

# Keysight X-Series Signal Analyzers

This manual provides documentation for the following Analyzers:

PXA Signal Analyzer N9030A  
EXA Signal Analyzer N9010A  
MXE EMI Receiver N9038A

MXA Signal Analyzer N9020A  
CXA Signal Analyzer N9000A

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Spectrum  
Analyzer Mode  
Measurement  
Guide

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<http://www.keysight.com/find/exa>

<http://www.keysight.com/find/cxa>

<http://www.keysight.com/find/mxe>

To receive the latest updates by email, subscribe to Keysight Email Updates at the following URL:

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# 1 Getting Started with the Spectrum Analyzer Measurement Application

This chapter provides some basic information about using the Spectrum Analyzer and IQ Analyzer Measurement Application Modes. It includes topics on:

- “Making a Basic Measurement” on page 12
- “Recommended Test Equipment” on page 17
- “Accessories Available” on page 18

## Technical Documentation Summary:

<b>Your Signal Analysis measurement platform:</b>	
Getting Started	Turn on process, Windows XP use/configuration, Front and rear panel
Specifications	Specifications for all available Measurement Applications and optional hardware (for example, Spectrum Analyzer and W-CDMA)
Functional Testing	Quick checks to verify overall instrument operation.
Instrument Messages	Descriptions of displayed messages of Information, Warnings and Errors
<b>Measurement Application specific documentation:</b> (for example, Spectrum Analyzer Measurement Application or W-CDMA Measurement Application)	
Measurement Guide	Examples of measurements made using the front panel keys or over a remote interface.
User's/Programmer's Reference	Descriptions of front panel key functionality and the corresponding SCPI commands. May also include some concept information.

## Making a Basic Measurement

Refer to the description of the instrument front and rear panels to improve your understanding of the Keysight Signal Analyzer measurement platform. This knowledge will help you with the following measurement example.

This section includes:

- “Using the front panel” on page 12
- “Presetting the signal analyzer” on page 13
- “Viewing a signal” on page 14

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CAUTION

Make sure that the total power of all signals at the analyzer input does **not** exceed +30 dBm (1 watt).

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### Using the front panel

#### Entering data

When setting measurement parameters, there are several ways to enter or modify the value of the **active** function:

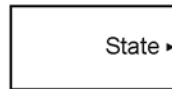
Knob	Increments or decrements the current value.
Arrow Keys	Increments or decrements the current value.
Numeric Keypad	Enters a specific value. Then press the desired terminator (either a unit softkey, or the <b>Enter</b> key).
Unit Softkeys	Terminate a value that requires a unit-of-measurement.
Enter Key	Terminates an entry when either no unit of measure is needed, or you want to use the default unit.

#### Using Menu Keys

Menu Keys (which appear along the right side of the display) provide access to many analyzer functions. Here are examples of menu key types:

Toggle	Allows you to activate/deactivate states.
Example:	<div><div><div>On</div><div>Signal</div><div>Off</div></div><div>Toggles the selection (underlined choice) each time you press the key.</div></div>
Submenu	Displays a new menu of softkeys.

**Example:**

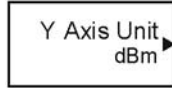


A submenu key allows you to view a new menu of softkeys related to the submenu key category.

**Choice**

Allows you to make a selection from a list of values.

**Example:**



A choice key displays the currently selected submenu choice, in this example, dBm. When the choice is made, the submenu automatically returns.

**Adjust**

Highlights the softkey and sets the active function.

**Examples:**



Press this type of key and enter a value.



The default for softkeys with an automatic (**Auto**) or manual (**Man**) choice is automatic. **After** you enter a value, the selection changes to manual. You can also press the softkey twice to change to manual.

## Presetting the signal analyzer

The preset function provides a known starting point for making measurements. The analyzer has two main types of preset:

**User Preset** Restores the analyzer to a user-defined state.

**Mode Preset** This type of preset restores the currently selected mode to a default state.

For details, see the help or User's and Programmer's Reference.

### Creating a user preset

If you constantly use settings which are not the normal defaults, use the following steps to create a user-defined preset:

Step	Action
1 Set analyzer parameters as desired	
2 Set the current parameters as the user preset state	▪ Press <b>User Preset, Save User Preset</b>
3 To select a preset state	▪ Press <b>User Preset, User Preset</b>

## Viewing a signal

Step	Action	Notes
4 Return the current mode settings to factory defaults.	<ul style="list-style-type: none"> <li>Press <b>Mode Preset</b>.</li> </ul>	
5 Route the internal 50 MHz signal to the analyzer input.	<ul style="list-style-type: none"> <li>Press <b>Input/Output, RF Calibrator, 50, MHz</b>.</li> </ul>	
6 Set the reference level to 10 dBm.	<ul style="list-style-type: none"> <li>Press <b>AMPTD Y Scale, 10, dBm</b>.</li> </ul>	
7 Set the center frequency to 40 MHz.	<ul style="list-style-type: none"> <li>Press <b>FREQ Channel, Center Freq, 40, MHz</b>.</li> </ul>	The 50 MHz reference signal appears on the display
8 Set the frequency span to 50 MHz.	<ul style="list-style-type: none"> <li>Press <b>SPAN, 50, MHz</b>.</li> </ul>	

## Reading frequency and amplitude

Step	Action	Notes
1 Activate a marker and place it on the highest amplitude signal.	<ul style="list-style-type: none"> <li>Press <b>Peak Search</b>.</li> </ul>	The frequency and amplitude of the marker appear in the active function block in the upper-right of the display. You can use the knob, the arrow keys, or the softkeys in the Peak Search menu to move the marker around on the signal.
2 To return the marker to the peak of the signal.	<ul style="list-style-type: none"> <li>Press <b>Peak Search</b>.</li> </ul>	

## Changing reference level

Step	Action	Notes
1 Change the reference level.	<ol style="list-style-type: none"> <li>Press <b>AMPLTD Y Scale</b>.</li> <li>Press <b>Marker →, Mkr → Ref Lvl</b>.</li> </ol>	The reference level is now the active function.

### Improving frequency accuracy

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<b>NOTE</b>	When you use the frequency count function, if the ratio of the resolution bandwidth to the span is less than 0.002, you will get a display message that you need to reduce the Span/RBW ratio. This is because the resolution bandwidth is too narrow.
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Step	Action	Notes
<b>2</b> Activate the Marker Count menu.	▪ Press <b>Marker</b> , <b>More 1 of 2</b> , <b>Marker Count</b> .	
<b>3</b> To increase the accuracy of the frequency reading in the marker annotation.	▪ Press <b>Counter</b> .	The marker active function annotation changes from Mkr1 to Cntr1.  The displayed resolution in the marker annotation improves.
<b>4</b> Move the signal peak to the center of the display.	▪ Press <b>Marker</b> →, <b>Mkr</b> → <b>CF</b> .	

### Valid marker count range

<b>NOTE</b>	Marker count functions properly only on CW signals or discrete peaks. For a valid reading, the marker must be $\geq 26$ dB above the noise.
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Step	Action	Notes
<b>1</b> Move the marker down the skirt of the 50 MHz peak.		Although the readout in the active function changes, as long as the marker is at least 26 dB above the noise, the counted value (upper-right corner of display) does not change.  For an accurate count, the marker does not have to be exactly at the displayed peak
<b>2</b> Enter a new value.	▪ Press <b>BW</b> , <b>Res BW</b> and enter a value.	This action makes the resolution band width (RBW) the active function and allows you to experiment with different resolution band width values.
<b>3</b> Turn off the marker.	▪ Press <b>Marker, Off</b> .	



## Recommended Test Equipment

The following table list the test equipment you will need to perform the example measurements describe in this manual.

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**NOTE**

To find descriptions of specific analyzer functions, for the N9060A Spectrum Analyzer Measurement Application, refer to the *Keysight Technologies X-Series User's and Programmer's Reference*.

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Test Equipment	Specifications	Recommended Model
<b>Signal Sources</b>		
Signal Generator (2)	0.25 MHz to 4.0 GHz Ext Ref Input	E443XB series or E4438C
<b>Adapters</b>		
Type-N (m) to BNC (f) (6)		1250-0780
<b>Cables</b>		
BNC, 122 cm (48 in) (3)		10503A
<b>Miscellaneous</b>		
Directional Bridge		86205A

## Accessories Available

A number of accessories are available from Keysight Technologies to help you configure your analyzer for your specific applications. They can be ordered through your local Keysight Sales and Service Office and are listed below.

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### NOTE

There are also some instrument options available that can improve your measurements. Some options can only be ordered when you make your original equipment purchase. But some are also available as kits that you can order and install later. Order kits through your local Keysight Sales and Service Office.

For the latest information on Keysight signal analyzer options and upgrade kits, visit the following Internet URL: [http://www.keysight.com/find/sa\\_upgrades](http://www.keysight.com/find/sa_upgrades)

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### 50 ohm load

The Keysight 909 series of loads come in several models and options providing a variety of frequency ranges and VSWRs. Also, they are available in either 50 ohm or 75 Ohm. Some examples include the:

909A: DC to 18 GHz  
909C: DC to 2 GHz  
909D: DC to 26.5 GHz

### 50 ohm/75 ohm minimum loss pad

The Keysight 11852B is a low VSWR minimum loss pad that allows you to make measurements on 75 Ohm devices using an analyzer with a 50 Ohm input. It is effective over a frequency range of dc to 2 GHz.

### 75 ohm matching transformer

The Keysight 11694A allows you to make measurements in 75 Ohm systems using an analyzer with a 50 Ohm input. It is effective over a frequency range of 3 to 500 MHz.

### AC probe

The Keysight 85024A high frequency probe performs in-circuit measurements without adversely loading the circuit under test. The probe has an input capacitance of 0.7 pF shunted by 1 megohm of resistance and operates over a frequency range of 300 kHz to 3 GHz. High probe sensitivity and low distortion levels allow measurements to be made while taking advantage of the full dynamic range of the signal analyzer.

## **AC probe (low frequency)**

The Keysight 41800A low frequency probe has a low input capacitance and a frequency range of 5 Hz to 500 MHz.

## **Broadband preamplifiers and power amplifiers**

Preamplifiers and power amplifiers can be used with your signal analyzer to enhance measurements of very low-level signals.

- The Keysight 8447D preamplifier provides a minimum of 25 dB gain from 100 kHz to 1.3 GHz.
- The Keysight 87405A preamplifier provides a minimum of 22 dB gain from 10 MHz to 3 GHz. (Power is supplied by the probe power output of the analyzer.)
- The Keysight 83006A preamplifier provides a minimum of 26 dB gain from 10 MHz to 26.5 GHz.
- The Keysight 85905A CATV 75 ohm preamplifier provides a minimum of 18 dB gain from 45 MHz to 1 GHz. (Power is supplied by the probe power output of the analyzer.)
- The 11909A low noise preamplifier provides a minimum of 32 dB gain from 9 kHz to 1 GHz and a typical noise figure of 1.8 dB.

## **GPIB cable**

The Keysight 10833 Series GPIB cables interconnect GPIB devices and are available in four different lengths (0.5 to 4 meters). GPIB cables are used to connect controllers to a signal analyzer.

## **USB/GPIB cable**

The Keysight 82357A USB/GPIB interface provides a direct connection from the USB port on your laptop or desktop PC to GPIB instruments. It comes with the SICL and VISA software for Windows® 2000/XP. Using VISA software, your existing GPIB programs work immediately, without modification. The 82357A is a standard Plug and Play device and you can interface with up to 14 GPIB instruments.

## **RF and Transient Limiters**

The Keysight 11867A and N9355B RF and Microwave Limiters protect the analyzer input circuits from damage due to high power levels. The N9355B operates over a frequency range of dc to 1800 MHz and begins reflecting signal levels over 1 mW up to 10 W average power and 100 watts peak power. The 11693A microwave limiter (0.1 to 18 GHz) guards against input signals over 10 milliwatt up to 1 watt average power.

The Keysight 11947A Transient Limiter protects the analyzer input circuits from damage due to signal transients. It specifically is needed for use with a line impedance stabilization network (LISN). It operates over a frequency range of 9 kHz to 200 MHz, with 10 dB of insertion loss.

### **Power splitters**

The Keysight 11667A/B/C power splitters are two-resistor type splitters that provide excellent output SWR, at 50  $\Omega$  impedance. The tracking between the two output arms, over a broad frequency range, allows wideband measurements to be made with a minimum of uncertainty.

11667A: DC to 18 GHz

11667B: DC to 26.5 GHz

11667C: DC to 50 GHz

### **Static safety accessories**

9300-1367	Wrist-strap, color black, stainless steel. Four adjustable links and a 7 mm post-type connection.
9300-0980	Wrist-strap cord 1.5 m (5 ft.)

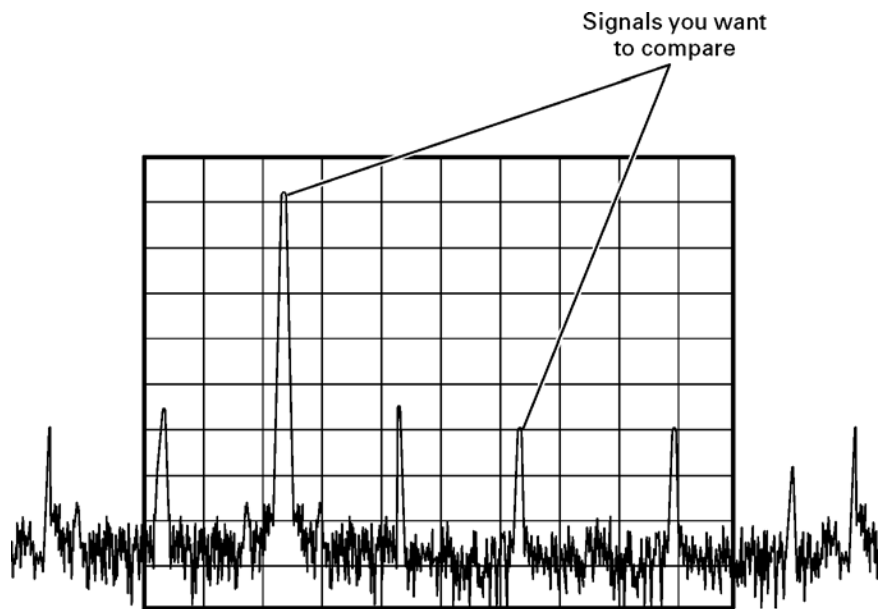
## 2 Measuring Multiple Signals

## Comparing Signals on the Same Screen Using Marker Delta

Using the analyzer, you can easily compare frequency and amplitude differences between signals, such as radio or television signal spectra. The analyzer delta marker function lets you compare two signals when both appear on the screen at one time.

In this procedure, the analyzer 10 MHz signal is used to measure frequency and amplitude differences between two signals on the same screen. Delta marker is used to demonstrate this comparison.

Figure 2-1      *An Example of Comparing Signals on the Same Screen*



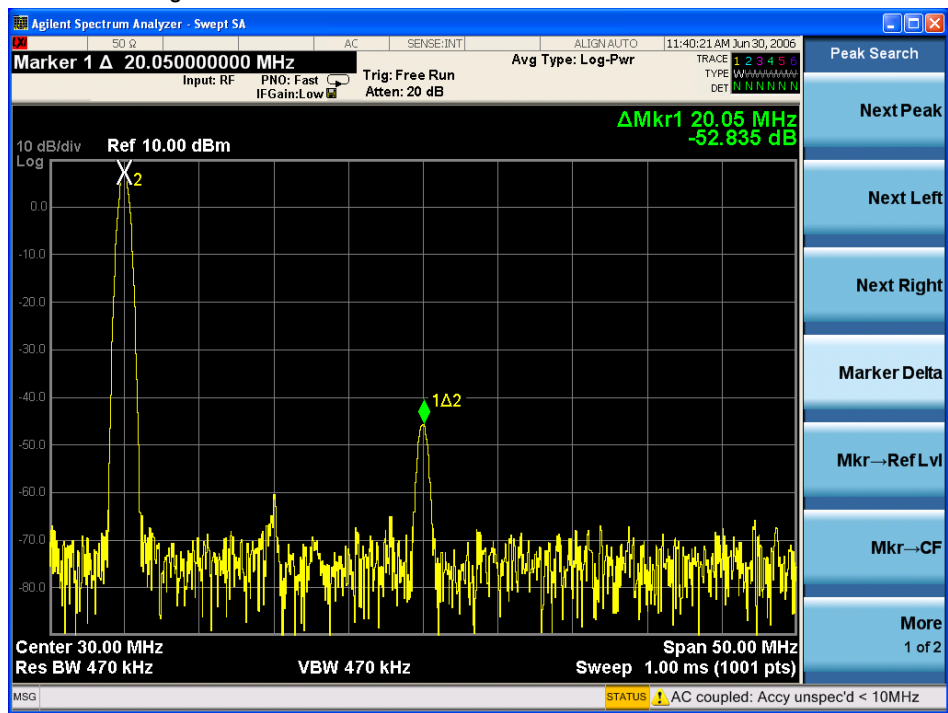
Step	Action	Notes
1	Connect the 10 MHz OUT from the rear panel to the front panel RF input.	
2	Select the mode. <ul style="list-style-type: none"><li>▪ Press <b>Mode, Spectrum Analyzer.</b></li></ul>	
3	Preset the mode. <ul style="list-style-type: none"><li>▪ Press <b>Mode Preset.</b></li></ul>	
4	Configure the analyzer settings. <ul style="list-style-type: none"><li>a. Press <b>FREQ Channel, Center Freq, 30, MHz.</b></li><li>b. Press <b>SPAN X Scale, Span, 50, MHz.</b></li><li>c. Press <b>AMPTD Y Scale, Ref Level, 10, dBm.</b></li></ul>	This sets the analyzer center frequency, span and reference level to view the 10 MHz signal and its harmonics up to 50 MHz.

Step	Action	Notes
5 Place a marker at the highest peak on the display (10 MHz).	▪ Press <b>Peak Search</b> .	The <b>Next Pk Right</b> and <b>Next Pk Left</b> softkeys are available to move the marker from peak to peak. The marker should be on the 10 MHz reference signal.
6 Anchor the first marker and activate a second delta marker.	▪ Press <b>Marker, Delta</b> .	The symbol for the first marker is changed from a diamond to a cross with a label that now reads 2, indicating that it is the fixed marker (reference point). The second marker symbol is a diamond labeled 1Δ2, indicating it is the delta marker. When you first press the Delta key, both markers are at the same frequency with the symbols superimposed over each other. It is not until you move the delta marker to a new frequency that the different marker symbols are easy to discern.
7 Move the delta marker to another signal peak.	▪ Press <b>Peak Search, Next Peak</b> .	The amplitude and frequency <b>difference</b> between the markers is displayed in the marker results block of the screen. Refer to the upper right portion of the screen.  See <a href="#">Figure 2-2</a> .

Measuring Multiple Signals  
Comparing Signals on the Same Screen Using Marker Delta

Step	Action	Notes
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Figure 2-2 Using the Delta Marker Function



NOTE	The frequency resolution of the marker readings can be increased by turning on the marker count function.
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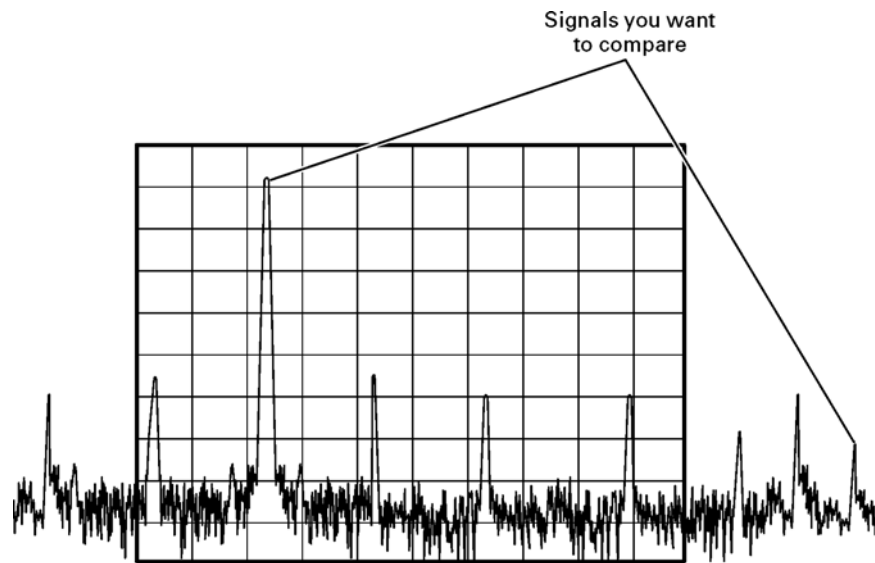


## Comparing Signals not on the Same Screen Using Marker Delta

Measure the frequency and amplitude difference between two signals that do not appear on the screen at one time. (This technique is useful for harmonic distortion tests when narrow span and narrow bandwidth are necessary to measure the low level harmonics.)

