Agilent ESA Series analyzers is the easy-to-use file system. In the internal file system, you may save 50 instrument *states* and 200 *traces, limit lines, or amplitude correction tables* with complete alphanumeric filenames. In addition, each file is stored complete with size, time, and date stamping. You can also use the internal floppy disk drive for storage and easy transfer of files to a PC.

In this section, the state of the instrument is saved to a filename of your choice so that it can be recalled for use in later sections.

INSTRUCTIONS	KEYSTROKES
Save the instrument state:	
1. Call up the file save menu.	[File] {Save} {State}
2. Enter the filename using alpha editor.	Enter a filename using  alphabet and/or number keys.
3. Choose internal memory drive.	[ ] (If file directory is highlighted press {Select}; otherwise skip.) use [↑] or [↓] to highlight -C- drive {Select}
4. Save into internal memory.	[Enter]
Recall (load) the instrument state.	[Preset] [File] {Load} {State} highlight filename with KNOB [Enter]

## Part 3. Analyzing Harmonic Distortion Marker Δ and CF Step

Harmonic distortion is present in any electronic system where a signal travels through an active device. Communications engineers are extremely concerned with harmonic distortion. For example, cellular radio systems must be checked for harmonics of the carrier signal that might interfere with other systems operating at the same frequencies as the harmonics. The ESA family of spectrum analyzers has several features that make analyzing harmonic distortion a simple task.

In this section, the 10 MHz reference signal's harmonics will be located using two methods: Marker Δ and CF Step. The Marker Δ function allows for easy comparison of amplitude and frequency differences between two signals, while the center frequency (CF) step function is a feature that allows the center frequency of the display to be adjusted by incremental steps. The CF Step method also allows for more accurate reading and better-resolved harmonics.

INSTRUCTIONS	KEYSTROKES
Recall (load) the instrument state.	[Preset] [File] {Load} {State} highlight filename with KNOB [Enter]
View harmonic distortion.	[View Trace] {Harmonics & THD}
Use the Marker Δ to locate the 7th harmonic (Figure 3). <i>The Marker Δ display should read about 60 MHz, which indicates the 7th harmonic.</i>	[Search] [Meas Tools] {Delta} {Next Pk Right} until marker Δ frequency is about 60 MHz
Switch off marker when finished.	[Marker] {Off}
Adjust frequency and span.	[FREQUENCY] [10] {MHz} [SPAN] [10] {MHz}
Use CF Step to locate the 7th harmonic (Figure 4). 1. Set the CF Step to the marker location. 2. Step the center frequency through the harmonics.	[Marker] [10] {MHz} [Marker→] {Mkr →CF Step} [Marker] {Delta} [FREQUENCY] [↑] until center frequency reads about 70 MHz