In this procedure, the analyzer 10 MHz signal is used to measure frequency and amplitude differences between one signal on screen and one signal off screen. Delta marker is used to demonstrate this comparison.

Figure 2-3      *Comparing One Signal on Screen with One Signal Off Screen*



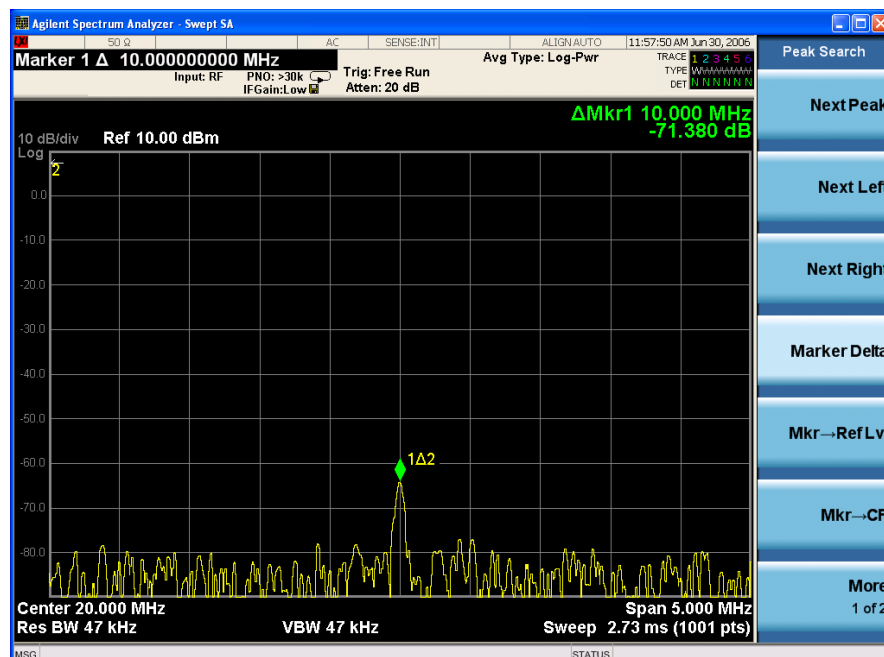
Step	Action	Notes
1	Connect the 10 MHz OUT from the rear panel to the front panel RF input.	
2	Select the mode. <ul style="list-style-type: none"><li>▪ Press <b>Mode, Spectrum Analyzer.</b></li></ul>	
3	Preset the mode. <ul style="list-style-type: none"><li>▪ Press <b>Mode Preset.</b></li></ul>	
4	Configure the analyzer settings. <ul style="list-style-type: none"><li>a. Press <b>FREQ Channel, Center Freq, 10, MHz.</b></li><li>b. Press <b>SPAN X Scale, Span, 5, MHz.</b></li><li>c. Press <b>AMPTD Y Scale, Ref Level, 10, dBm.</b></li></ul>	This sets the analyzer center frequency, span and reference level to view the 10 MHz signal and its harmonics up to 50 MHz.

## Measuring Multiple Signals

### Comparing Signals not on the Same Screen Using Marker Delta

Step	Action	Notes
5 Place a marker at the highest peak on the display (10 MHz).	<ul style="list-style-type: none"> <li>Press <b>Peak Search</b>.</li> </ul>	
6 Set the center frequency step size equal to the marker frequency.	<ul style="list-style-type: none"> <li>Press <b>Marker →, Mkr → CF Step</b>.</li> </ul>	
7 Activate the marker delta function.	<ul style="list-style-type: none"> <li>.</li> </ul>	
8 Increase the center frequency by 10 MHz.	<ul style="list-style-type: none"> <li>Press <b>FREQ Channel, Center Freq, ↑</b>.</li> </ul>	The first marker and delta markers move to the left edge of the screen, at the amplitude of the first signal peak.
9 Move the delta marker to the new center frequency.	<ul style="list-style-type: none"> <li>Press <b>Peak Search</b>.</li> </ul>	Figure 2-4 shows the reference annotation for the first marker (52) at the left side of the display, indicating that the 10 MHz reference signal is at a lower frequency than the frequency range currently displayed. The delta marker (1Δ2) appears on the peak of the 20 MHz component. The delta marker results block displays the amplitude and frequency difference between the 10 and 20 MHz signal peaks.

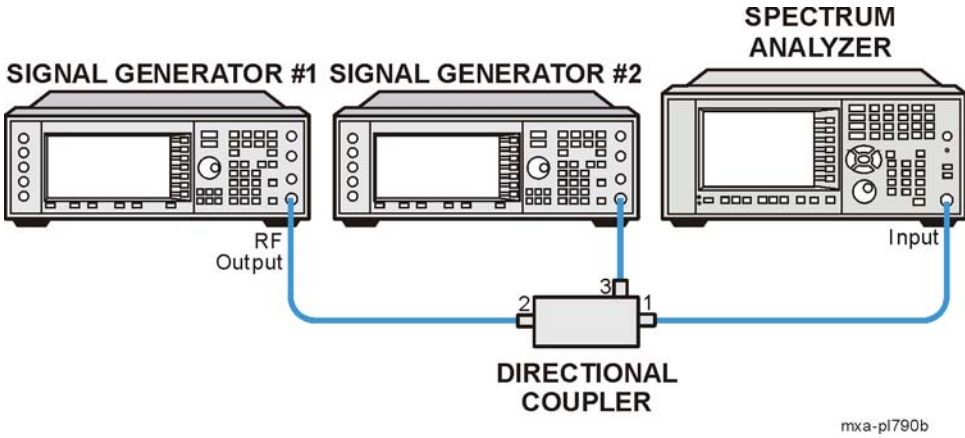
Figure 2-4 Delta Marker with Reference Signal Off-Screen



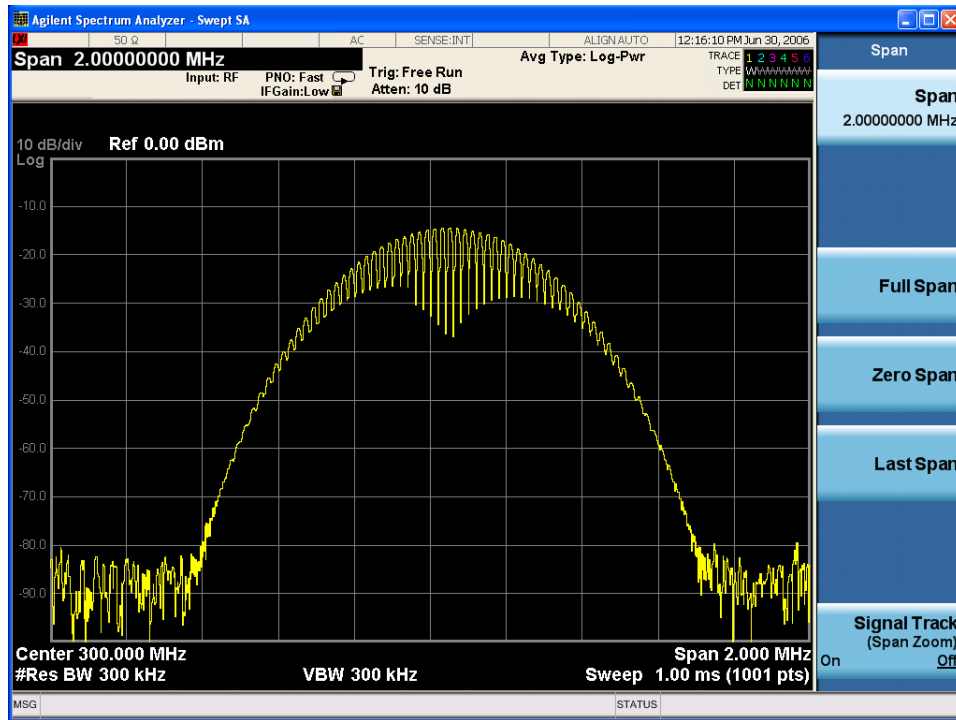
Step	Action	Notes
10	Turn the markers off.	<ul style="list-style-type: none"><li>Press <b>Marker, Off</b>.</li></ul>

## Resolving Signals of Equal Amplitude

In this procedure a decrease in resolution bandwidth is used in combination with a decrease in video bandwidth to resolve two signals of equal amplitude with a frequency separation of 100 kHz. Notice that the final RBW selection to resolve the signals is the same width as the signal separation while the VBW is slightly narrower than the RBW.

Step	Action	Notes
1	Connect two sources to the analyzer RF INPUT as shown.	
 <p style="text-align: right;">mx-a-pl790b</p>		
2	Set up the signal sources. <ol style="list-style-type: none"> <li>Set the frequency of signal generator #1 to 300 MHz.</li> <li>Set the frequency of signal generator #2 to 300.1 MHz.</li> <li>Set signal generator #1 amplitude to -20 dBm.</li> <li>Set signal generator #2 amplitude to -4 dBm.</li> </ol>	The amplitude of both signals should be approximately -20 dBm at the output of the bridge/directional coupler. (The -4 dBm setting plus -16 dB coupling factor of the 86205A results in a -20 dBm signal.)
3	Select the mode.	<ul style="list-style-type: none"> <li>Press <b>Mode, Spectrum Analyzer</b>.</li> </ul>
4	Preset the analyzer.	<ul style="list-style-type: none"> <li>Press <b>Mode Preset</b>.</li> </ul>
5	Set up the analyzer to view the signals.	<ol style="list-style-type: none"> <li>Press <b>FREQ Channel, Center Freq, 300, MHz</b>.</li> <li>Press <b>BW, Res BW, 300, kHz</b>.</li> <li>Press <b>SPAN X Scale, Span, 2, MHz</b>.</li> </ol> A single signal peak is visible. See Figure 2-5.

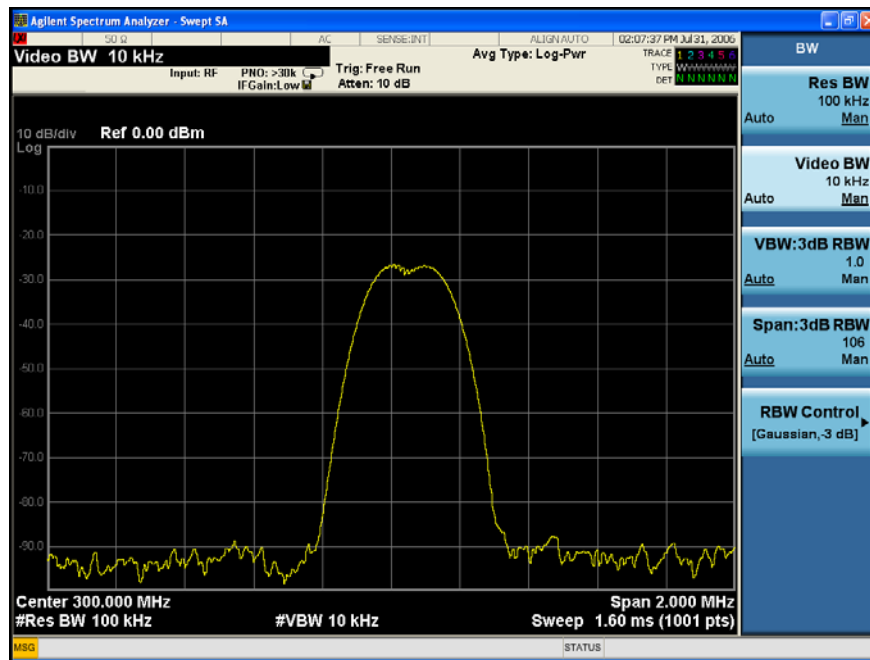
Step	Action	Notes
<i>Figure 2-5 Unresolved Signals of Equal Amplitude</i>		



6	Change the RBW.	<ul style="list-style-type: none"> <li>Press <b>BW, Res BW, 100, kHz</b>.</li> </ul>	The RBW setting is less than or equal to the frequency separation of the two signals
7	Decrease the video BW.	<ul style="list-style-type: none"> <li>Press <b>Video BW, 10, kHz</b>.</li> </ul>	Notice that the peak of the signal has become two peaks separated by a 2.5 dB dip indicating that two signals may be present. See <a href="#">Figure 2-6</a> .

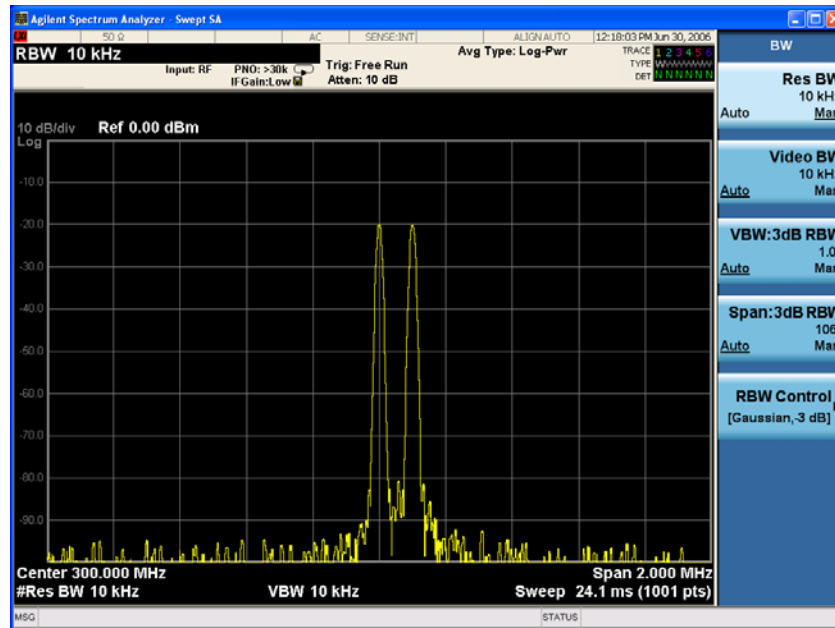
# Measuring Multiple Signals Resolving Signals of Equal Amplitude

Step	Action	Notes
Figure 2-6	Unresolved Signals of Equal Amplitude	



- |                                   |   |  |
|-----------------------------------|---|--|
| <p><b>8</b> Decrease the RBW.</p> | <ul style="list-style-type: none"> <li>Press <b>BW, Res BW, 10, kHz</b>.</li> </ul> | <p>Two signals are now visible, see <a href="#">Figure 2-7</a>. You can use the front-panel knob or step keys to further reduce the resolution bandwidth and better resolve the signals.</p> |
|-----------------------------------|---|--|

Step	Action	Notes
Figure 2-7	Resolving signals of equal amplitude	



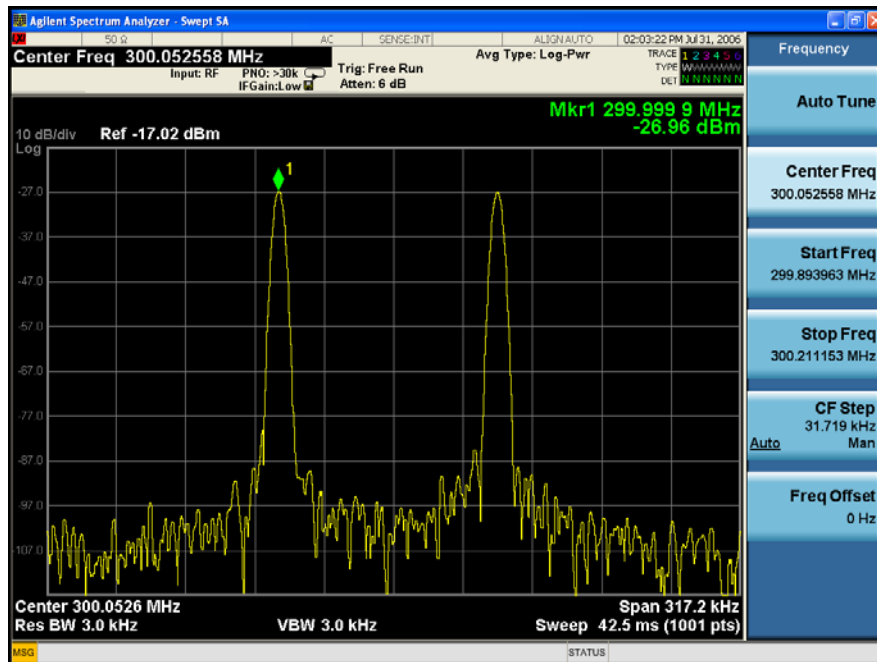
As the resolution bandwidth is decreased, resolution of the individual signals is improved and the sweep time is increased. For fastest measurement times, use the widest possible resolution bandwidth. Under mode preset conditions, the resolution bandwidth is “coupled” (or linked) to the span.

Since the resolution bandwidth has been changed from the coupled value, a # mark appears next to Res BW in the lower-left corner of the screen, indicating that the resolution bandwidth is uncoupled. (For more information on coupling, refer to the **Auto Couple** key description in the *Keysight Technologies X-Series User’s and Programmer’s Reference*.)

<b>NOTE</b>	<p>An alternative method for resolving two equal amplitude signals is to use the Auto Tune Function as follows:</p> <p>Press <b>Mode Preset</b>.</p> <p>Press <b>Freq Channel</b>, <b>Auto Tune</b>.</p> <p>The two signals are fully resolved with a marker placed on the highest peak. Refer to <a href="#">Figure 2-8</a>.</p>
-------------	---

## Measuring Multiple Signals Resolving Signals of Equal Amplitude

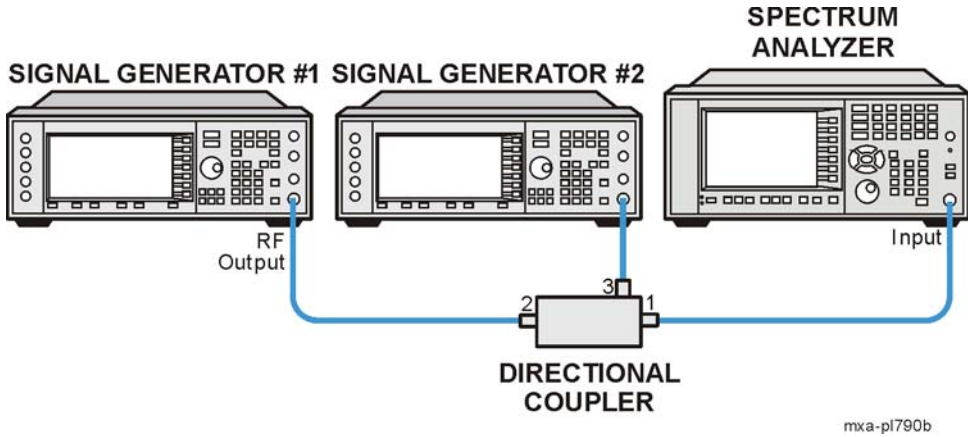
Figure 2-8 *Resolving Signals of Equal Amplitude*





## Resolving Small Signals Hidden by Large Signals

This procedure uses narrow resolution bandwidths to resolve two input signals with a frequency separation of 50 kHz and an amplitude difference of 60 dB.

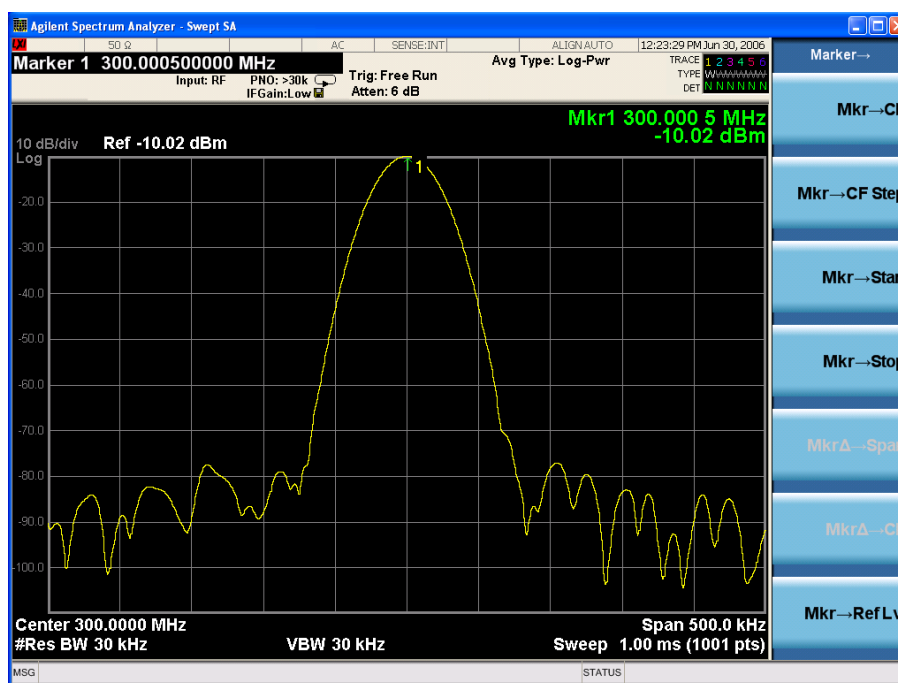
Step	Action	Notes
1	Connect two sources to the analyzer RF INPUT as shown.	
		
2	Set up the signal sources. <ol style="list-style-type: none"> <li>Set the frequency of signal generator #1 to 300 MHz.</li> <li>Set the frequency of the signal generator #2 to 300.05 MHz.</li> <li>Set signal generator #1 amplitude to -10 dBm.</li> <li>Set signal generator #2 amplitude to -54 dBm.</li> </ol>	<p>This signal is 50 kHz higher in frequency than the first signal.</p> <p>The -54 dBm setting plus -16 dB coupling factor of the 86205A results in a signal 60 dB below the first signal.</p>
3	Select the mode	<ul style="list-style-type: none"> <li>Press <b>Mode, Spectrum Analyzer</b>.</li> </ul>
4	Preset the analyzer:	<ul style="list-style-type: none"> <li>Press <b>Mode Preset</b>.</li> </ul>
5	Set up the analyzer to view the signals.	<ol style="list-style-type: none"> <li>Press <b>FREQ Channel, Center Freq, 300, MHz</b>.</li> <li>Press <b>BW, Res BW, 30, kHz</b>.</li> <li>Press <b>SPAN X Scale, Span, 500, kHz</b>.</li> </ol>

## Measuring Multiple Signals

### Resolving Small Signals Hidden by Large Signals

Step	Action	Notes
6 Set the 300 MHz signal peak to the reference level.	<ul style="list-style-type: none"> <li>Press <b>Peak Search, Mkr → Ref Lvl</b>.</li> </ul>	The Signal Analyzer 30 kHz filter shape factor of 4.1:1 has a bandwidth of 123 kHz at the 60 dB point. The half-band width, or 61.5 kHz, is NOT narrower than the frequency separation of 50 kHz, so the input signals can not be resolved. See <a href="#">Figure 2-9</a> .

Figure 2-9 Signal resolution with a 30 kHz RBW



7 Change the RBW.	<ul style="list-style-type: none"> <li>Press <b>BW, Res BW, 10, kHz</b>.</li> </ul>	The reduced resolution bandwidth filter allows you to view the smaller hidden signal.
8 Place a delta marker on the smaller signal.	<ul style="list-style-type: none"> <li>Press <b>Peak Search, Marker Delta, 50, kHz</b>.</li> </ul>	Notice that the peak of the signal has become two peaks separated by a 2.5 dB dip indicating that two signals may be present. See <a href="#">Figure 2-10</a> .

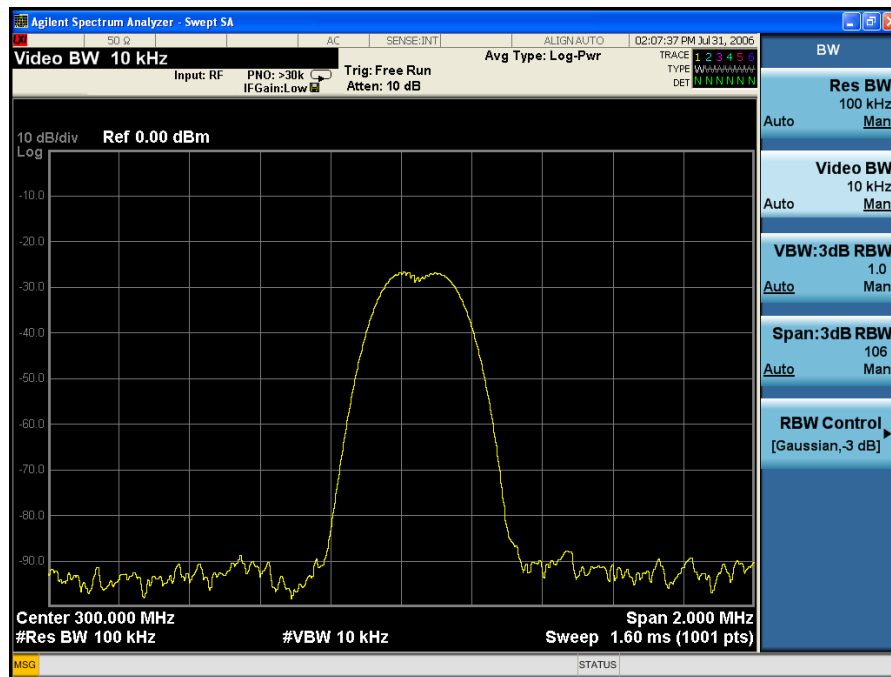
Step

Action

Notes

Figure 2-10

Unresolved Signals of Equal Amplitude



9 Decrease the RBW.

- Press **BW, 10, kHz**.

The Signal Analyzer 10 kHz filter shape factor of 4.1:1 has a band width of 4.1 kHz at the 60 dB point. The half-band width, or 20.5 kHz, is narrower than 50 kHz, so the input signals can be resolved. See [Figure 2-11](#).

# Measuring Multiple Signals

## Resolving Small Signals Hidden by Large Signals

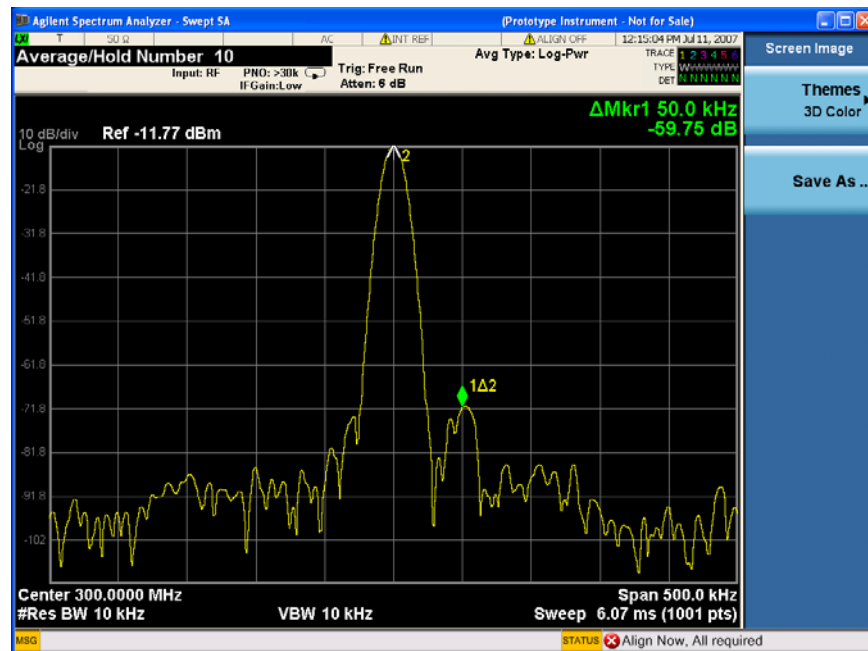
Step

Action

Notes

Figure 2-11

Signal resolution with a 10 kHz RBW



### NOTE

To make the separate signals more clear in the display, you may need to use averaging. To set the averaging to 10 averages:

Press **Meas Setup**.

Press **Average/Hold Number**, 10, **Enter**.

## Decreasing the Frequency Span Around the Signal

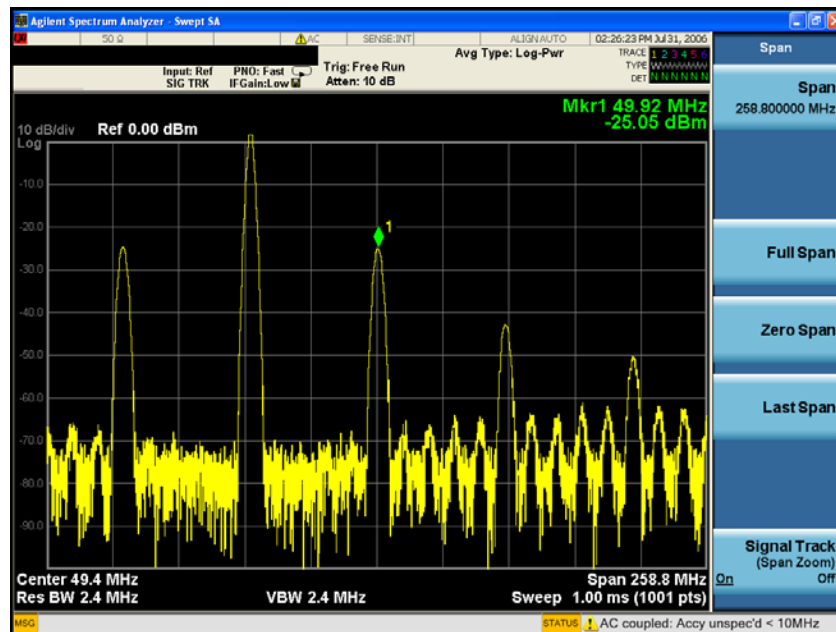
Using the analyzer signal track function, you can quickly decrease the span while keeping the signal at center frequency. This is a fast way to take a closer look at the area around the signal to identify signals that would otherwise not be resolved.

This procedure uses signal tracking with span zoom to view the analyzer 50 MHz reference signal in a 200 kHz span.

Step	Action	Notes
1 Select the mode.	• Press <b>Mode, Spectrum Analyzer</b> .	
2 Preset the analyzer.	• Press <b>Mode Preset</b> .	
3 Enable the internal 50 MHz amplitude reference signal.	• Press <b>Input/Output, RF Calibrator, 50 MHz</b> .	
4 Set the start and stop frequencies.	a. Press <b>FREQ Channel, Start Freq, 20, MHz</b> . b. Press <b>FREQ Channel, Stop Freq, 1, GHz</b> .	
5 Turn on the signal tracking function.	• Press <b>Span X Scale, Signal Track (Span Zoom) (On)</b> .	This places a marker at the peak, moves the signal to the center of the screen, and initiates Signal Track.  See <a href="#">Figure 2-12</a> .

Figure 2-12

Signal Tracking on Before Span Decrease



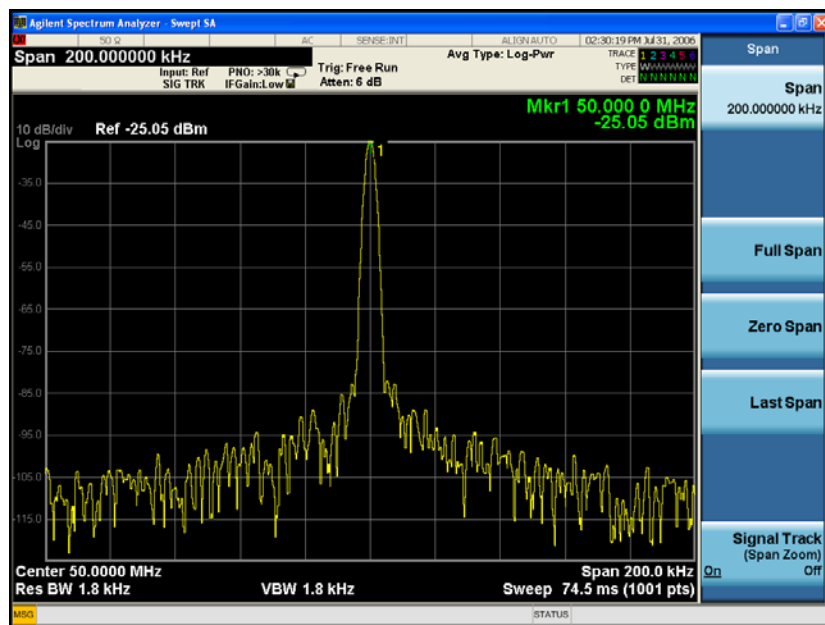
## Measuring Multiple Signals

### Decreasing the Frequency Span Around the Signal

Step	Action	Notes
6 Set the calibration signal to the reference level.	<ul style="list-style-type: none"> <li>Press <b>Mkr</b> →, <b>Mkr</b> → <b>Ref Lvl</b>.</li> </ul>	Because the signal track function automatically maintains the signal at the center of the screen, you can reduce the span quickly for a closer look. If the signal drifts off of the screen as you decrease the span, use a wider frequency span.
7 Reduce the span and resolution bandwidth.	<ul style="list-style-type: none"> <li>Press <b>SPAN X Scale</b>, <b>Span</b>, <b>200</b>, <b>kHz</b>.</li> </ul>	If the span change is large enough, the span decreases in steps as automatic zoom is completed. You can also use the front-panel knob or step keys to decrease the span and resolution bandwidth values.  See <a href="#">Figure 2-13</a> .

Figure 2-13

Signal Tracking After Zooming in on the Signal



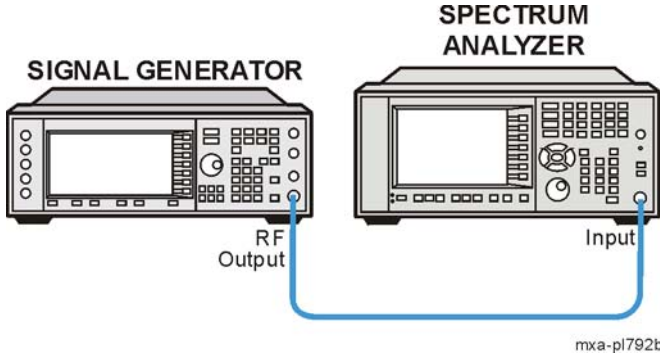
- |                             |   |
|-----------------------------|---|
| 8 Turn Signal tracking off. | <ul style="list-style-type: none"> <li>Press <b>SPAN X Scale</b>, <b>Signal Track (Off)</b>.</li> </ul> |
|-----------------------------|---|

## Easily Measure Varying Levels of Modulated Power Compared to a Reference

This section demonstrates a method to measure the complex modulated power of a reference device or setup and then compare the result of adjustments and changes to that or other devices.

The Delta Band/Interval Power Marker function will be used to capture the simulated signal power of a reference device or setup and then compare the resulting power level due to adjustments or DUT changes.

An important key to making accurate Band Power Marker measurements is to insure that the Average Type under the Meas Setup key is set to “Auto”.

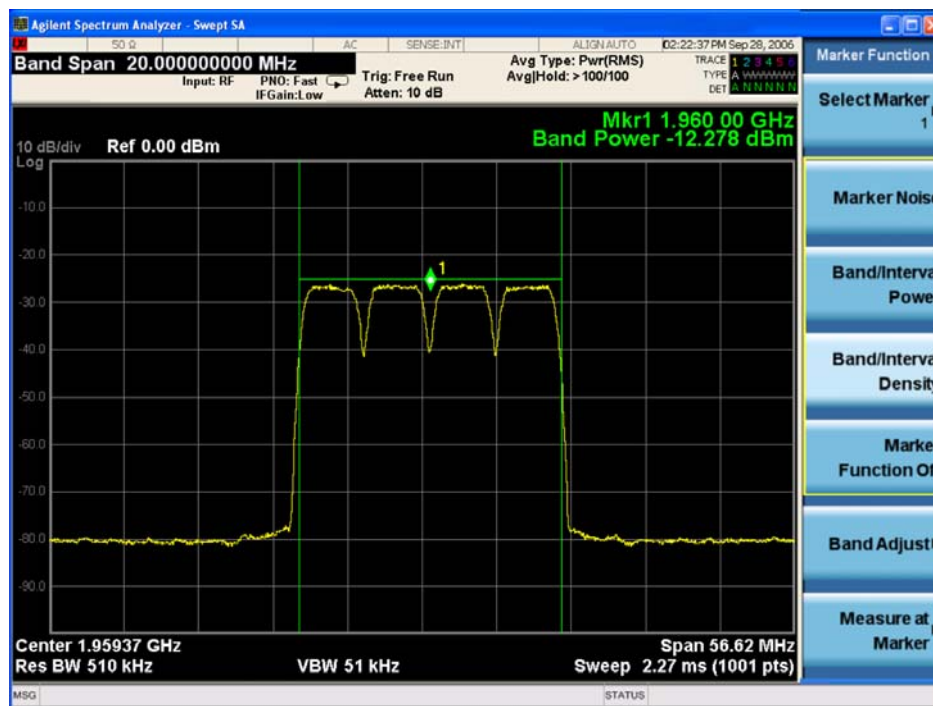
Step	Action	Notes
1	Connect the source RF OUTPUT to the analyzer RF INPUT as shown.	
		
2	Set up the signal sources.	<ul style="list-style-type: none"> <li>a. Set up a 4-carrier W-CDMA signal.</li> <li>b. Set the source frequency to 1.96 GHz.</li> <li>c. Set the source amplitude to -10 dBm.</li> </ul>
3	Select the mode.	<ul style="list-style-type: none"> <li>• Press <b>Mode, Spectrum Analyzer</b>.</li> </ul>
4	Preset the analyzer.	<ul style="list-style-type: none"> <li>• Press <b>Mode Preset</b>.</li> </ul>
5	Tune to W-CDMA signal.	<ul style="list-style-type: none"> <li>• Press <b>FREQ Channel, Auto Tune, 300, MHz</b>.</li> </ul>
6	Set the analyzer reference level.	<ul style="list-style-type: none"> <li>• Press <b>AMPTD Y Scale, Ref Level, 0, dBm</b>.</li> </ul>

## Measuring Multiple Signals

### Easily Measure Varying Levels of Modulated Power Compared to a Reference

Step	Action	Notes
7 Enable trace averaging.	<ul style="list-style-type: none"> <li>Press <b>Trace/Detector</b>, <b>Select Trace</b>, <b>Trace 1</b>, <b>Trace Average</b>.</li> </ul>	
8 Enable the Band/Interval Power Marker function.	<ul style="list-style-type: none"> <li>Press <b>Marker Function</b>, <b>Band/Interval Power</b>.</li> </ul>	This measures the total power of the reference 4-carrier W-CDMA signal
9 Center the frequency of the Band/Interval Power marker.	<ul style="list-style-type: none"> <li>Press <b>Select Marker</b>, <b>Marker 1</b>, <b>1.96, GHz</b>.</li> </ul>	This centers the marker on the 4-carrier reference signal envelope.
10 Adjust the width (or span) of the Band/Interval Power marker.	<ul style="list-style-type: none"> <li>Press <b>Marker Function</b>, <b>Band Adjust</b>, <b>Band/Interval Span</b>, <b>20, MHz</b>.</li> </ul>	<p>This encompasses the entire 4-carrier W-CDMA reference signal. See <a href="#">Figure 2-14</a>.</p> <p>Note the green vertical lines of Marker 1 representing the span of signals included in the Band/Interval Power measurement and the carrier power indicated in Markers Result Block.</p>

Figure 2-14 Measured Power of Reference 4-carrier W-CDMA Signal Using Band/Interval Power Marker

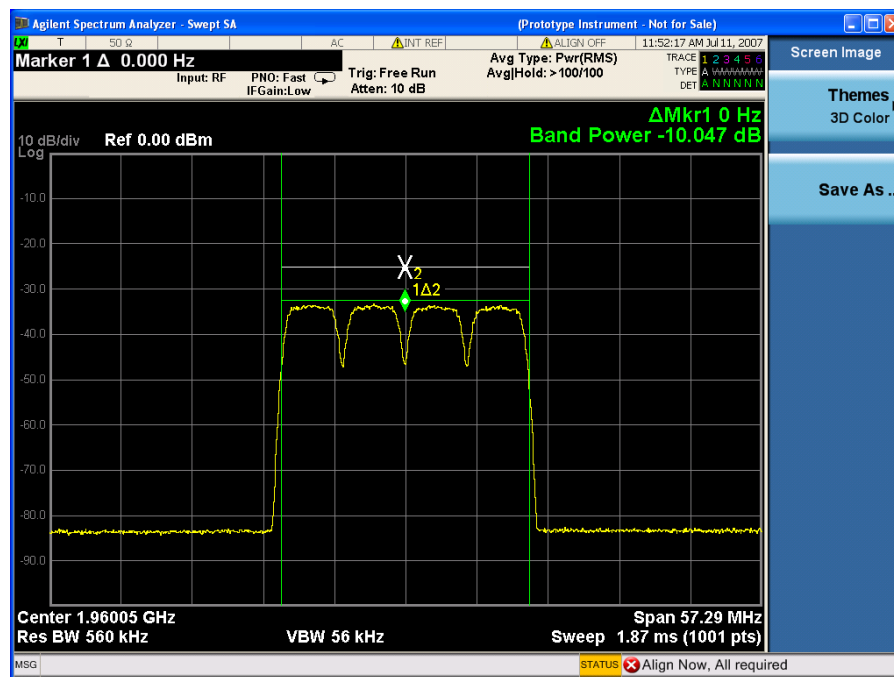




# Measuring Multiple Signals Easily Measure Varying Levels of Modulated Power Compared to a Reference

Step	Action	Notes
11 Enable the Delta Band Power Marker functionality.	<ul style="list-style-type: none"> <li>Press <b>Marker</b>, <b>Select Marker</b>, <b>Marker 1, Delta</b>.</li> </ul>	This will change the reference Band Power Marker into a fixed power value (labeled X2) and initiate a second Band Power Marker (labeled 1 $\Delta$ 2) to measure any changes in power levels relative to the reference Band Power Marker X2.
12 Simulate a varying power level resulting from either adjustments, changes to the reference DUT, or a different DUT by lowering the signal source power.	<ul style="list-style-type: none"> <li>Set the source amplitude to -20 dBm.</li> </ul>	Note the Delta Band Power Marker value displayed in the Marker Result Block showing the 10 dB difference between the modulated power of the reference and the changed power level.  See <a href="#">Figure 2-15</a>

Figure 2-15 Delta Band Power Markers Displaying Lower Modulated Power Level Compared to a Reference



Measuring Multiple Signals

Easily Measure Varying Levels of Modulated Power Compared to a Reference

### 3 Measuring a Low-Level Signal

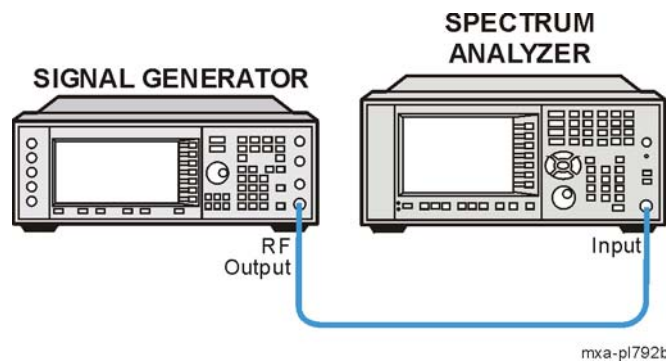
Reducing Input Attenuation

The ability to measure a low-level signal is limited by internally generated noise in the signal analyzer. The measurement setup can be changed in several ways to improve the analyzer sensitivity.