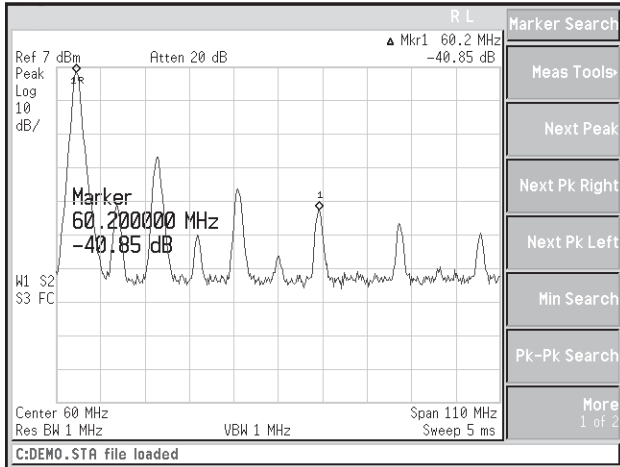


Figure 3. Marker  $\Delta$

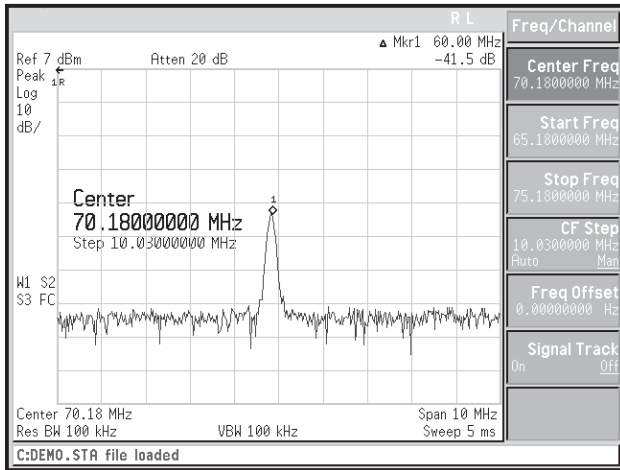


Figure 4. 7th harmonic

## Part 4. Marker Functions

### Peak table

The peak table feature of this spectrum analyzer family lets you measure multiple peaks simultaneously. Not only does this save time; it also gives you a clear printout of frequency and amplitude data. With the 5 ms sweep time and 28 measurements per second, you can rest assured that the analyzer is displaying the most current data.

### INSTRUCTIONS

Recall (load) the instrument state.

### KEYSTROKES

[Preset] [File] {Load} {State}  
highlight filename with KNOB  
[Enter]

Activate the Peak Table (Figure 5). [Search] {More 1 of 2} {Peak Table}  
*Note that the marker sorting can be by frequency or amplitude.* {Peak Table off}

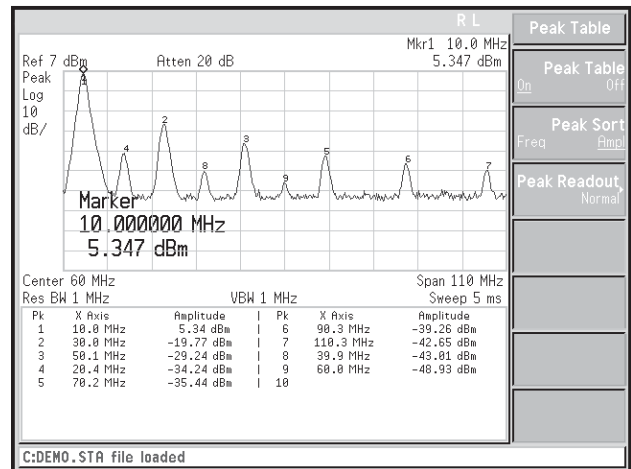


Figure 5. Peak table

## Part 5. One-Button Measurement Routines

### Harmonic distortion

One-button measurement capabilities are an important feature in modern spectrum analyzers. These test routines allow you to make complex measurements quickly. The Agilent ESA family comes with many one-button measurements, such as: Adjacent Channel Power (ACP), Channel Power, Occupied Bandwidth (OBW), and Harmonic Distortion.

This demonstration will show how the harmonic distortion function can be used to analyze the 10 MHz reference signal's harmonics. We performed a similar measurement in Part 3, but this time it will be done faster. Once the center frequency is set to the fundamental signal, the analyzer can automatically complete the measurement. The set-up conditions can also be modified to best suit your individual requirements.

#### INSTRUCTIONS

#### KEYSTROKES

Recall (load) the instrument state.	[Preset] [File] {Load} {State} highlight filename with KNOB [Enter]
Set the center frequency to the fundamental and set span.	[FREQUENCY] [10] {MHz} [SPAN] [10] {MHz}
Implement the one-button test. <i>This display should now be split showing the fundamental signal and giving a tabular reading for the first 10 harmonics (Figure 6).</i>	[MEASURE] {Harmonic Dist}
Adjust the measurement.	[Meas Setup] {Harmonics} [5] {Enter}
Switch off measurement.	[MEASURE] {Meas Off}