The input attenuator affects the level of a signal passing through the instrument. If a signal is very close to the noise floor, reducing input attenuation can bring the signal out of the noise.

**CAUTION** Ensure that the total power of all input signals at the analyzer RF input does not exceed +30 dBm (1 watt).

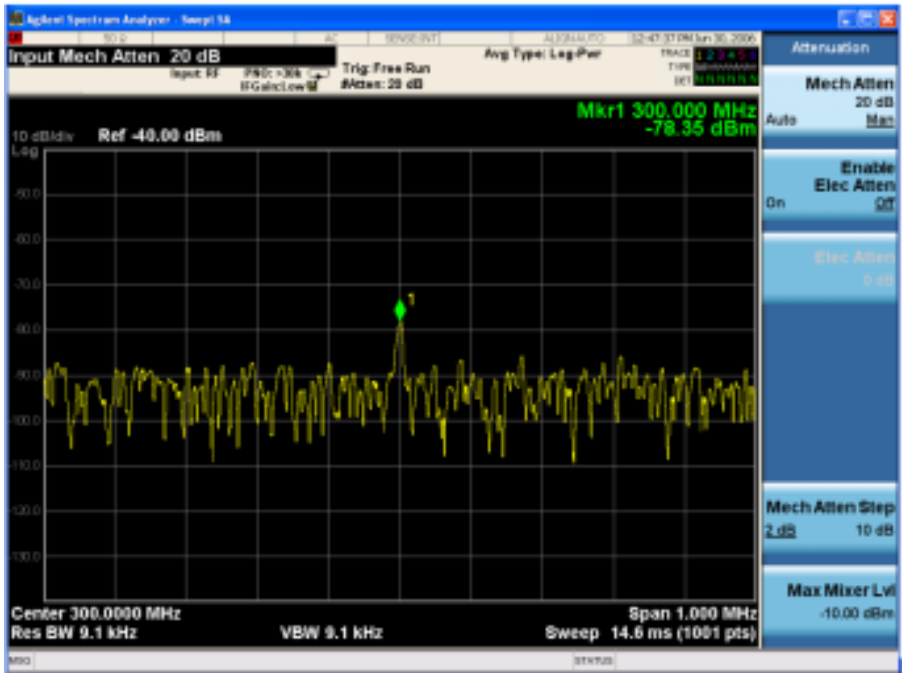
Step	Action	Notes
1	Set up the signal generator. a. Set the frequency to 300 MHz. b. Set the amplitude to -80 dBm.	
2	Connect the source RF OUTPUT to the analyzer RF INPUT as shown.	



3	Select the mode.	▪ Press <b>Mode, Spectrum Analyzer</b> .
4	Preset the mode.	▪ Press <b>Mode Preset</b> .
5	Set the center frequency, span and reference level.	a. Press <b>FREQ Channel, Center Freq, 300, MHz</b> . b. Press <b>SPAN X Scale, Span, 5, MHz</b> . c. Press <b>AMPTD Y Scale, Ref Level, 40, -dBm</b> .
6	Move the peak to the center of the display.	▪ Press <b>Peak Search, Marker -&gt;, Mkr -&gt; CF</b> .

Step	Action	Notes
7 Reduce the span.	<ul style="list-style-type: none"><li>Press <b>Span, 1, MHz</b>.</li></ul>	If necessary re-center the peak.
8 Set the attenuation.	<ul style="list-style-type: none"><li>Press <b>AMPTD Y Scale, Attenuation, Mech Atten</b> or <b>Atten (Man)</b>, 20, dB.</li></ul>	<p>Increasing the attenuation moves the noise floor closer to the signal level.</p> <p>A “#” mark appears next to the Atten annotation at the top of the display, indicating that the attenuation is no longer coupled to other analyzer settings.</p> <p>See <a href="#">Figure 3-1</a>.</p>

Figure 3-1 Measuring a Low-Level Signal Using Mechanical Attenuation

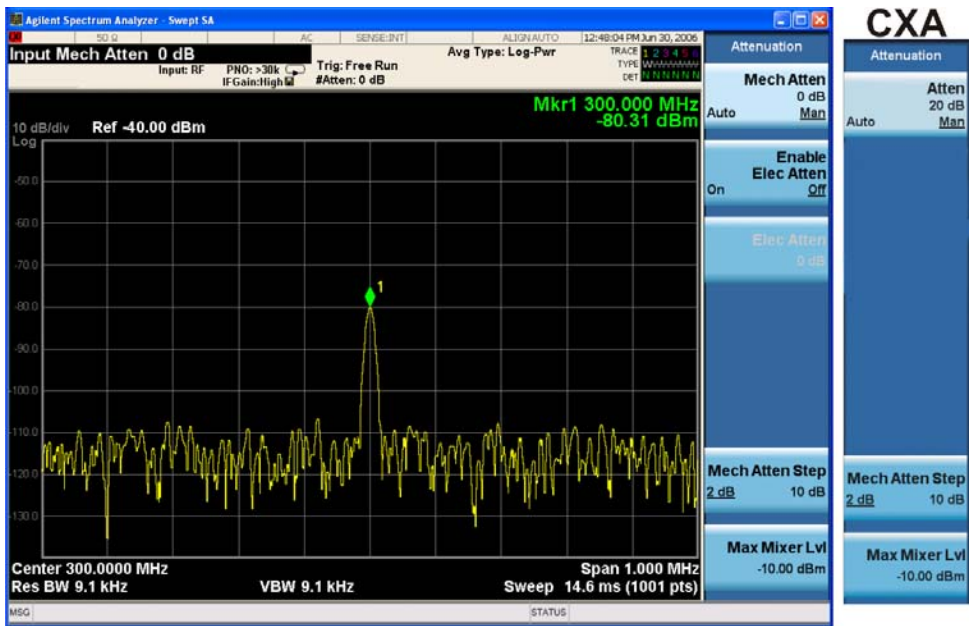


**NOTE** The CXA does not have a mechanical attenuator. Therefore, the Attenuation menu will be different than the one shown.

9 Change the attenuation to see the signal more clearly.	<ul style="list-style-type: none"><li>Press <b>AMPTD Y Scale, Attenuation, Mech Atten</b> or <b>Atten (Man)</b>, 0, dB.</li></ul>
--	---

Measuring a Low-Level Signal  
Reducing Input Attenuation

Step	Action	Notes
Figure 3-2	Measuring a Low-Level Signal Using 0 dB Attenuation	



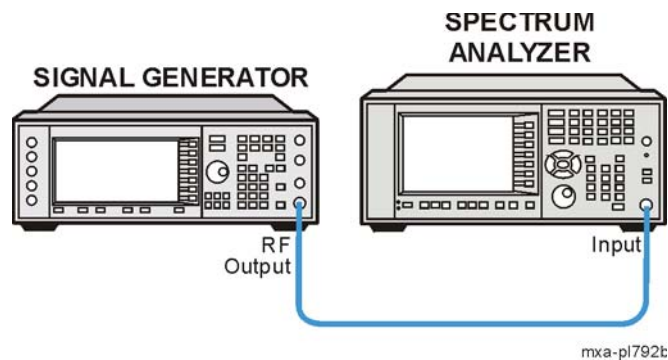
**CAUTION** When you finish this example, increase the attenuation to protect the analyzer RF input:

Press **AMPTD Y Scale**, **Attenuation**, **Mech Atten** or **Atten** (Auto), or press **Auto Couple**.

## Decreasing the Resolution Bandwidth

Resolution bandwidth settings affect the level of internal noise without affecting the level of continuous wave (CW) signals. Decreasing the RBW by a decade reduces the noise floor by 10 dB.

Step	Action	Notes
1	Set up the signal generator. <div>a. Set the frequency to 300 MHz. b. Set the amplitude to -80 dBm.</div>	
2	Connect the source RF OUTPUT to the analyzer RF INPUT as shown.	



3	Select the mode.	▪ Press <b>Mode, Spectrum Analyzer</b> .	
4	Preset the mode.	▪ Press <b>Mode Preset</b> .	
5	Set the center frequency, span and reference level.	<div>a. Press <b>FREQ Channel, Center Freq, 300, MHz</b>.</div> <div>b. Press <b>SPAN X Scale, Span, 50, MHz</b>.</div> <div>c. Press <b>AMPTD Y Scale, Ref Level, 40, -dBm</b>.</div>	See <a href="#">Figure 3-3</a> .

## Measuring a Low-Level Signal Decreasing the Resolution Band width

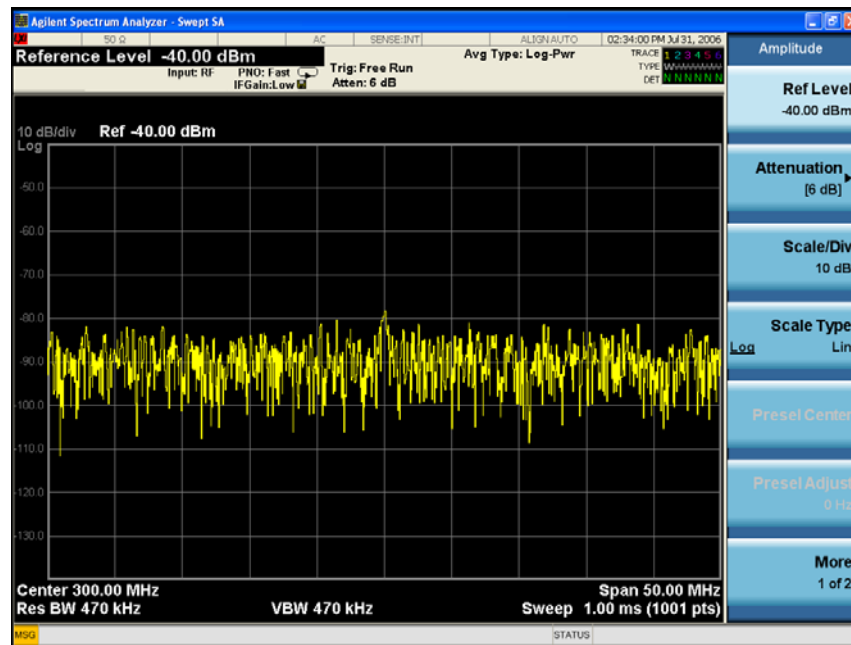
### Step

### Action

### Notes

Figure 3-3

Default resolution band width



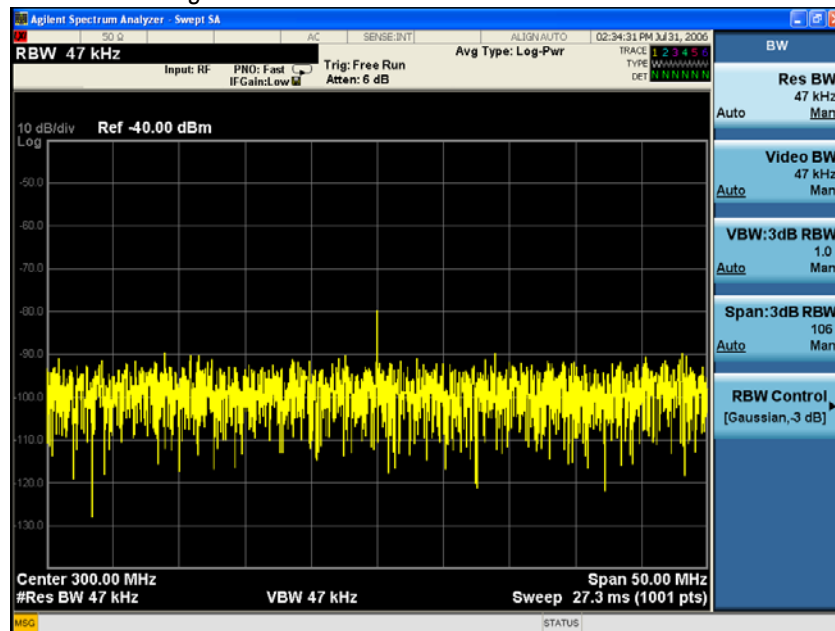
6 Decrease the RBW.

▪ Press **BW**, **47, kHz**.

The low-level signal appears more clearly because the noise level is reduced. See Figure 3-4.

Figure 3-4

Decreasing Resolution Band width



A “#” mark appears next to the Res BW annotation in the lower left corner of the screen, indicating that the resolution band width is uncoupled.



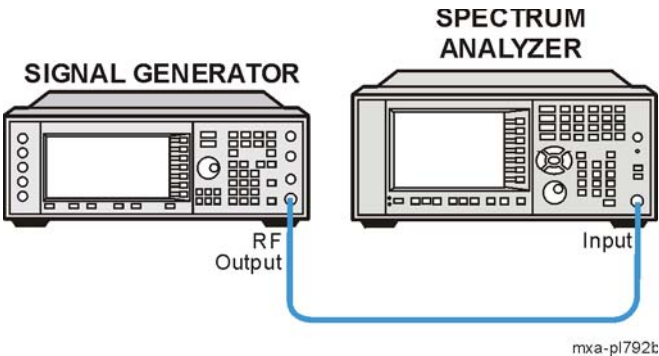
**RBW Selections**      You can use the step keys to change the RBW in a 1–3–10 sequence.

All the Signal Analyzer RBWs are digital and have a selectivity ratio of 4.1:1. Choosing the next lower RBW (in a 1–3–10 sequence) for better sensitivity increases the sweep time by about 10:1 for swept measurements, and about 3:1 for FFT measurements (within the limits of RBW). Using the knob or keypad, you can select RBWs from 1 Hz to 3 MHz in approximately 10% increments, plus 4, 5, 6 and 8 MHz. This enables you to make the trade off between sweep time and sensitivity with finer resolution.

Using the Average Detector and Increased Sweep Time

When the analyzer noise masks low-level signals, changing to the average detector and increasing the sweep time smooths the noise and improves the signal visibility. Slower sweeps are required to average more noise variations.

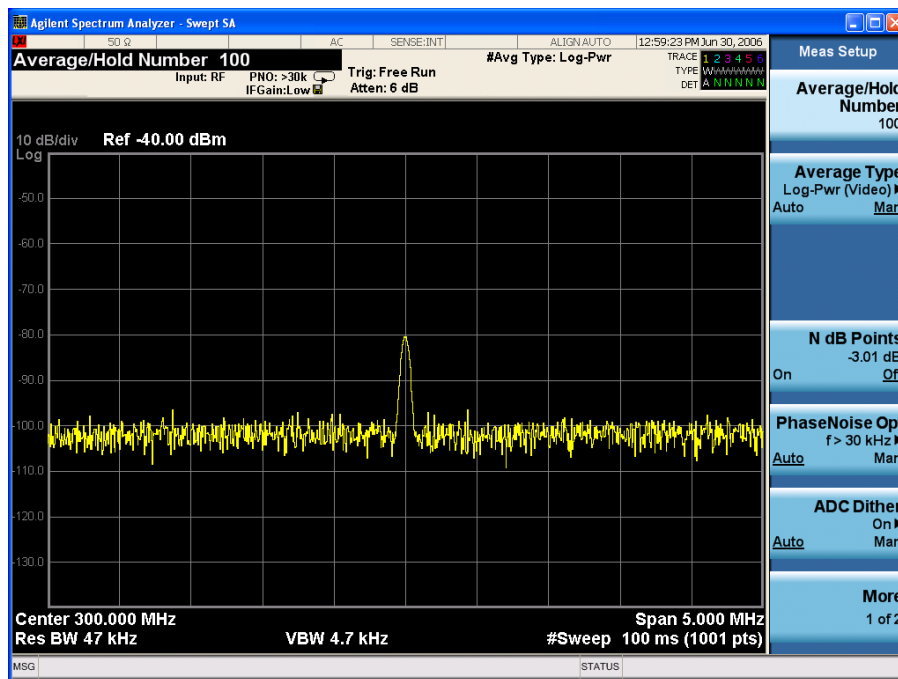
Step	Action	Notes
1	Set up the signal generator.  a. Set the frequency to 300 MHz.  b. Set the amplitude to -80 dBm.	
2	Connect the source RF OUTPUT to the analyzer RF INPUT as shown.	



3	Select the mode.	▪ Press <b>Mode, Spectrum Analyzer.</b>
4	Preset the mode.	▪ Press <b>Mode Preset.</b>
5	Set the center frequency, span and reference level.	a. Press <b>FREQ Channel, Center Freq, 300, MHz.</b>  b. Press <b>SPAN X Scale, Span, 5, MHz.</b>  c. Press <b>AMPTD Y Scale, Ref Level, 40, -dBm.</b>

Step	Action	Notes
6 Select the average detector.	<ul style="list-style-type: none"> <li>Press <b>Trace/Detector</b>, <b>More 1 of 2</b>, <b>Detector</b>, <b>Average (Log/RMS/V)</b>.</li> </ul>	The number 1 (Trace 1 indicator) in the Trace/Detector panel (in the upper right-hand corner of the display) changes from green to white, indicating that the detector has been chosen manually. In addition, the letter in the Det row has been set to "A" indicating that the Average detector has been selected. See <a href="#">Figure 3-5</a> .
7 Increase the sweep time.	<ul style="list-style-type: none"> <li>Press <b>Sweep/Control</b>, <b>Sweep Time (Man)</b>, <b>100</b>, <b>ms</b>.</li> </ul>	The noise smooths out, as there is more time to average the values for each of the displayed data points.
8 Change the average type to log averaging.	<ul style="list-style-type: none"> <li>Press <b>Meas Setup</b>, <b>Average Type</b>, <b>Log-Pwr Avg (Video)</b>.</li> </ul>	Note how the noise level drops.

Figure 3-5 Varying the sweep time with the average detector

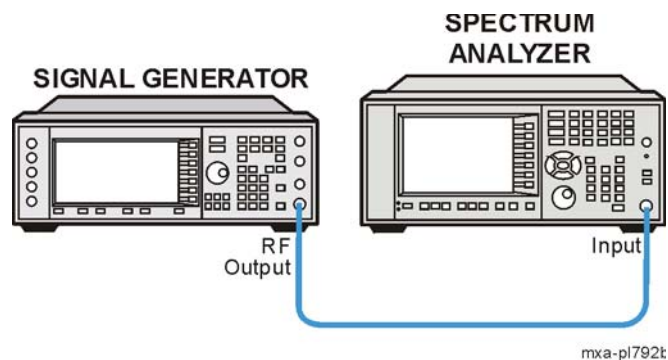


Trace Averaging

Averaging is a digital process in which each trace point is averaged with the previous average for the same trace point. Selecting averaging, when the analyzer is autocoupled, changes the detection mode from normal to sample. Sample mode may not measure a signal amplitude as accurately as normal mode, because it may not find the true peak.

**NOTE** This is a trace processing function and is not the same as using the average detector (as described on [page 50](#)).