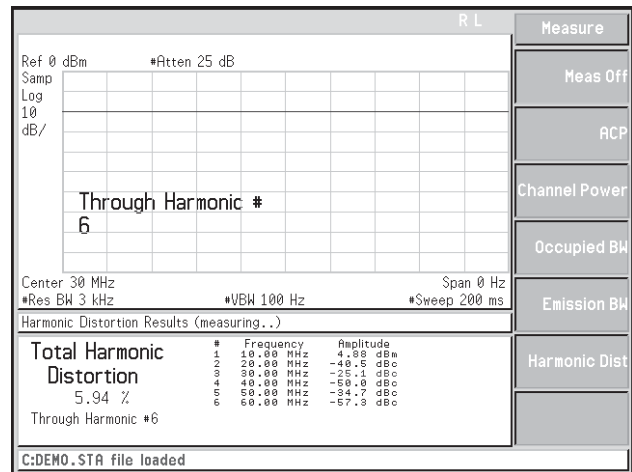


Figure 6. Harmonic distortion

## Part 6. Resolving Low-Level Signals

### Resolution bandwidth, input attenuation, and video averaging

One of the primary uses of a spectrum analyzer is searching out and measuring low-level signals (such as the 7th harmonic of our oscillator). Sensitivity optimization of the analyzer is absolutely crucial when trying to resolve signals of this nature. The spectrum analyzer input attenuator and bandwidth settings affect the levels of signals that can be seen on the display. The attenuator affects the level of a signal passing through the instrument. The bandwidth filter determines how close a small signal can be to a large signal and still be seen, and how small a signal can be displayed in the presence of the analyzer's internal noise level. The Agilent ESA family provides a 5 dB step attenuator to allow maximum flexibility when setting the analyzer's dynamic range.

If, after adjusting the attenuation and resolution bandwidth, a signal is still near the noise, visibility can be improved by using the video bandwidth or video averaging functions. The video bandwidth function changes the bandwidth of the analyzer's post-detection (video) low-pass filter. This filter is used to smooth small signal variations, which smoothes the trace. Video averaging simply averages the traces on screen as the sweep is made. The frequency counter within the spectrum analyzer can be used to make accurate frequency readings of signals.

INSTRUCTIONS	KEYSTROKES
Zoom in on the 7th harmonic (100 kHz span). <i>This automatically sets the RBW to 1 kHz.</i>	[Auto Couple] [FREQUENCY] [70] {MHz} [SPAN] [100] {kHz}
Bring the peak of the harmonic to the top graticule line (adjust ref. level). <i>The attenuation is set when the reference level is set.</i>	[AMPLITUDE] KNOB counter-clockwise or [↓]
Manually reduce the attenuation. <i>Notice the noise floor is now lower.</i>	{Attenuation} [0] {dB}
Reduce the video bandwidth to 1 Hz.	[BW/Avg] {Video BW} [↓]
Return the default settings for attenuation and video bandwidth.	[Auto Couple]
Smooth out the noise using Video Averaging (Figure 7).	[BW/Avg] { Average On} {Average Off} when done
Activate frequency counter and note the resolution (Figure 8) .	[Freq Count] {Resolution} {Marker Count Off} when done

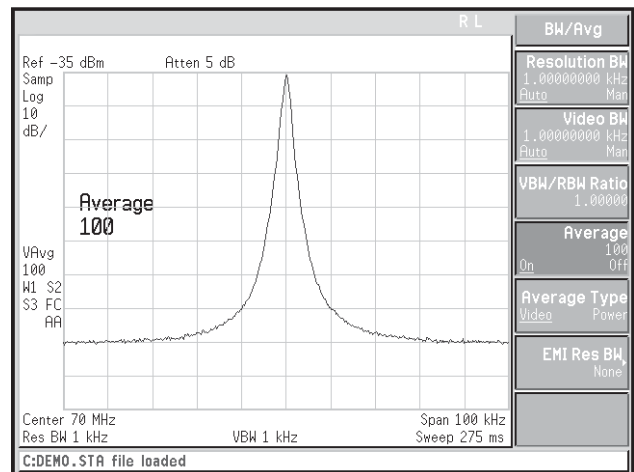


Figure 7. Fully smoothed noise

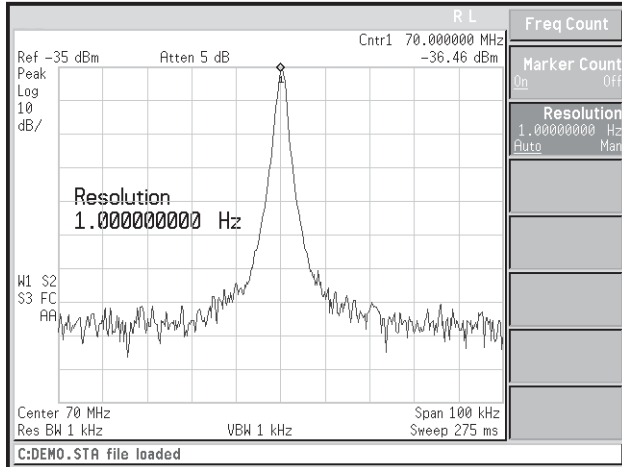


Figure 8. Frequency counter

Also featured in this section is a demo for those systems containing the optional narrow resolution bandwidth feature. The narrow resolution bandwidth option decreases the narrowest resolution bandwidth from 1 kHz to 10 Hz. These narrow digital filters improve the sensitivity of the spectrum analyzer by reducing the noise floor and increasing the selectivity. This improved selectivity is gained in part from the shape factor of the digital resolution bandwidth filters. Additionally, the Agilent ESA family completes narrow-bandwidth measurements up to 225 times faster than spectrum analyzers that use traditional analog resolution bandwidth filters.

**NOTE: This demo will only work with spectrum analyzers that contain the optional narrow resolution bandwidth feature (Option 1DR).** You can use the Show System feature of the instrument to see if your instrument has this option (use these keystrokes to check if you are not sure: [System] {More 1 of 3} {Show System} [Return]).

#### INSTRUCTIONS

Set the frequency and span.  
*The resolution bandwidth filter will automatically change to 10 Hz.*

#### KEYSTROKES

[FREQUENCY] [70] {MHz}  
 [SPAN] [1] {kHz}

Fully resolve harmonic using Video Averaging (Figure 9).

[BW/Avg] {Average On}  
 {Average Off} when done

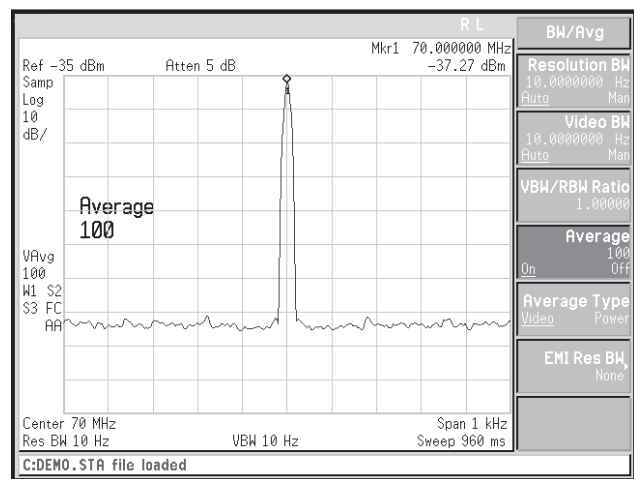


Figure 9. Narrow resolution bandwidth

## Part 7. Dealing with Random Noise

### The marker noise function, detector sampling, and internal preamp (Option 1DS)

Modern spectrum analyzers utilize digital technology for data acquisition and manipulation. In these analyzers, the analog signal at the input of the analyzer is segmented into “bins” that are digitally sampled for further data processing and display, as shown in Figure 10. The question that naturally arises is: What point in the bin do we use for our data point? The answer to this question is particularly important when performing measurements involving noise (such as signal-to-noise ratio).

The multiple trace display ability of the analyzer will be used to show the effect that the sampling mode has on the displayed noise level. Also, this ability highlights the analyzer’s color display (ESA-E Series), which makes it easy to distinguish between traces. To illustrate peak detection differences, Trace 1 will be used to show *positive peak detection*, Trace 2 to show *negative peak detection* and Trace 3 to show *sample detection*. *Positive and negative peak detection* detect the maximum and minimum power levels in the bin, respectively, and *sample detection* samples at the same point in each bin.