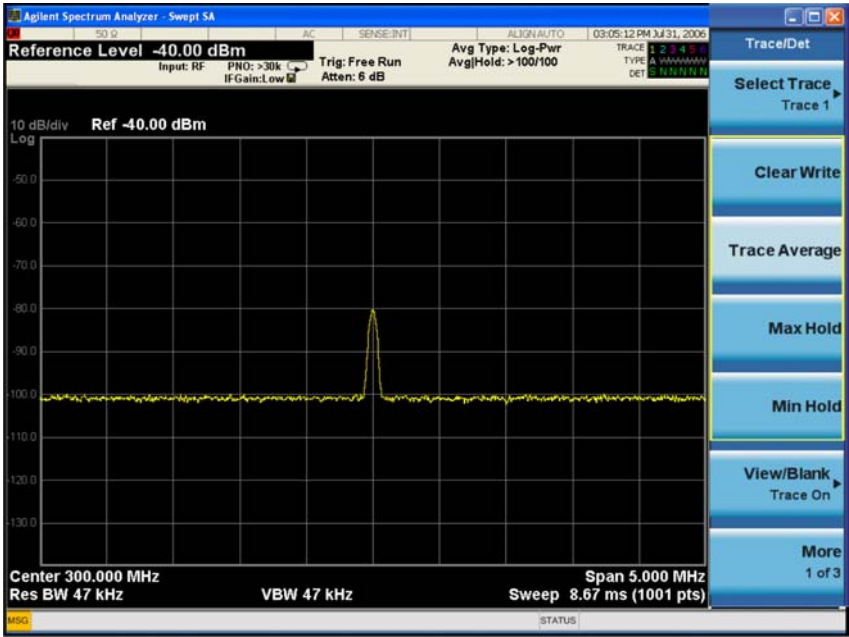
Step	Action	Notes
1	Set up the signal generator. a. Set the frequency to 300 MHz. b. Set the amplitude to -80 dBm.	
2	Connect the source RF OUTPUT to the analyzer RF INPUT as shown.	



3	Select the mode.	▪ Press <b>Mode, Spectrum Analyzer</b> .
4	Preset the mode.	▪ Press <b>Mode Preset</b> .
5	Set the center frequency, span and reference level.	a. Press <b>FREQ Channel, Center Freq, 300, MHz</b> . b. Press <b>SPAN X Scale, Span, 5, MHz</b> . c. Press <b>AMPTD Y Scale, Ref Level, 40, -dBm</b> .

Step	Action	Notes
6 Turn on Averaging.	<ul style="list-style-type: none"><li>Press <b>Trace/Detector, Trace Average</b>.</li></ul>	As the averaging routine smooths the trace, low level signals become more visible. Avg/Hold >100 appears in the measurement bar near the top of the screen. See <a href="#">Figure 3-6</a> .
7 Set number of averages.	<ul style="list-style-type: none"><li>Press <b>Meas Setup, Average/Hold Number, 25, Enter</b>.</li></ul>	Annotation above the graticule in the measurement bar to the right of center shows the type of averaging, Log-Power. Also, the number of traces averaged is shown on the Average/Hold Number key.

Figure 3-6 Trace Averaging



Changing most active functions restarts the averaging, as does pressing the **Restart** key. Once the set number of sweeps completes, the analyzer continues to provide a running average based on this set number.

**NOTE** If you want the measurement to stop after the set number of sweeps, use single sweep: Press **Single** and then press the **Restart** key.

## Measuring a Low-Level Signal

### Trace Averaging

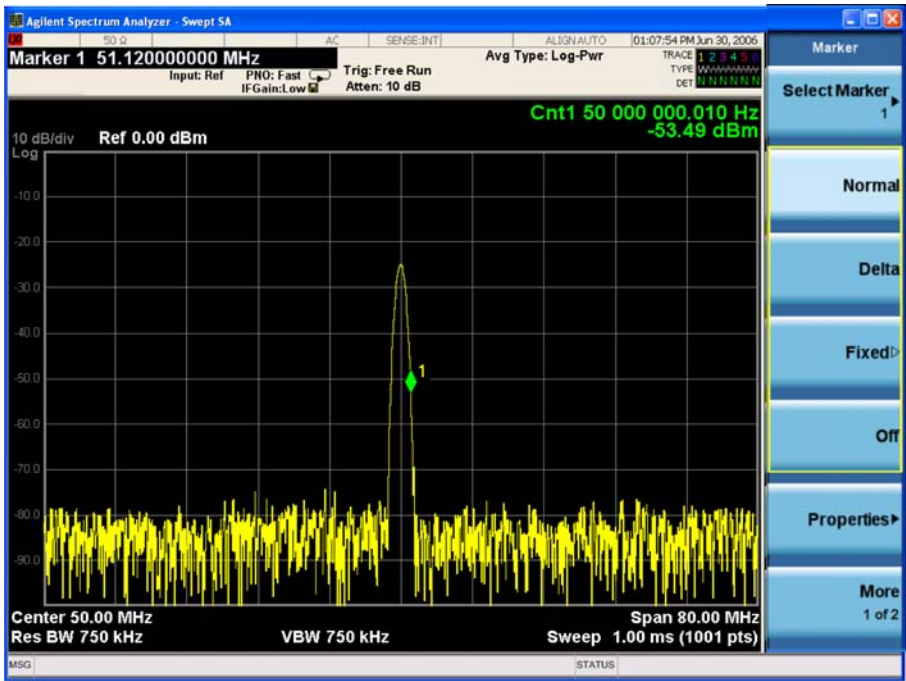
## 4 Improving Frequency Resolution and Accuracy

## Using a Frequency Counter to Improve Frequency Resolution and Accuracy

This procedure uses the signal analyzer internal frequency counter to increase the resolution and accuracy of the frequency readout.

Step	Action	Notes
1 Select the mode.	▪ Press <b>Mode, Spectrum Analyzer</b> .	
2 Preset the mode.	▪ Press <b>Mode Preset</b> .	
3 Enable the internal reference signal.	▪ Press <b>Input/Output, RF Calibrator, 50 MHz</b> .	
4 Set the center frequency and span.	a. Press <b>FREQ Channel, Center Freq, 50, MHz</b> b. Press <b>SPAN X Scale, Span, 80, MHz</b> .	
5 Turn the frequency counter on.	▪ Press <b>Marker, More, Marker Count, Counter (On)</b> .	The marker counter remains on until turned off.

Figure 4-1 Using Marker Counter



- |                                |  |
|--------------------------------|--|
| 6 Turn off the marker counter. | ▪ Press <b>Marker, More, Marker Count, Count (Off)</b> .<br>Or<br>Press <b>Marker, Off</b> . |
|--------------------------------|--|



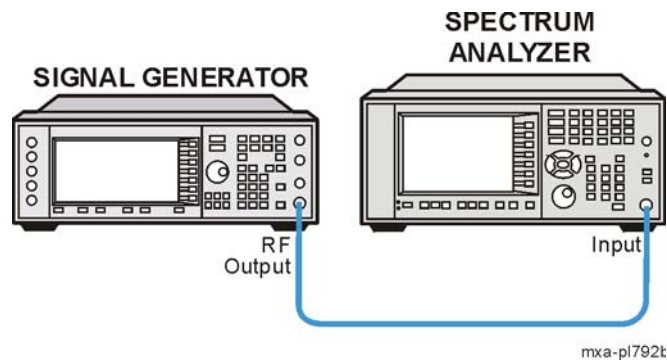
## 5 Tracking Drifting Signals

## Measuring a Source Frequency Drift

The analyzer can measure the short- and long-term stability of a source. The maximum amplitude level and the frequency drift of an input signal trace can be displayed and held by using the maximum-hold function. You can also use the maximum hold function if you want to determine how much of the frequency spectrum a signal occupies.

This procedure uses signal tracking to keep the drifting signal in the center of the display. The drifting is captured by the analyzer using maximum hold.

Step	Action	Notes
1 Set up the signal sources.	<ul style="list-style-type: none"><li>a. Set the frequency of the signal source to 300 MHz.</li><li>b. Set the source amplitude to -20 dBm</li></ul>	
2 Instrument setup.	<ul style="list-style-type: none"><li>▪ Connect the source RF OUTPUT to the analyzer RF INPUT as shown.</li></ul>	



3 Set the analyzer to the Spectrum Analyzer mode.	<ul style="list-style-type: none"><li>▪ Press <b>Mode, Spectrum Analyzer</b>.</li></ul>	This enables the spectrum analyzer measurements.
4 Preset the analyzer	<ul style="list-style-type: none"><li>▪ Press <b>Mode Preset</b>.</li></ul>	
5 Set the analyzer center frequency, span and reference level.	<ul style="list-style-type: none"><li>a. Press <b>FREQ Channel, Center Freq, 300, MHz</b>.</li><li>b. Press <b>SPAN X Scale, Span, 10, MHz</b>.</li><li>c. Press <b>AMPTD Y Scale, Ref Level, 10, -dBm</b>.</li></ul>	
6 Place a marker on the peak of the signal.	<ul style="list-style-type: none"><li>▪ Press <b>Peak Search</b>.</li></ul>	

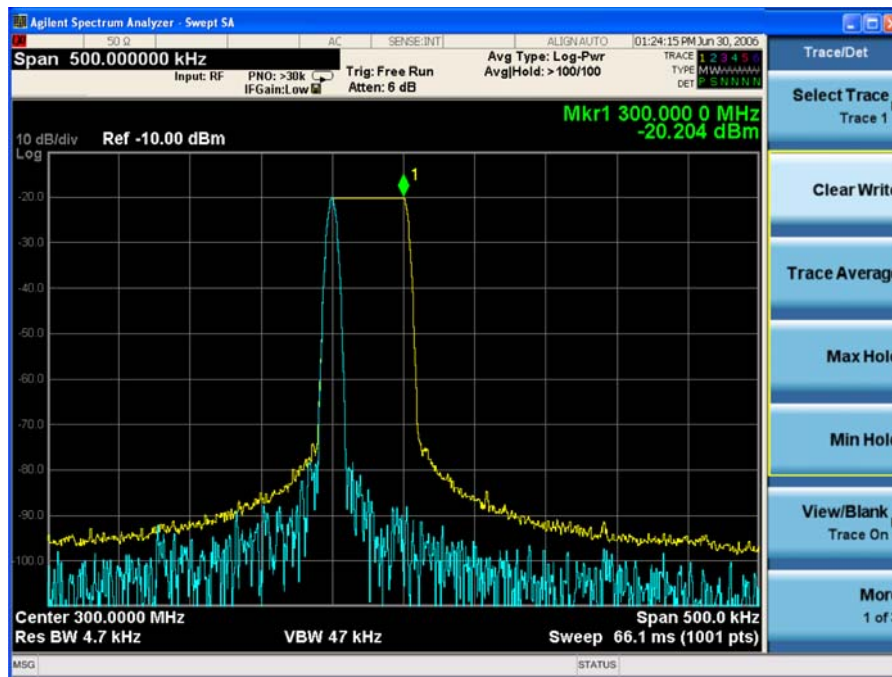
Step	Action	Notes
<b>7</b> Turn on the signal tracking function.	▪ Press <b>SPAN X Scale, Signal Track (On)</b> .	
<b>8</b> Reduce the span to 500 kHz.	▪ Press <b>SPAN, 500, kHz</b> .	Notice that the signal is held in the center of the display.
<b>9</b> Turn off the signal track function.	▪ Press <b>SPAN X Scale, Signal Track (Off)</b> .	
<b>10</b> Measure the excursion of the signal.	▪ Press <b>Trace/Detector, Max Hold</b> .	As the signal varies, maximum hold maintains the maximum responses of the input signal.  Annotation in the Trace/Detector panel, upper right corner of the screen, indicates the trace mode. In this example, the M in the Type row under TRACE 1 indicates trace 1 is in maximum-hold mode.
<b>11</b> Activate trace 2.	▪ Press <b>Trace/Detector, Select Trace, Trace (2)</b> .	Trace 1 remains in maximum hold mode to show any drift in the signal.
<b>12</b> Change the mode to continuous sweeping.	▪ Press <b>Clear Write</b> .	
<b>13</b> Slowly change the frequency of the signal generator $\pm 50$ kHz in 1 kHz increments.		Your analyzer display should look similar to <a href="#">Figure 5-1</a> .

# Tracking Drifting Signals

## Measuring a Source Frequency Drift

Step	Action	Notes
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Figure 5-1 Viewing a Drifting Signal With Max Hold and Clear Write

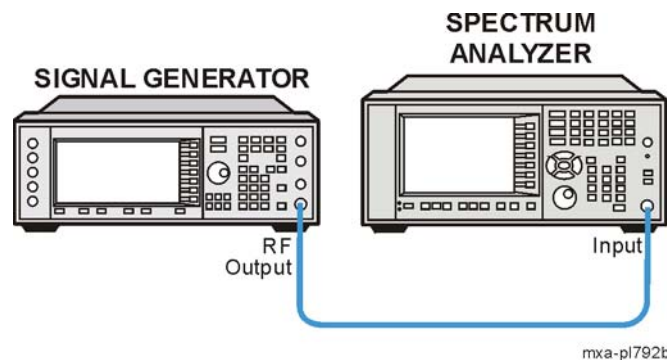


## Tracking a Signal

The signal track function is useful for tracking drifting signals that drift relatively slowly by keeping the signal centered on the display as the signal drifts. This procedure tracks a drifting signal.

Note that the primary function of the signal track function is to track unstable signals, not to track a signal as the center frequency of the analyzer is changed. If you choose to use the signal track function when changing center frequency, check to ensure that the signal found by the tracking function is the correct signal.

Step	Action	Notes
1 Set up the signal sources.	<div>a. Set the frequency of the signal source to 300 MHz.</div> <div>b. Set the source amplitude to -20 dBm.</div>	
2 Instrument setup.	<div>▪ Connect the source RF OUTPUT to the analyzer RF INPUT as shown.</div>	

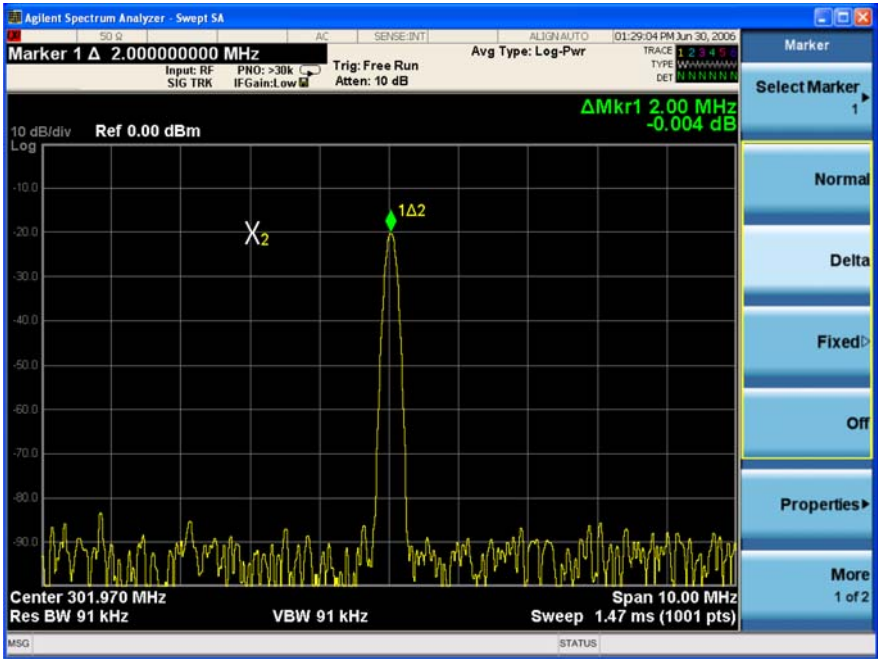


3 Set the analyzer to the Spectrum Analyzer mode.	<div>▪ Press <b>Mode, Spectrum Analyzer.</b></div>	This enables the spectrum analyzer measurements.
4 Preset the analyzer.	<div>▪ Press <b>Mode Preset.</b></div>	
5 Set the analyzer center frequency, span and reference level.	<div>▪ Press <b>FREQ Channel, Center Freq, 301, MHz.</b></div> <div>▪ .Press <b>SPAN X Scale, Span, 10, MHz.</b></div>	
6 Place a marker on the peak of the signal.	<div>▪ Press <b>Peak Search.</b></div>	

Tracking Drifting Signals  
Tracking a Signal

Step	Action	Notes
7 Turn on the signal tracking function.	▪ Press <b>SPAN X Scale, Signal Track (On)</b> .	Notice that signal tracking places a marker on the highest amplitude peak and then brings the selected peak to the center of the display. After each sweep the center frequency of the analyzer is adjusted to keep the selected peak in the center.
8 Turn on the delta marker.	▪ Press <b>Marker, Delta</b> .	
9 Tune the frequency of the signal generator in 100 KHz increments.		Notice that the center frequency of the analyzer also changes in 100 kHz increments, centering the signal with each increment.

Figure 5-2 Tracking a Drifting Signal



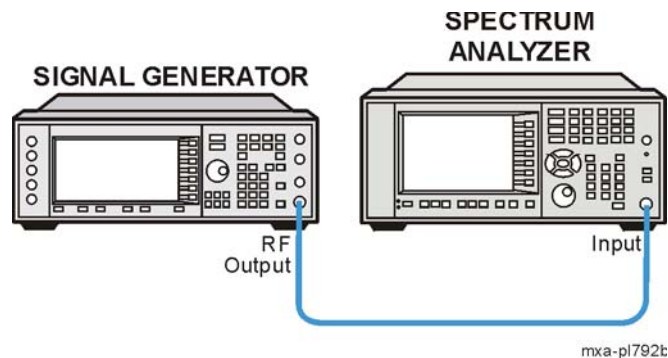
## 6 Making Distortion Measurements

## Identifying Analyzer Generated Distortion

High level input signals may cause internal analyzer distortion products that could mask the real distortion measured on the input signal. Using trace 2 and the RF attenuator, you can determine which signals, if any, are internally generated distortion products.

Using a signal from a signal generator, determine whether the harmonic distortion products are generated by the analyzer.

Step	Action	Notes
1	Set up the signal generator. <div>a. Set the frequency to 200 MHz. b. Set the amplitude to 0 dBm.</div>	
2	Connect the source RF OUTPUT to the analyzer RF INPUT as shown.	