INSTRUCTIONS	KEYSTROKES
Set frequency, span, and amplitude.	[Preset] [FREQUENCY] [100] {MHz} [SPAN] [30] {MHz} [AMPLITUDE] [35] {-dBm}
Set Trace 1 to peak detection mode.	[Det/Demod] {Detector>} {Peak} [View/Trace] {Trace} (Press {Trace} until 1 is underlined) {Clear Write} {View} (The View command freezes the trace)
Set Trace 2 to negative peak detection mode. <i>Note the effective noise floor drop.</i>	[Det/Demod] {Detector>} {Negative Peak} [View/Trace] {Trace} (Press {Trace} until 2 is underlined) {Clear Write} {View} (The View command freezes the trace)
Set Trace 3 to sample detection mode (Figure 11). <i>This mode best used with noise. As an experiment, compare relative amplitudes of the harmonics by scrolling Trace 3 (the active trace) past the frozen traces.</i>	[Det/Demod] {Detector>} {Sample} [View/Trace] {Trace} (Press {Trace} until 3 is underlined) {Clear Write}

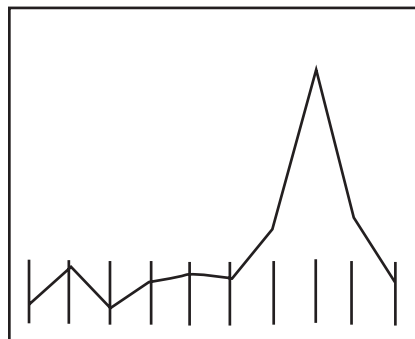
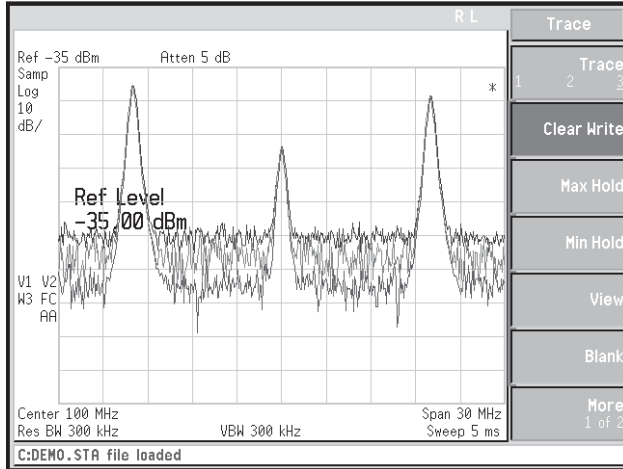


Figure 10. Analog signal bins





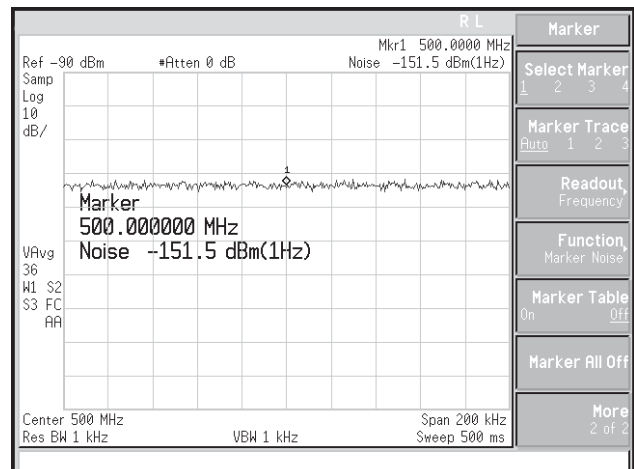
**Figure 11. Detector modes**

The marker noise function accurately calculates the average noise level at the marker position, referenced to a 1 Hz noise power bandwidth. It is a very useful tool for making quick and accurate noise measurements.