3	Select the mode.	• Press <b>Mode, Spectrum Analyzer</b> .	
4	Set the analyzer center frequency, span, and video bandwidth.	<div>a. Press <b>FREQ Channel, Center Freq, 400, MHz</b>.</div> <div>b. Press <b>SPAN X Scale, Span, 500, MHz</b>.</div> <div>c. Press <b>BW, Video BW, 30, kHz</b>.</div>	The signal produces harmonic distortion products (spaced 200 MHz from the original 200 MHz signal) in the analyzer input mixer as shown in the following graphic. See <a href="#">Figure 6-1</a>



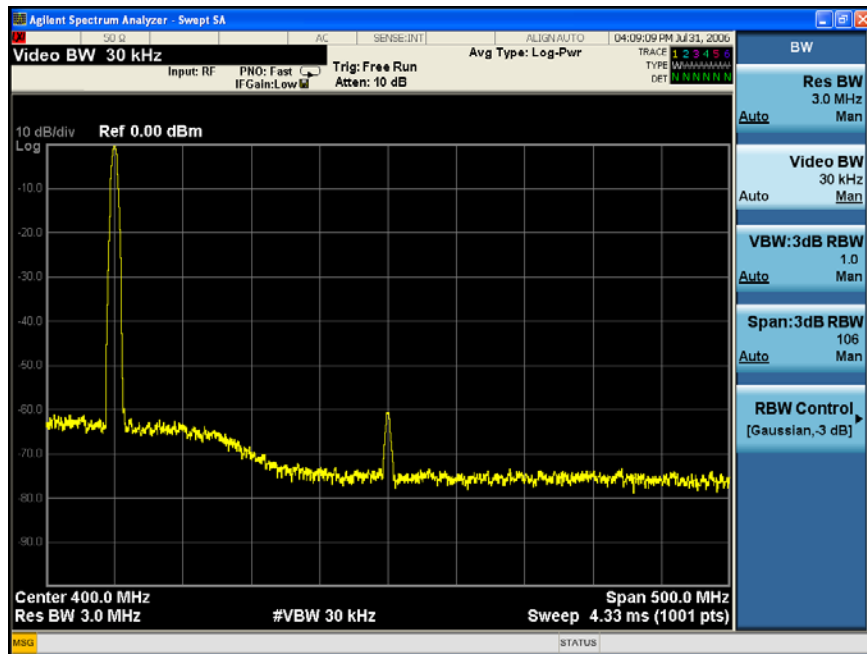
Step

Action

Notes

Figure 6-1

Harmonic Distortion

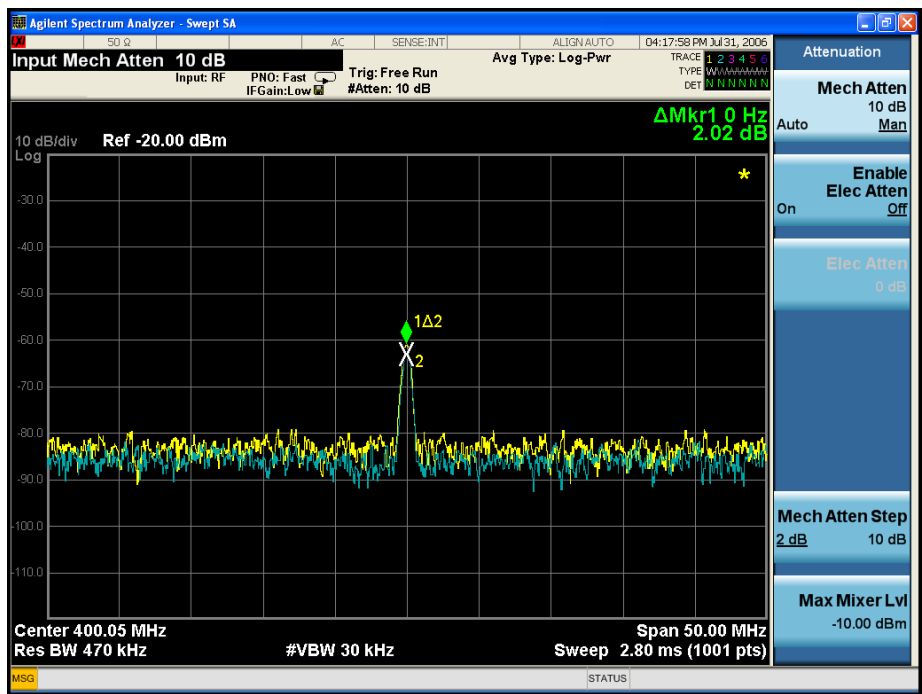


- |    |  |  |  |
|----|--|--|--|
| 5  | Change the center frequency to the value of the second harmonic. | <ul style="list-style-type: none"> <li>Press <b>Peak Search, Next Peak, Mkr→CF</b>.</li> </ul>   |  |
| 6  | Change the span to 50 MHz and re-center the signal.              | <ul style="list-style-type: none"> <li>a. Press <b>SPAN X Scale, Span, 50, MHz</b>.</li> <li>b. Press <b>Peak Search, Mkr→CF</b>.</li> </ul> |  |
| 7  | Set the attenuation to 0 dB.                                     | <ul style="list-style-type: none"> <li>Press <b>AMPTD Y Scale, Attenuation, 0, dB</b>.</li> </ul>  |  |
| 8  | Save the trace data in trace 2.                                  | <ul style="list-style-type: none"> <li>Press <b>Trace/Detector, Select Trace, Trace 2, Clear Write</b>.</li> </ul>                           |  |
| 9  | Allow trace 2 to update.   | <ul style="list-style-type: none"> <li>Press <b>Trace/Detector, View/Blank, View, Trace On</b>.</li> </ul>                                   | Minimum of two sweeps.   |
| 10 | Place a delta marker on the harmonic of trace 2.                 | <ul style="list-style-type: none"> <li>Press <b>Peak Search, Marker Delta</b>.</li> </ul>  | The analyzer display shows the stored data in trace 2 and the measured data in trace 1. The $\Delta\text{Mkr1}$ amplitude reading is the difference in amplitude between the reference and active markers. |

Making Distortion Measurements  
Identifying Analyzer Generated Distortion

Step	Action	Notes
11 Increase the RF attenuation to 10 dB.	<ul style="list-style-type: none"><li>Press <b>AMPTD Y Scale, Attenuation, 10, dB</b>.</li></ul>	<p>Notice the <math>\Delta</math>Mkr1 amplitude reading. This is the difference in the distortion product amplitude readings between 0 dB and 10 dB input attenuation settings. If the <math>\Delta</math>Mkr1 amplitude absolute value is approximately <math>\geq 1</math> dB for an input attenuator change of 10 dB, the distortion is being generated, at least in part, by the analyzer. In this case more input attenuation is necessary. Increase the input attenuation until <math>\Delta</math>Mkr1 amplitude stops increasing or decreasing in value. Return to the previous attenuator step and the input signal distortion measured will be minimally impacted by the analyzer internally generated distortion. See <a href="#">Figure 6-2</a>.</p>

Figure 6-2 RF Attenuation of 10 dB

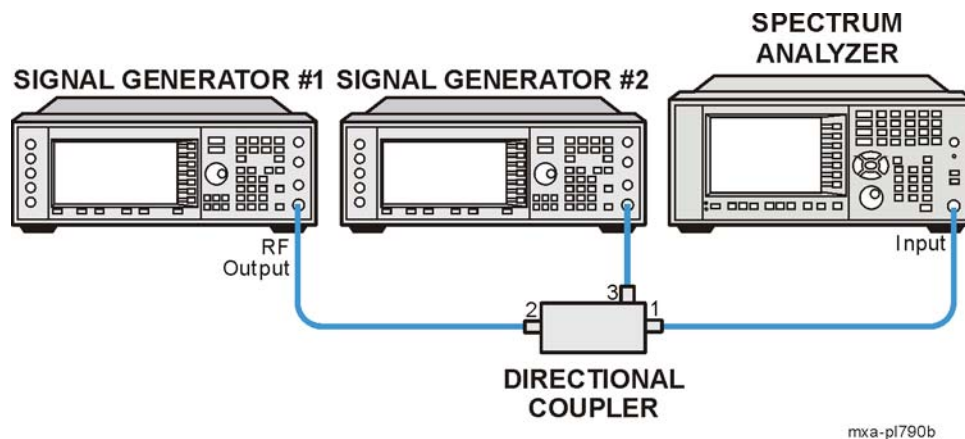


## Third-Order Intermodulation Distortion

Two-tone, third-order intermodulation distortion is a common test in communication systems. When two signals are present in a non-linear system, they can interact and create third-order intermodulation distortion products that are located close to the original signals. These distortion products are generated by system components such as amplifiers and mixers.

This procedure tests a device for third-order intermodulation using markers. Two sources are used, one set to 300 MHz and the other to 301 MHz. This combination of signal generators and a directional coupler (used as a combiner) results in a two-tone source with very low intermodulation distortion. Although the distortion from this setup may be better than the specified performance of the analyzer, it is useful for determining the TOI performance of the source/analyzer combination. After the performance of the source/analyzer combination has been verified, the device-under-test (DUT) (for example, an amplifier) would be inserted between the directional coupler output and the analyzer input.

Step	Action	Notes
1	Connect two sources to the analyzer RF INPUT as shown.	The coupler should have a high degree of isolation between the two input ports so the sources do not intermodulate.



2	Set up the signal sources.	<ol style="list-style-type: none"> <li>Set the frequency of signal generator #1 to 300 MHz.</li> <li>Set the frequency of signal generator #2 to 300.1 MHz.</li> <li>Set signal generator #1 amplitude to <math>-5</math> dBm.</li> <li>Set signal generator #2 amplitude to <math>-5</math> dBm.</li> </ol>	<p>This produces a frequency separation of 1 MHz.</p> <p>Sets the sources equal in amplitude as measured by the analyzer.</p>
---	----------------------------	--	---

## Making Distortion Measurements

### Third-Order Intermodulation Distortion

Step	Action	Notes
3 Select the mode.	▪ Press <b>Mode, Spectrum Analyzer</b> .	
4 Preset the analyzer.	▪ Press <b>Mode Preset</b> .	
5 Set the analyzer center frequency and span.	a. Press <b>FREQ Channel, Center Freq, 300.5, MHz</b> . b. Press <b>SPAN X Scale, Span, 5, MHz</b>	
6 Set the analyzer detector to Peak.	▪ Press <b>Trace/Detector, Detector, Peak</b> .	
7 Set the mixer level to improve dynamic range.	▪ Press <b>AMPTD Y Scale, Attenuation, Max Mixer Lvl, -10, dBm</b> .	The analyzer automatically sets the attenuation so that a signal at the reference level has a maximum value of -10 dBm at the input mixer.
8 Move the signal to the reference level.	▪ Press <b>Peak Search, Mkr →, Mkr → Ref Lvl</b> .	
9 Reduce the RBW until the distortion products are visible.	▪ Press <b>BW, Res BW, ↓</b> .	
10 Activate the second marker and place it on the peak of the distortion product closest to the marker test signal.	▪ Press <b>Peak Search, Marker Delta, Next Left</b> or <b>Next Right</b> (as appropriate).	Use the <b>Next Right</b> key (if the first marker is on the right test signal) or <b>Next Left</b> key (if the first marker is on the left test signal):
11 Measure the other distortion product	▪ Press <b>Marker, Normal, Peak Search, Next Peak</b> .	
12 Activate the second marker and place it on the peak of the distortion product closest to the marked test signal.	▪ Press <b>Marker, Normal, Marker Delta, Next Left</b> or <b>Next Right</b> (as appropriate).	See <a href="#">Figure 6-3</a> .

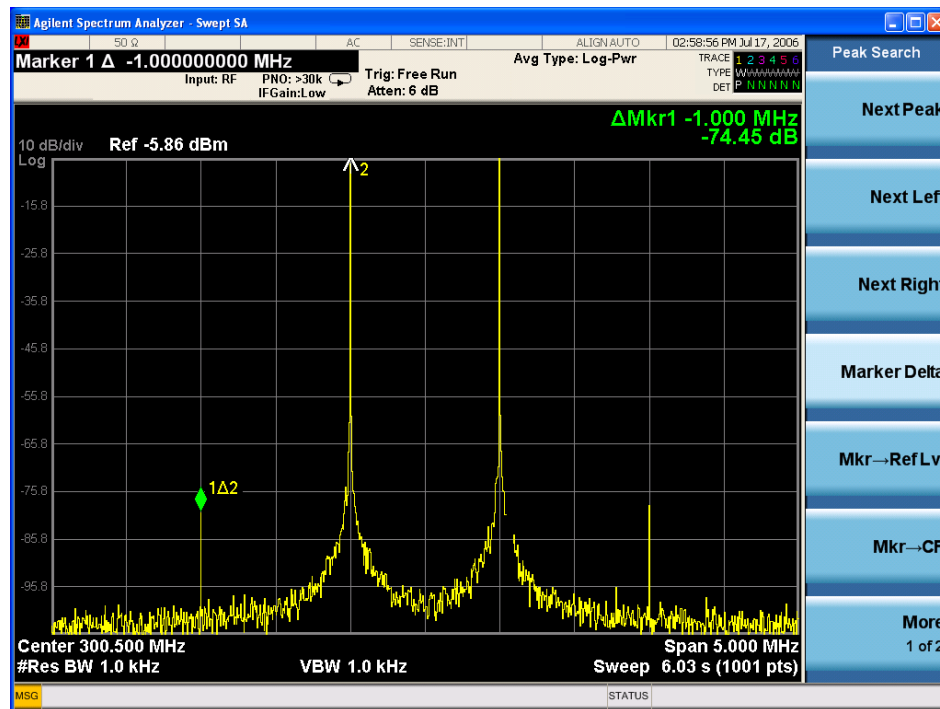
Step

Action

Notes

Figure 6-3

Measuring the Distortion Product





## 7 Measuring Noise

## Measuring Signal-to-Noise

Signal-to-noise is a ratio used in many communication systems as an indication of noise in a system. Typically the more signals added to a system adds to the noise level, reducing the signal-to-noise ratio making it more difficult for modulated signals to be demodulated. This measurement is also referred to as carrier-to-noise in some communication systems.

The signal-to-noise measurement procedure below may be adapted to measure any signal in a system if the signal (carrier) is a discrete tone. If the signal in your system is modulated, it is necessary to modify the procedure to correctly measure the modulated signal level.

In this example the 50 MHz amplitude reference signal is used as the fundamental signal. The amplitude reference signal is assumed to be the signal of interest and the internal noise of the analyzer is measured as the system noise. To do this, you need to set the input attenuator such that both the signal and the noise are well within the calibrated region of the display.

Step	Action	Notes
1 Set the analyzer to the Spectrum Analyzer mode.	▪ Press <b>Mode, Spectrum Analyzer</b> .	This enables the spectrum analyzer measurements.
2 Preset the analyzer.	▪ Press <b>Mode Preset</b> .	
3 Enable the internal reference signal.	▪ Press <b>Input/Output, RF Calibrator, 50, MHz</b> .	
4 Set the center frequency, span, reference level and attenuation.	a. Press <b>FREQ Channel, Center Freq, 50, MHz</b> . b. Press <b>SPAN X Scale, Span, 1, MHz</b> . c. Press <b>AMPTD Y Scale, Ref Level, -10, dBm</b> . d. Press <b>AMPTD Y Scale, Attenuation, 40, dB</b> .	
5 Place a marker on the peak of the signal and place a delta marker in the noise.	▪ Press <b>Peak Search, Marker Delta, 200, kHz</b> .	
6 Turn on the marker noise function.	▪ Press <b>Marker Function, Marker Noise</b> .	This enables you to view the signal-to-noise measurement results.



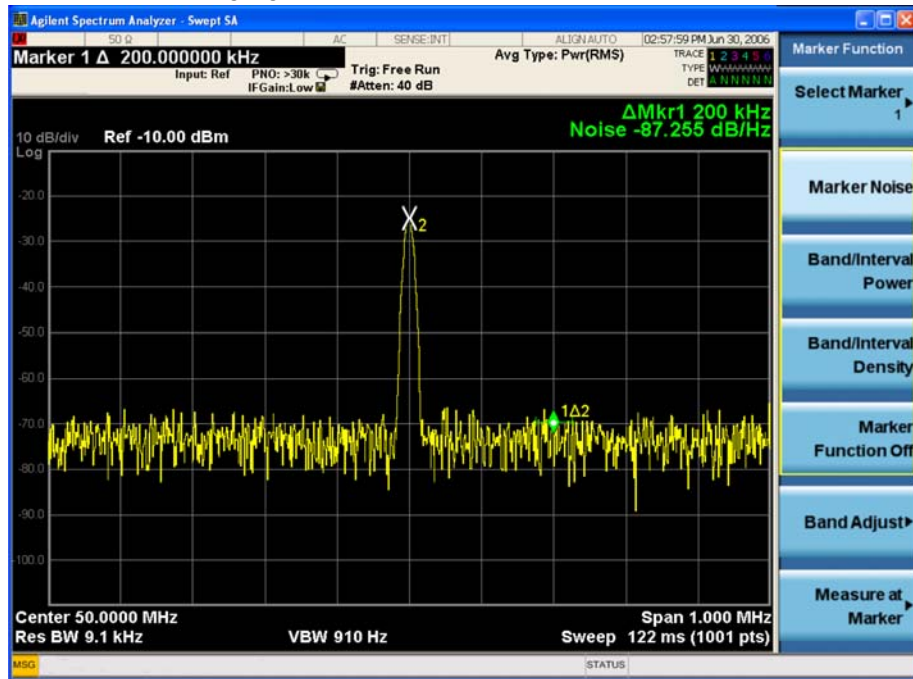
Step

Action

Notes

Figure 7-1

Measuring signal-to-noise



Read the signal-to-noise in dB/Hz, that is with the noise value determined for a 1 Hz noise bandwidth. If you wish the noise value for a different bandwidth, decrease the ratio by  $10 \times \log(BW)$ . For example, if the analyzer reading is  $-70$  dB/Hz but you have a channel bandwidth of 30 kHz:

$$S/N = -70 \text{ dB/Hz} + 10 \times \log(30 \text{ kHz}) = -25.23 \text{ dB/(30 kHz)}$$

NOTE

When Noise Marker is activated, the display detection mode is set to Average.

NOTE

When using the Noise Marker, if the delta marker is closer than one quarter of a division from the edge of a discrete signal response, the amplitude reference signal in this case, there is a potential for error in the noise measurement. See [“Measuring Noise Using the Noise Marker”](#) on page 74.

## Measuring Noise Using the Noise Marker

This procedure uses the marker function, **Marker Noise**, to measure noise in a 1 Hz bandwidth. In this example the noise marker measurement is made near the 50 MHz reference signal to illustrate the use of **Marker Noise**.

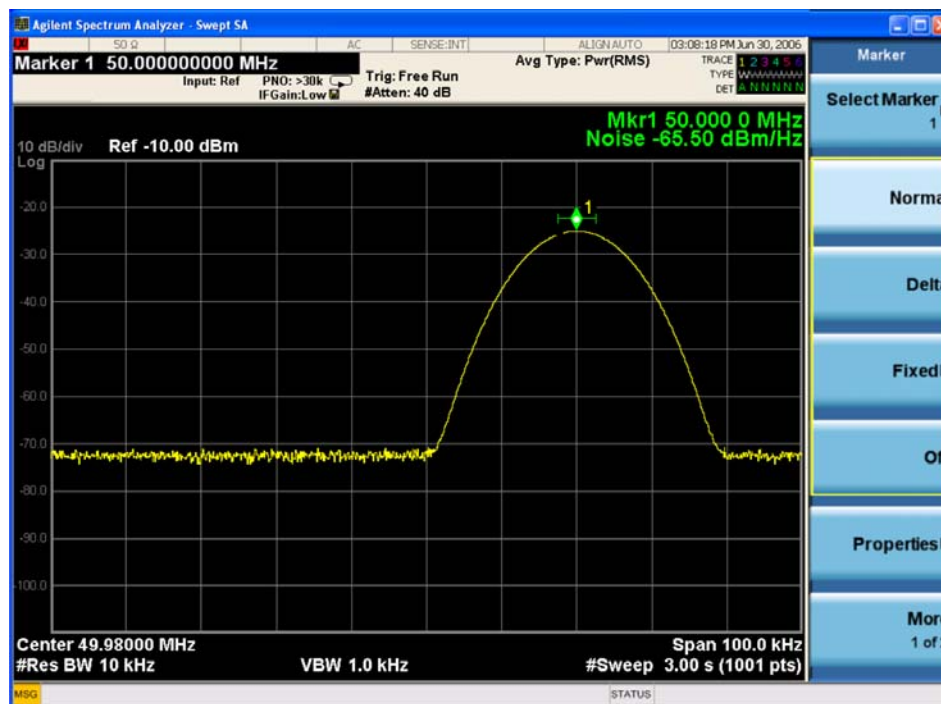
Step	Action	Notes
1 Set the analyzer to the Spectrum Analyzer mode.	<ul style="list-style-type: none"> <li>Press <b>Mode, Spectrum Analyzer</b>.</li> </ul>	This enables the spectrum analyzer measurements
2 Preset the analyzer.	<ul style="list-style-type: none"> <li>Press <b>Mode Preset</b>.</li> </ul>	
3 Enable the internal reference signal.	<ul style="list-style-type: none"> <li>Press <b>Input/Output, RF Calibrator, 50, MHz</b>.</li> </ul>	
4 Set the center frequency, span, reference level and attenuation.	<ul style="list-style-type: none"> <li>a. Press <b>FREQ Channel, Center Freq, 49.98, MHz</b>.</li> <li>b. Press <b>SPAN X Scale, Span, 100, kHz</b>.</li> <li>c. Press <b>AMPTD Y Scale, Ref Level, -10, dBm</b>.</li> <li>d. Press <b>AMPTD Y Scale, Attenuation, Mech Atten Man, 40, dB</b>.</li> </ul>	
5 Turn on the noise marker.	<ul style="list-style-type: none"> <li>Press <b>Marker Function, Marker Noise</b>.</li> </ul>	<p>Note that display detection automatically changes to "Avg"; average detection calculates the noise marker from an average value of the displayed noise. Notice that the noise marker floats between the maximum and the minimum displayed noise points. The marker readout is in dBm (1 Hz) or dBm per unit band width.</p> <p>For noise power in a different band width, add <math>10 \times \log(BW)</math>. For example, for noise power in a 1 kHz band width, dBm (1 kHz), add <math>10 \times \log(1000)</math> or 30 dB to the noise marker value.</p>
6 Reduce the variations of the sweep-to-sweep marker value by increasing the sweep time.	<ul style="list-style-type: none"> <li>Press <b>Sweep/Control, Sweep Time, 3, s</b>.</li> </ul>	Increasing the sweep time when the average detector is enabled allows the trace to average over a longer time interval, thus reducing the variations in the results (increases measurement repeatability).

Step	Action	Notes
7 Move the marker.	<ul style="list-style-type: none"> <li>Press <b>Marker, 50, MHz</b>.</li> </ul>	<p>The noise marker value is based on the mean of 5% of the total number of sweep points centered at the marker in the initially selected span. The points that are averaged span one-half of a division. Changing spans after enabling the noise marker will result in the marker averaging a progressively wider or narrower portion of the newly selected span and corresponding sweep points. This occurs because the marker is locked to 5% of the initially selected span.</p>
8 Adjust the width of the noise marker relative to the span.	<ul style="list-style-type: none"> <li>Press <b>Marker Function, Band Adjust, Band/Interval Span</b>, and adjust the value to the desired marker width.</li> </ul>	<p>Notice that the marker does not go to the peak of the signal unless the Band/Interval Span is set to 0 Hz because otherwise there are not enough points at the peak of the signal. With a Band Interval Span greater than 0 Hz, the noise marker is also averaging points below the peak due to the narrow RBW.</p>
9 Widen the resolution bandwidth.	<ul style="list-style-type: none"> <li>Press <b>BW, Res BW, 10, kHz</b>.</li> </ul>	<p>This allows the marker to make a more accurate peak power measurement using the noise marker as shown in <a href="#">Figure 7-2</a>.</p>

## Measuring Noise

### Measuring Noise Using the Noise Marker

Step	Action	Notes
Figure 7-2	Noise marker	



- 10 Set the analyzer to zero span at the marker frequency.
- Press **Mkr→**, **Mkr→CF**.
  - Press **SPAN X Scale**, **Zero Span**.
  - Press **Marker**.

Note that the marker amplitude value is now correct since all points averaged are at the same frequency and not influenced by the shape of the bandwidth filters. See Figure 7-3.

Remember that the noise marker calculates a value based on an average of the points around the frequency of interest. Generally when making power measurements using the noise marker on discrete signals, first tune to the frequency of interest and then make your measurement in zero span (time domain).

Step

Action

Notes

Figure 7-3 Noise Marker with Zero Span



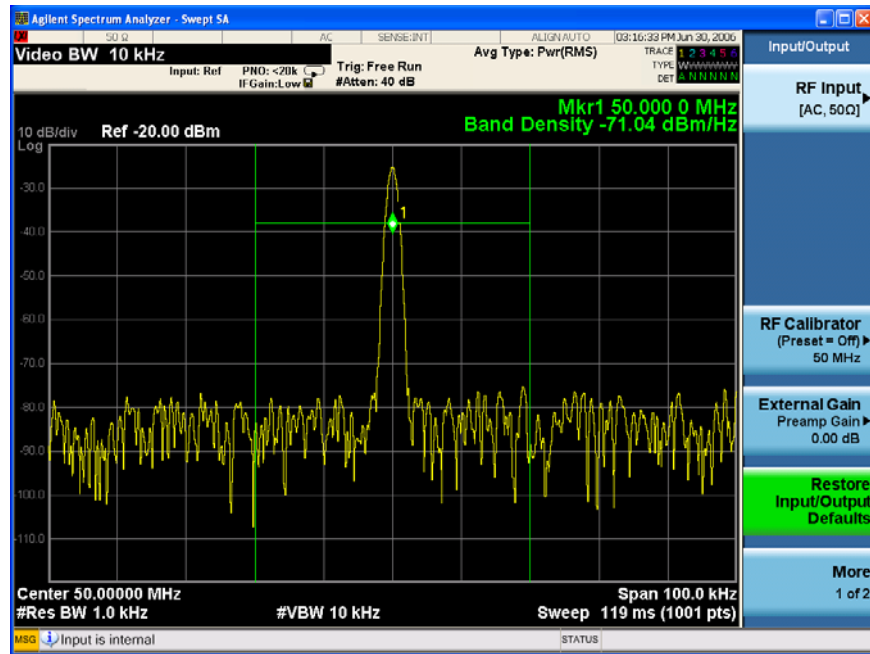
## Measuring Noise-Like Signals Using Band/Interval Density Markers

Band/Interval Density Markers let you measure power over a frequency span. The markers allow you to easily and conveniently select any arbitrary portion of the displayed signal. However, while the analyzer, when autocoupled, makes sure the analysis is power-responding (rms voltage-responding), you must set all of the other parameters.

Step	Action	Notes
1 Set the analyzer to the Spectrum Analyzer mode.	▪ Press <b>Mode, Spectrum Analyzer</b> .	This enables the spectrum analyzer measurements.
2 Preset the analyzer	▪ Press <b>Mode Preset</b> .	
3 Set the center frequency, span, reference level and attenuation.	a. Press <b>FREQ Channel, Center Freq, 50, MHz</b> . b. Press <b>SPAN X Scale, Span, 100, kHz</b> . c. Press <b>AMPTD Y Scale, Ref Level, -20, dBm</b> . d. Press <b>AMPTD Y Scale, Attenuation, 40, dB</b> .	
4 Measure the total noise power between the markers.	▪ Press <b>Marker Function, Band/Interval Density</b> .	
5 Set the band span.	▪ Press <b>Band Adjust, Band/Interval Span, 40, kHz</b> .	
6 Set the resolution and video bandwidths.	a. Press <b>BW, Res BW, 1, kHz</b> . b. Press <b>BW, Video BW, 10, kHz</b> .	Common practice is to set the resolution band width from 1% to 3% of the measurement (marker) span, 40 kHz in this example.
7 Enable the internal 50 MHz amplitude reference signal of the analyzer.	▪ Press <b>Input/Output, RF Calibrator, 50 MHz</b> .	Adds a discrete tone to see the effects on the reading. See <a href="#">Figure 7-4</a> .

Step	Action	Notes
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Figure 7-4 Band/Interval Density Measurement

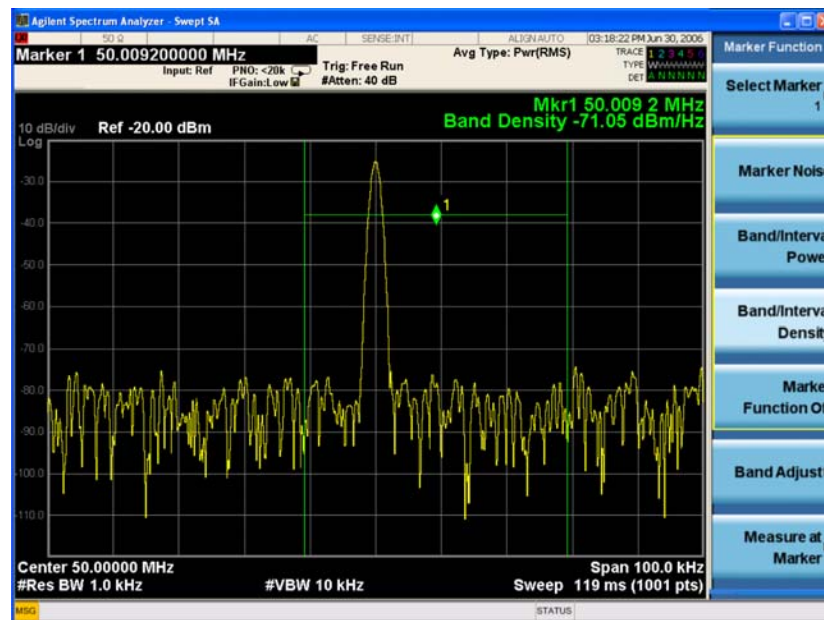


- |  |  |   |
|--|--|---|
| 8 Set the Band/Interval Density Markers. | <ul style="list-style-type: none"> <li>Press <b>Marker Function, Band/Interval Density</b>.</li> </ul> | This allows you to move the markers (set at 40 kHz span) around without changing the Band/Interval span. Use the front-panel knob to move the band power markers and note the change in the power reading |
|--|--|---|

# Measuring Noise

## Measuring Noise-Like Signals Using Band/Interval Density Markers

Step	Action	Notes
Figure 7-5	Band/Interval Density Measurement	



**NOTE** Band/Interval Density Markers can be changed to read the total absolute power by pressing **Marker Function, Band/Interval Power**.



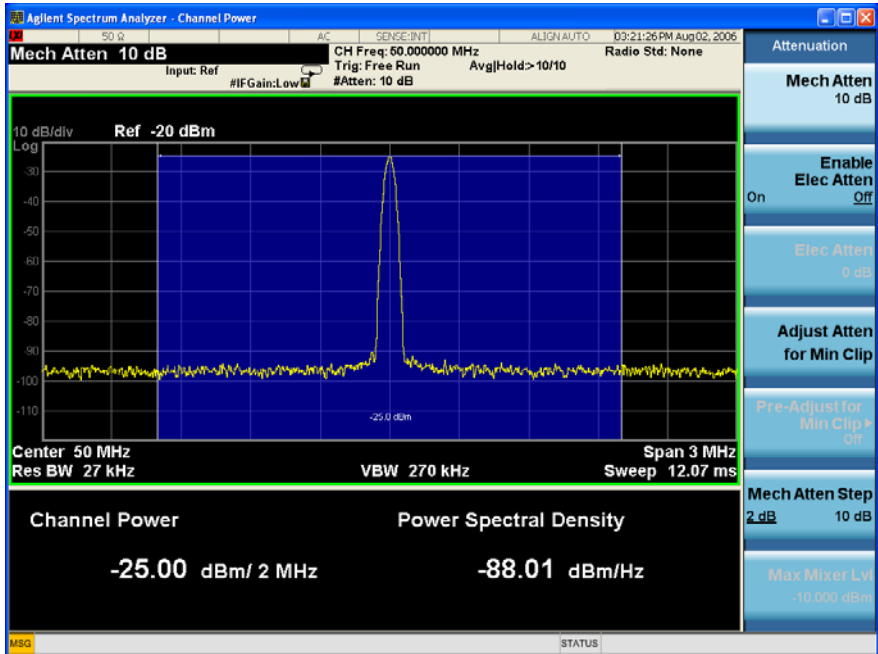
## Measuring Noise-Like Signals Using the Channel Power Measurement

You may want to measure the total power of a noise-like signal that occupies some bandwidth. Typically, channel power measurements are used to measure the total (channel) power in a selected bandwidth for a modulated (noise-like) signal. Alternatively, to manually calculate the channel power for a modulated signal, use the noise marker value and add  $10 \times \log(\text{channel BW})$ . However, if you are not certain of the characteristics of the signal, or if there are discrete spectral components in the band of interest, you can use the channel power measurement. This example uses the noise of the analyzer, adds a discrete tone, and assumes a channel bandwidth (integration bandwidth) of 2 MHz. If desired, a specific signal may be substituted.

Step	Action	Notes
1 Set the analyzer to the Spectrum Analyzer mode	▪ Press <b>Mode, Spectrum Analyzer</b> .	This enables the spectrum analyzer measurements.
2 Preset the analyzer.	▪ Press <b>Mode Preset</b> .	
3 Set the center frequency,	▪ Press <b>FREQ Channel, Center Freq, 50, MHz</b> .	
4 Start the channel power measurement.	▪ Press <b>Meas, Channel Power</b> ,	
5 Enable the bar graph.	▪ Press <b>View/Display, Bar Graph, On</b> .	
6 Enable the internal 50 MHz amplitude reference signal.	▪ Press <b>Input/Output, RF Calibrator, 50 MHz</b> .	This adds a discrete tone to see the effects on the reading.
7 Optimize the analyzer attenuation level setting.	▪ Press <b>AMPTD, Attenuation, Adjust Atten for Min Clip</b> .	Your display should be similar to <a href="#">Figure 7-6</a> .

## Measuring Noise

### Measuring Noise-Like Signals Using the Channel Power Measurement

Step	Action	Notes
Figure 7-6	Measuring Channel Power	 The screenshot shows the Agilent Spectrum Analyzer interface in Channel Power mode. The main display is a log-scale plot of power versus frequency. A sharp peak is visible at 50 MHz, reaching a level of -25.00 dBm. The noise floor is significantly lower, at -88.01 dBm/Hz. The plot is set to a center frequency of 50 MHz, a resolution bandwidth (Res BW) of 27 kHz, and a span of 3 MHz. The vertical scale is 10 dB/div. The reference level is -20 dBm. The plot is labeled 'Log' and 'Ref -20 dBm'. The peak is labeled '-25.0 dBm'. The noise floor is labeled '-88.01 dBm/Hz'. The plot is labeled 'Channel Power' and 'Power Spectral Density'. The plot is labeled '-25.00 dBm / 2 MHz' and '-88.01 dBm/Hz'. The plot is labeled 'Center 50 MHz', 'Res BW 27 kHz', 'Span 3 MHz', 'Sweep 12.07 ms', 'VBW 270 kHz'. The plot is labeled 'Mech Atten 10 dB', 'Input Ref', '#IF Gain: Low', 'CH Freq: 50.000000 MHz', 'Trig: Free Run', 'Avg/Hold > 10/10', 'Radio Std: None', 'ALIGN AUTO', '03:21:26 PM Aug 02, 2006'. The plot is labeled 'MSG' and 'STATUS'. The plot is labeled 'Attenuation', 'Mech Atten 10 dB', 'Enable Elec Atten On', 'Elec Atten 0 dB', 'Adjust Atten for Min Clip', 'Pre-Adjust for Min Clip Off', 'Mech Atten Step 2 dB', '10 dB', 'Max Mixer Lvl -10.000 dBm'.

The power reading is essentially that of the tone; that is, the total noise power is far enough below that of the tone that the noise power contributes very little to the total.

The algorithm that computes the total power works equally well for signals of any statistical variant, whether tone-like, noise-like, or combination.

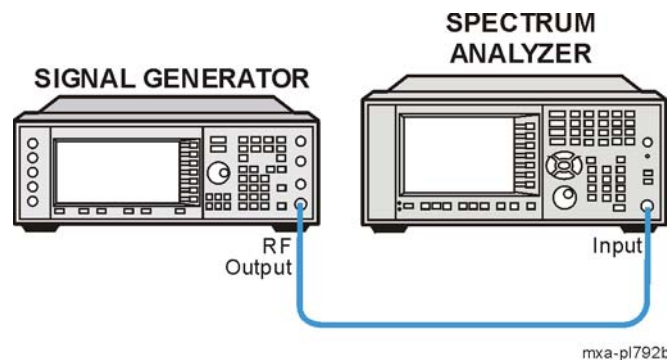
## Measuring Signal-to-Noise of a Modulated Carrier

Signal-to-noise (or carrier-to-noise) is a ratio used in many communication systems as indication of the noise performance in the system. Typically, the more signals added to the system or an increase in the complexity of the modulation scheme can add to the noise level. This can reduce the signal-to-noise ratio and impact the quality of the demodulated signal. For example, a reduced signal-to-noise in digital systems may cause an increase in EVM (error vector magnitude).

With modern complex digital modulation schemes, measuring the modulated carrier requires capturing all of its power accurately. This procedure uses the Band Power Marker with a RMS average detector to correctly measure the carrier's power within a user adjustable region. A Noise Marker (normalized to a 1 Hz noise power bandwidth) with an adjustable noise region is also employed to allow the user to select and accurately measure just the system noise of interest. An important key to making accurate Band Power Marker and Noise Power measurements is to insure that the Average Type under the Meas Setup key is set to “Auto”.

In this example a 4 carrier W-CDMA digitally modulated carrier is used as the fundamental signal and the internal noise of the analyzer is measured as the system noise.

Step	Action	Notes
1 Set up the signal sources.	<div>a. Setup a 4 carrier W-CDMA signal.</div> <div>b. Set the source frequency to 1.96 GHz.</div> <div>c. Set the source amplitude to –10 dBm.</div>	
2 Instrument setup.	<div>• Connect the source RF OUTPUT to the analyzer RF INPUT as shown.</div>	



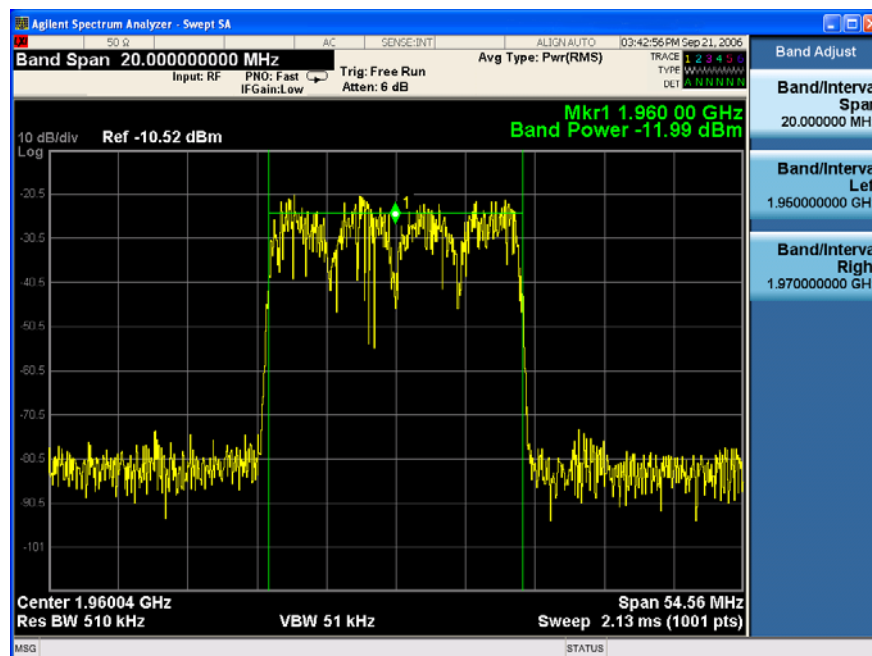
3 Set the analyzer to the Spectrum Analyzer mode.	<div>• Press <b>Mode, Spectrum Analyzer</b></div>	This enables the spectrum analyzer measurements
4 Preset the analyzer.	<div>• Press <b>Mode Preset.</b></div>	

## Measuring Noise

### Measuring Signal-to-Noise of a Modulated Carrier

Step	Action	Notes
5 Tune to the W-CDMA signal.	<ul style="list-style-type: none"> <li>Press <b>FREQ Channel, Auto Tune</b>.</li> </ul>	
6 Enable the Band Power Marker function.	<ul style="list-style-type: none"> <li>Press <b>Marker Function, Band/Interval Power</b>.</li> </ul>	This measures the total power of the 4 carrier W-CDMA signal.
7 Center the frequency of the Band Power marker on the signal.	<ul style="list-style-type: none"> <li>Press <b>Select Marker 1, 1.96, GHz</b></li> </ul>	
8 Adjust the width (or span) of the Band Power marker.	<ul style="list-style-type: none"> <li>Press <b>Marker Function, Band Adjust, Band/Interval Span, 20, MHz</b>.</li> </ul>	This encompasses the entire 4 carrier W-CDMA signal.

Figure 7-7 4 Carrier W-CDMA Signal Power using Band Power Marker

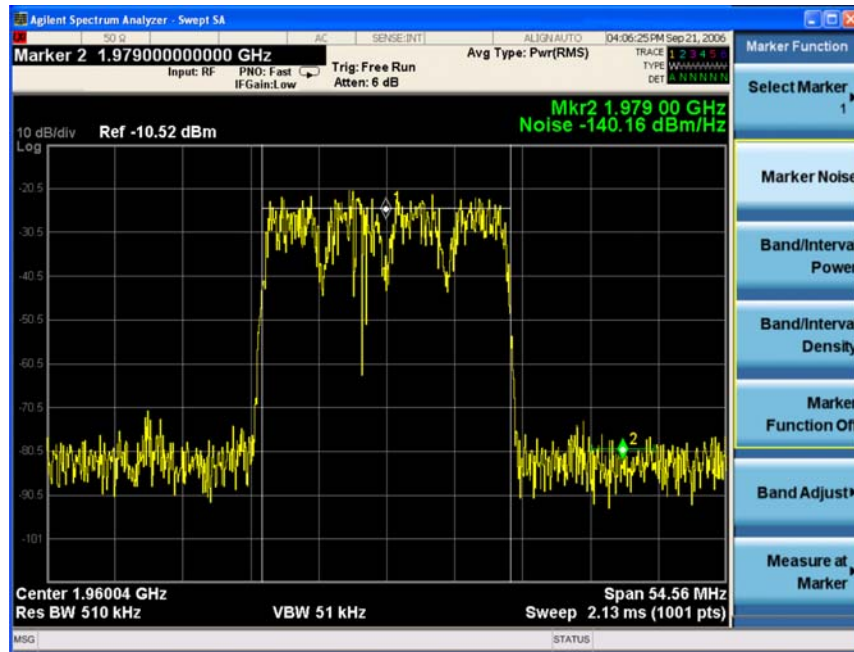


Note the green vertical lines of Marker 1 representing the span of signals included in the Band Power measurement and the carrier power indicated in Markers Result Block.

9 Enable the Noise Marker using marker 2.	<ul style="list-style-type: none"> <li>Press <b>Marker Function, Select Marker, Marker 2, Marker Noise</b>.</li> </ul>	This measures the system noise power.
10 Move the Noise Marker 2 to the system noise frequency of interest.	<ul style="list-style-type: none"> <li>Press <b>Select Marker 2, 1.979, GHz</b>.</li> </ul>	This encompasses the desired noise power.
11 Adjust the width of the noise marker region.	<ul style="list-style-type: none"> <li>Press <b>Marker Function, Select Marker, Marker 2, Band Adjust, Band/Interval, 5, MHz</b>.</li> </ul>	See <a href="#">Figure 7-8</a> .