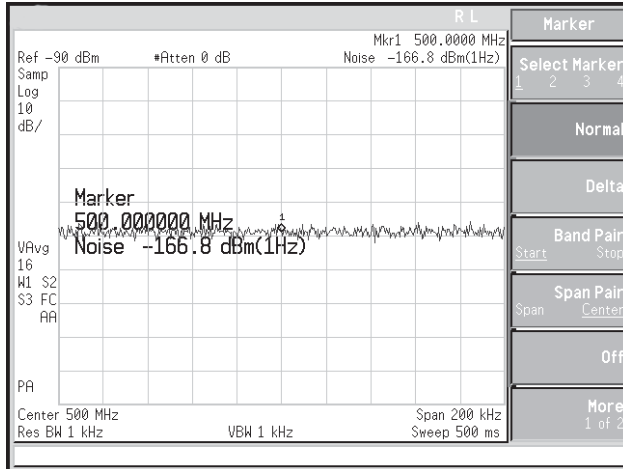
The optional internal preamplifier (Option 1DS) allows the measurement of very low signal levels. The preamplifier amplifies the input signal to raise it above the analyzer's noise level, allowing better viewing of low-level signals. In the following exercise, you will see how the preamp lowers the effective noise level.

INSTRUCTIONS	KEYSTROKES
Disconnect the cable from the 50 $\Omega$ input on the front panel.	No Keystrokes
Set the frequency, span, amplitude, and attenuation.	[Preset] [FREQUENCY] [500.1] {MHz} [SPAN] [200] {kHz} [AMPLITUDE] [-90] {dBm} {Attenuation} [0] {dB}
Smooth out noise floor with video averaging.	[BW/Avg] [Average ON]
Measure the noise floor using Marker Noise. <i>The input signal has to exceed this noise power to be seen on the display (Figure 12).</i>	[Marker] {More 1 of 2} {Function} {Marker Noise} Make a note of the noise level.
Enable the Internal Preamp (Figure 13).	[AMPLITUDE] {More 1 of 2} {Int Preamp On} [Marker] Compare the noise levels

Note: The following step is only for those systems containing the optional Internal Preamp (Option 1DS).



**Figure 12. Noise floor without preamplifier**



**Figure 13. Noise floor with preamplifier on**

## Part 8. Simple Pass/Fail Testing

### Creating a mask with limit lines

In many manufacturing test situations, it is necessary to quickly test a signal to see whether or not it falls within a set of frequency, amplitude, or time boundaries. For example, a radio transmitter manufacturer would want to make sure that the center frequency of a signal carrier falls within a certain amplitude and frequency “mask” and might tune a variable capacitor or resistor until it does. During this tuning, the manufacturer would require constant feedback from the spectrum analyzer indicating whether or not the carrier fits within the mask. *Limit lines* provide an easy way to make such measurements by comparing trace data to a set of amplitude and frequency (or time) parameters while the spectrum analyzer is sweeping the measurement range.

In this section, the analyzer’s easy-to-use limit-line feature is used to perform a simple pass/fail test by creating an upper limit line (mask) around the 10 MHz reference signal. When the reference signal is connected to the input of the spectrum analyzer, the test will fail because the signal exceeds the boundaries of the mask. This is indicated by the “LIMIT FAIL” indicator on the analyzer display. When the reference signal is disconnected, “LIMIT PASS” is displayed. This feature, coupled with its ease of programmability, makes the ESA family a perfect solution for high-volume manufacturing tests.

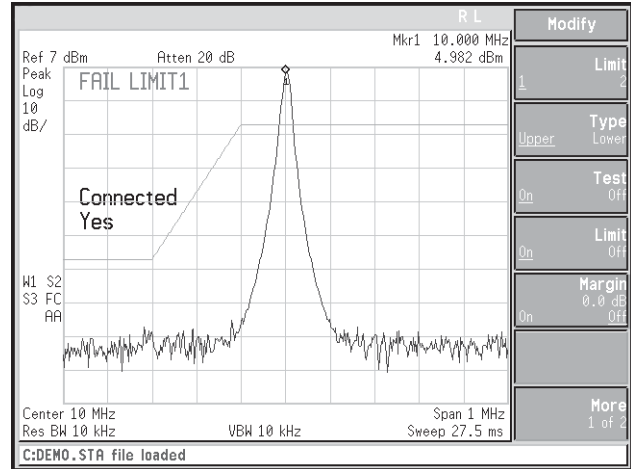
This feature also allows the points that make up the limit lines to be either connected or not. The benefit of being able to break the limit line is that sections of the frequency span can be excluded from the test. However, in the default setting, all points will be connected.

During this demonstration you will also use another one the Agilent ESA family’s special marker functions, marker to center frequency, which automatically changes the center frequency of the spectrum analyzer to the frequency of the marker.

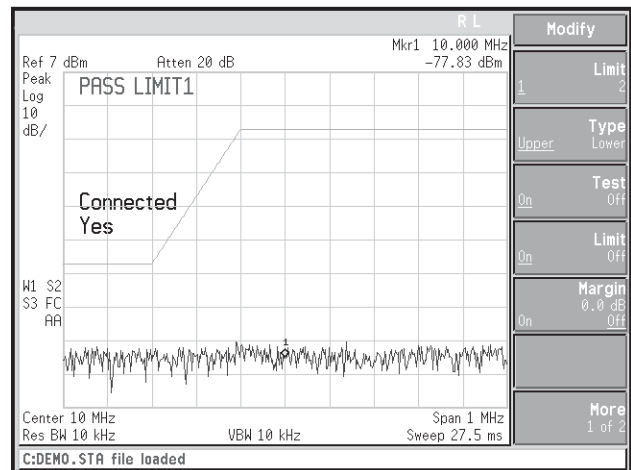
**INSTRUCTIONS**

**KEYSTROKES**

Reconnect the BNC cable from the 10 MHz reference and recall (load) the instrument state.	[Preset] [File] {Load} {State} highlight filename with KNOB [Enter]
Place 10 MHz peak signal in the center of the display.	[Search] [Marker→] {MKR→CF}
Adjust the span so the 10 MHz signal fills the screen.	[SPAN] [1] {MHz}
Delete old limit lines.	[Display] {Limits>} {Delete Limits}  {Delete Limits}
Set the upper limit.	{Modify >} {Type Upper} {More 1 of 2} {Edit >} Segment 1 {Point} [1] {Frequency} [9] {MHz} [50] {-dBm} [.] [.] Segment 2 [9.7] {MHz} [50] {-dBm} [.] [.] Segment 3 [9.9] {MHz} [10] {-dBm} [.] [.] Segment 4 [11] {MHz} [10] {-dBm} {Return}
Turn the limit test ON (Figure 14). Notice the LIMIT FAIL indicator on display.	{More 2 of 2} {Limit On} {Test On}
Disconnect the cable from the 50 Ω input on the front panel and reconnect when finished (Figure 15). Notice the LIMIT PASS indicator on display.	No Keystrokes {Limit Off}



**Figure 14. Limit test FAIL**



**Figure 15. Limit test PASS**

## Part 9. Other Features of the Agilent ESA Spectrum Analyzer Family

### Built-in help

When working with new equipment, do you ever get stuck on a feature or function that you do not understand? Well, when operating the Agilent ESA family of spectrum analyzers, answers to feature and function definition questions are only a button press away. The built-in Help feature provides you with on-screen explanations of analyzer functions and includes the SCPI remote programming command. This Help tool is as easy as 1-2-3.

INSTRUCTIONS	KEYSTROKES
Find out more about the ext amp gain functionality using the on-line Help.	[AMPLITUDE] [More 1 of 2] [Help] {Ext Amp gain}
Turn Help off.	Press any key to return to original screen.

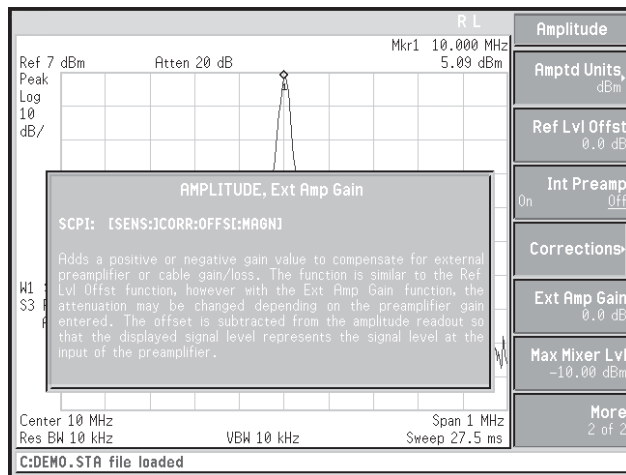


Figure 16. Help menu

### Expandable display

The expandable display is a versatile feature that enables users to view signals as desired. One can remove the soft keys from view and observe a signal over the entire screen by pressing only two buttons. Other abilities, such as removing the graticule and annotation from the display, add more dimensions to this already multi-dimensional spectrum analyzer.

INSTRUCTIONS	KEYSTROKES
View the display without softkeys and annotations (Figure 17).	[Display] {Preferences} {Annotation Off} [Return] {Full Screen}
Turn the graticule off.	[Display] {Preferences} {Graticule Off}
Turn the annotation and graticule back on.	{Graticule On} {Annotation On} when done

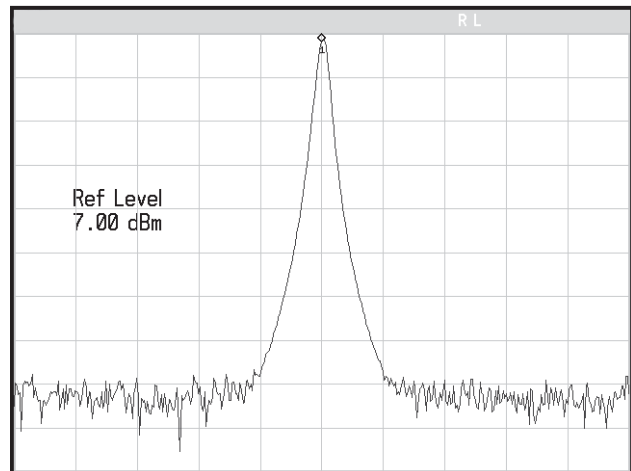


Figure 17. Expandable display

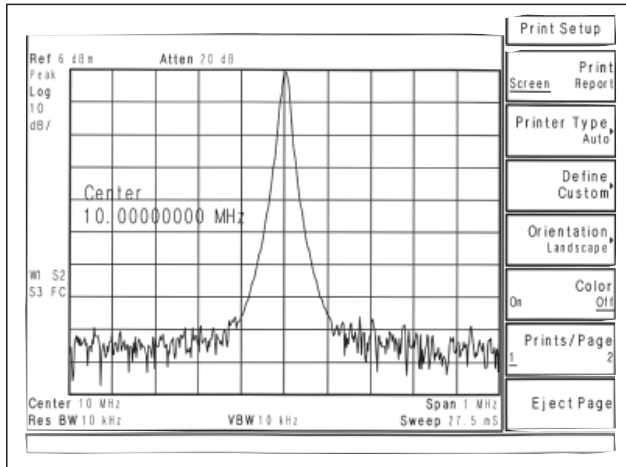
**Landscape printing**

When this family of spectrum analyzers is used with HP PCL5 printers you can enjoy the option of landscape printing. This added feature offers great flexibility in displaying and recording selected signal readings.

**INSTRUCTIONS**

**KEYSTROKES**

Set instrument up for printing.	[Print Setup] {Orientation} {Landscape}
Print if you have a printer connected (Figure 18).	[Print] if there is a printer hooked up to the instrument



**Figure 18. Landscape mode**

**Product Literature**

*Agilent ESA-E Series Spectrum Analyzers Brochure*, literature number 5968-3278E.

*Agilent ESA Series Spectrum Analyzers Data Sheet*, literature number 5968-3386E.

*Select the Right Agilent Signal Analyzer for Your Needs Selection Guide*, literature number 5968-3413E.

*Agilent E4444A BenchLink Spectrum Analyzer Product Overview*, literature number 5966-0676E.

*E1779A/B Snap On Battery Pack, Flyer*  
Literature number 5966-1851E.

*Agilent Application Note 150: Spectrum Analysis*  
literature number 5952-0292.



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