Step	Action	Notes
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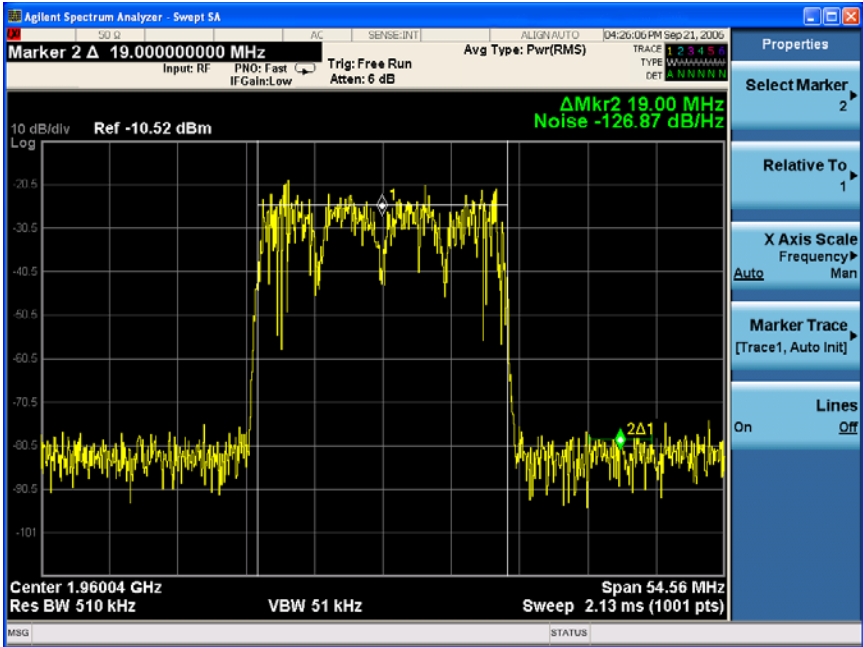
Figure 7-8 Noise Marker Measuring System Noise



Note the green “wings” of Marker 2 outlining the noise region to be included in the measurement and the resulting noise power expressed in dBm/Hz as shown in the Marker Results Block.

- |   |  |                 |
|---|--|-----------------|
| 12 Measure carrier-to-noise by making the Noise Marker relative to the carrier's Band Power Marker. | <ul style="list-style-type: none"> <li>Press <b>Marker, Properties, Select Marker, Marker 2, Relative to, Marker 1.</b></li> </ul> | See Figure 7-9. |
|---|--|-----------------|

# Measuring Noise Measuring Signal-to-Noise of a Modulated Carrier

Step	Action	Notes
<div> <div>Figure 7-9</div> <div>Signal-to-noise measurement</div> </div>		
		
13	Simultaneously measure carrier-to-noise on a second region of the system by enabling another Noise Marker.	Up to 11 are available.
	<ol style="list-style-type: none"> <li>Press <b>Marker Function</b>, Select <b>Marker</b>, <b>Marker 3</b>, <b>Marker Noise</b>.</li> <li>Press <b>Select Marker 3</b>, <b>1.941</b>, <b>GHz</b>.</li> <li>Press <b>Return</b>, <b>Band Adjust</b>, <b>Band/Interval</b>, <b>5</b>, <b>MHz</b>.</li> <li>Press <b>Marker</b>, <b>Properties</b>, Select <b>Marker</b>, <b>Marker 3</b>, <b>Relative to</b>, <b>Marker 1</b>.</li> </ol>	
14	Enable the Marker Table.	This enables you to view results of both carrier-to-noise measurements and all other markers. See <a href="#">Figure 7-10</a> .

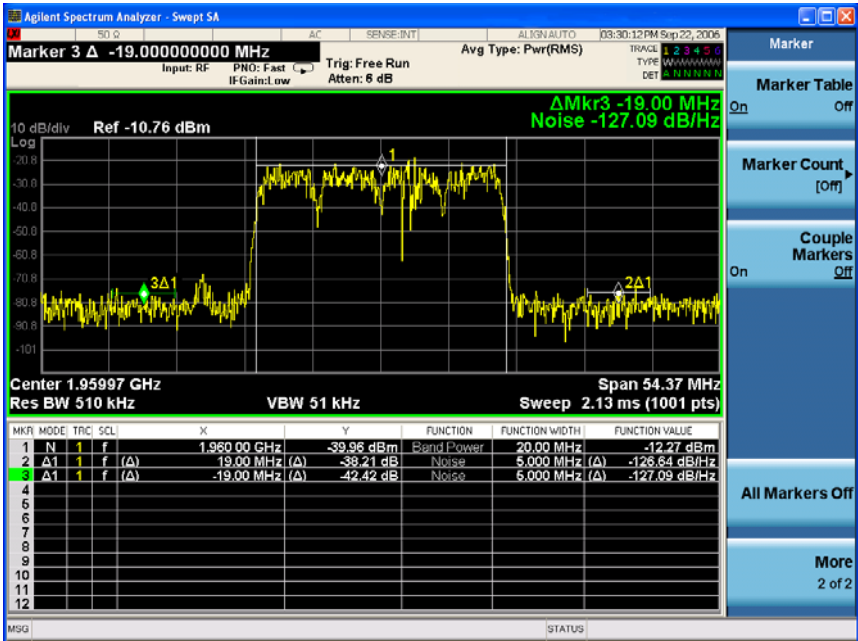
Step

Action

Notes

Figure 7-10

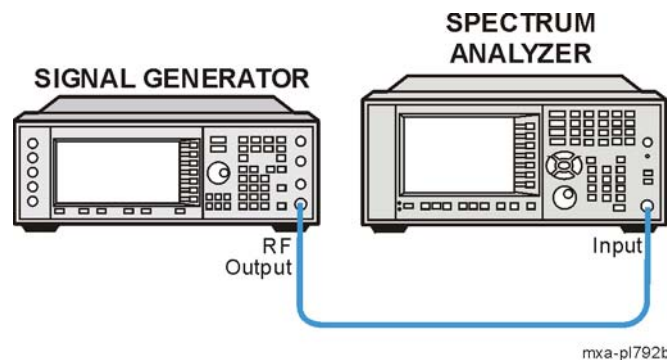
Multiple Signal-to Noise Measurements with Marker Table



## Improving Phase Noise Measurements by Subtracting Signal Analyzer Noise

Making noise power measurements (such as phase noise) near the noise floor of the signal analyzer can be challenging where every dB improvement is important. Utilizing the analyzer trace math function Power Diff and 3 separate traces allows measurement of the DUT phase noise in one trace, the analyzer noise floor in a second trace and then the resulting subtraction of those two traces displayed in a third trace with the analyzer noise contribution removed.

Step	Action	Notes
1 Set up the signal sources.	<div>a. Setup an unmodulated signal.</div> <div>b. Set the source frequency to 1.96 GHz.</div> <div>c. Set the source amplitude to –30 dBm.</div>	
2 Instrument setup.	<div>▪ Connect the source RF OUTPUT to the analyzer RF INPUT as shown.</div>	

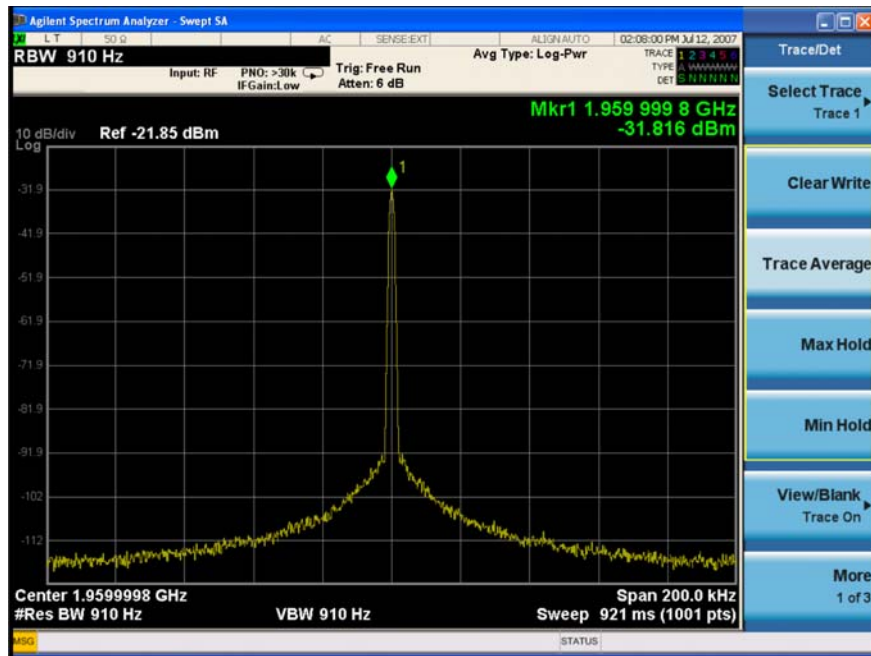


3 Set the analyzer to the Spectrum Analyzer mode.	<div>▪ Press <b>Mode, Spectrum Analyzer</b>.</div>	This enables the spectrum analyzer measurements.
4 Preset the analyzer.	<div>▪ Press <b>Mode Preset</b>.</div>	
5 Tune to the unmodulated carrier, adjust the span and RBW.	<div>a. Press <b>FREQ Channel, Auto Tune</b>.</div> <div>b. Press <b>Span, Span, 200, kHz</b>.</div> <div>c. Press <b>BW, Res BW, 910, Hz</b>.</div>	
6 Measure and store the DUT phase noise plus the analyzer noise.	<div>a. Press <b>Trace/Detector, Select Trace, Trace 1, Trace Average</b></div> <div>After sufficient averaging:</div> <div>b. Press <b>View/Blank, View</b></div>	<div>Allow time for sufficient averaging before initiating action b.</div> <div>See <a href="#">Figure 7-11</a>.</div>



Step	Action	Notes
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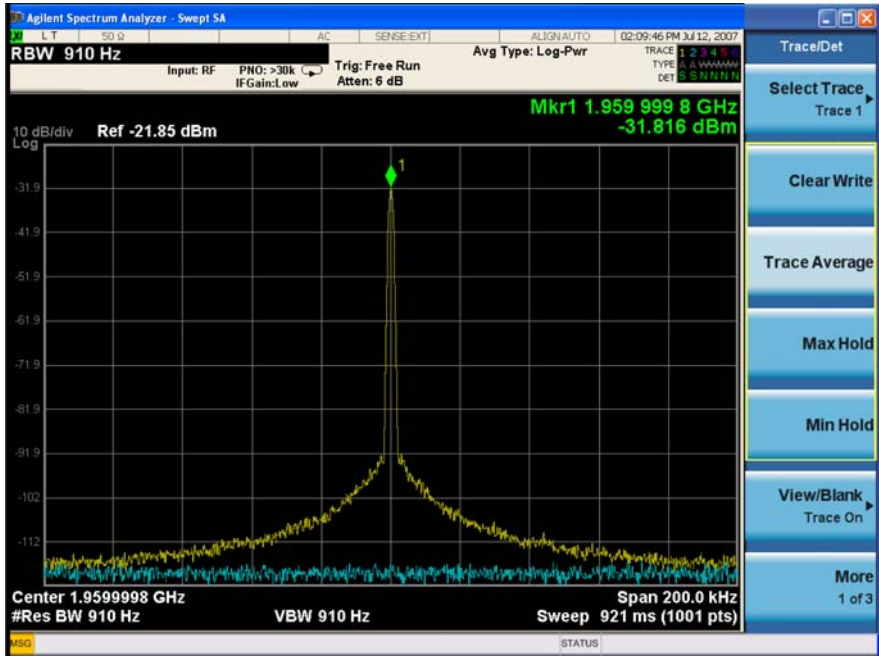
Figure 7-11 Measurement of DUT and Analyzer Noise



- |  |  |   |
|--|--|---|
| 7 Measure only the analyzer noise using trace 2 (blue trace) with trace averaging. | <p>a. Turn off or remove the DUT signal to the RF input of the analyzer.</p> <p>b. Press <b>Trace/Detector</b>, <b>Select Trace</b>, <b>Trace 2</b>, <b>Clear Write</b>, <b>Trace Average</b>.</p> <p>c. Press <b>View/Blank</b>, <b>View</b>.</p> | <p>Allow time for sufficient averaging.</p> <p>See <a href="#">Figure 7-12</a>.</p> |
|--|--|---|

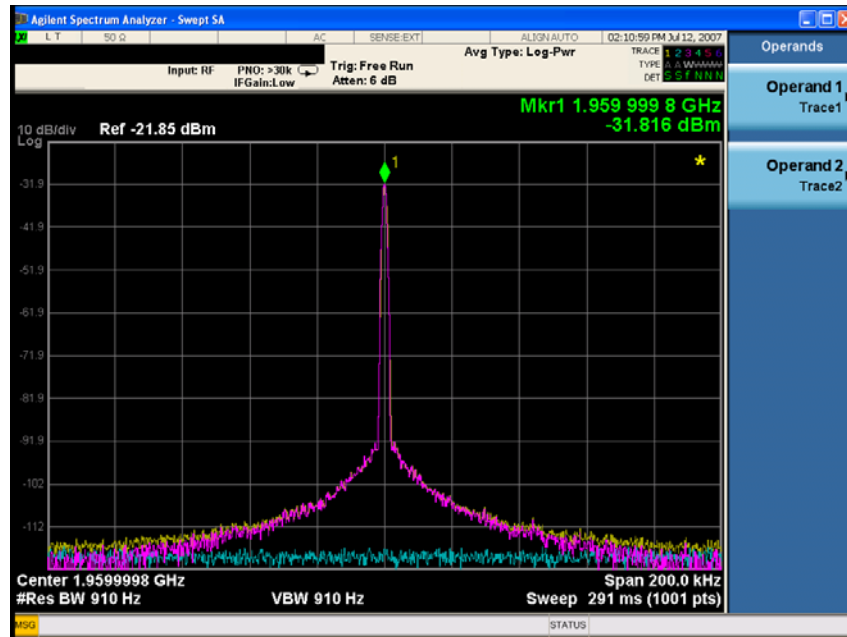
## Measuring Noise

### Improving Phase Noise Measurements by Subtracting Signal Analyzer Noise

Step	Action	Notes
<p><i>Figure 7-12</i>      <i>Measurement of Analyzer Noise</i></p> 		
8	<p>Subtract the noise from the DUT phase noise measurement using the Power Diff math function.</p> <ol style="list-style-type: none"> <li>Press <b>Trace/Detector, Select Trace, Trace 3, Clear Write</b>.</li> <li>Press <b>More, More, Math, Power Diff, Trace Operands, Operand 1, Trace 1, Operand 2, Trace 2</b>.</li> </ol>	<p>Notice the phase noise improvement at 100 kHz offset between trace 1 (yellow trace) and trace 3 (magenta trace).</p> <p>See <a href="#">Figure 7-13</a>.</p>

Step	Action	Notes
------	--------	-------

Figure 7-13 Improved Phase Noise Measurement



- |  |   |  |
|--|---|--|
| <p><b>9</b> Measure the noise measurement improvement with delta Noise markers between traces.</p> | <ol style="list-style-type: none"> <li>a. Press <b>Marker, Select Marker, Marker 1, Normal</b>.</li> <li>b. Press <b>Properties, Select Marker, Marker 1, Marker Trace, Trace 1</b>.</li> <li>c. Using the knob, adjust Marker 1 to approximately 90 kHz offset from the carrier on trace 1.</li> <li>d. Press <b>Return, Select Marker, Marker 2, Normal</b>.</li> <li>e. Press <b>Properties, Select Marker, Marker 2, Marker Trace, Trace 3</b>.</li> <li>f. Press <b>Relative To, Marker 1</b>.</li> <li>g. Using the knob, adjust Marker 2 to approximately 90 kHz offset from the carrier on trace 3.</li> <li>h. Press <b>Marker Function, Select Marker, Marker 1, Marker Noise</b>.</li> <li>i. Press <b>Select Marker, Marker 2, Marker Noise</b>.</li> </ol> | <p>Note the up to 6 dB improvement in the Marker Results Block. See <a href="#">Figure 7-14</a>.</p> |
|--|---|--|

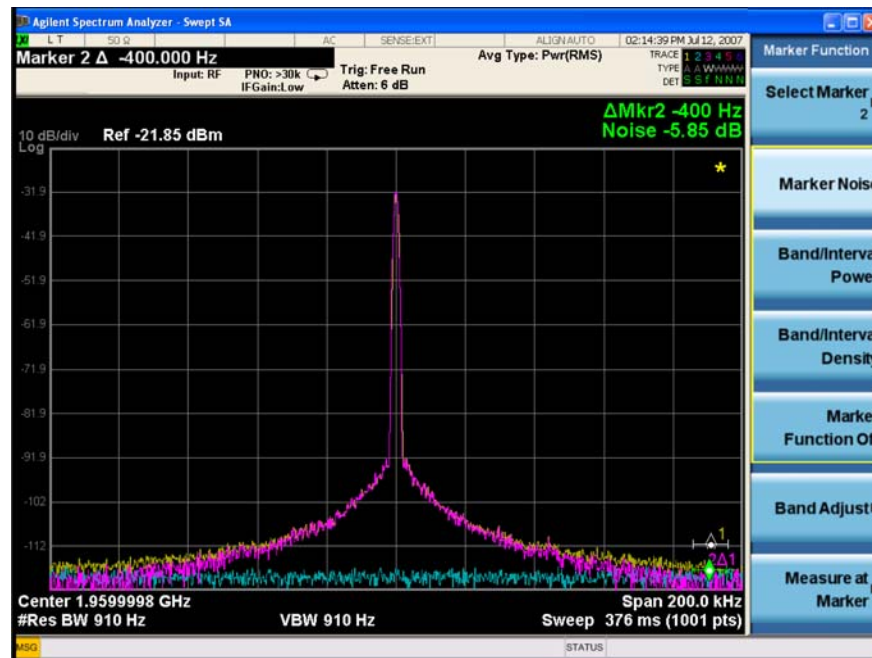
## Measuring Noise

### Improving Phase Noise Measurements by Subtracting Signal Analyzer Noise

Step	Action	Notes
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Figure 7-14

Improved Phase Noise Measurement with Delta Noise Markers



## 8 Making Time-Gated Measurements

Traditional frequency-domain spectrum analysis provides only limited information for certain signals. Examples of these difficult-to-analyze signal include the following:

- Pulsed-RF
- Time multiplexed
- Interleaved or intermittent
- Time domain multiple access (TDMA) radio formats
- Modulated burst

The time gating measurement examples use a simple frequency-modulated, pulsed-RF signal. The goal is to eliminate the pulse spectrum and then view the spectrum of the FM carrier as if it were continually on, rather than pulsed. This reveals low-level modulation components that are hidden by the pulse spectrum.

## Generating a Pulsed-RF FM Signal

When performing these measurements you can use a digitizing oscilloscope or your Keysight X-Series Signal Analyzer (using Gate View) to set up the gated signal. Refer back to these first three steps to set up the pulse signal, the pulsed-RF FM signal and the oscilloscope settings when performing the gated LO procedure (page 100), the gated video procedure (page 104) and gated FFT procedure (page 108).

For an instrument block diagram and instrument connections see “Connecting the Instruments to Make Time-Gated Measurements” on page 99.

### Signal source setup

**Step 1.** Set up the pulse signal with a period of 5 ms and a width of 4 ms:

There are many ways to create a pulse signal. This example demonstrates how to create a pulse signal using a pulse generator or by using the internal function generator in the ESG. See Table 8-1 if you are using a pulse generator or Table 8-2 if you are using a second ESG. Select either the pulse generator or a second ESG to create the pulse signal.

Table 8-1

81100 Family Pulse Generator Settings

Period	5 ms (or pulse frequency equal to 200 Hz)
Pulse width	4 ms
High output level	2.5 V
Waveform	pulse
Low output level	-2.5 V
Delay	0 or minimum

Table 8-2

ESG #2 Internal Function Generator (LF OUT) Settings

LF Out Source	FuncGen
LF Out Waveform	Pulse
LF Out Period	5 ms
LF Out Width (pulse width)	4 ms
LF Out Amplitude	2.5 Vp
LF Out	On
RF On/Off	Off
Mod On/Off	On

**Step 2.** Set up ESG #1 to transmit a pulsed-RF signal with frequency modulation. Set the FM deviation to 1 kHz and the FM rate to 50 kHz:

ESG #1 generates the pulsed FM signal by frequency modulating the carrier signal and then pulse modulating the FM signal. The pulse signal created in step 1 is connected to the EXT 2 INPUT (on the front of ESG #1). The ESG RF OUTPUT is the pulsed-RF FM signal to be analyzed by the spectrum analyzer.

Table 8-3

ESG #1 Instrument Connections

Frequency	40 MHz
Amplitude	0 dBm
Pulse	On
Pulse Source	Ext2 DC
FM	On
FM Path	1
FM Dev	1 kHz
FM Source	Internal
FM Rate	50 kHz
RF On/Off	On
Mod On/Off	On

### Analyzer setup

If you are using an Keysight X-Series Signal Analyzer (using Gate View), set up the analyzer to view the gated RF signal (see [Figure 8-1](#) and [Figure 8-2](#) for examples of the display).

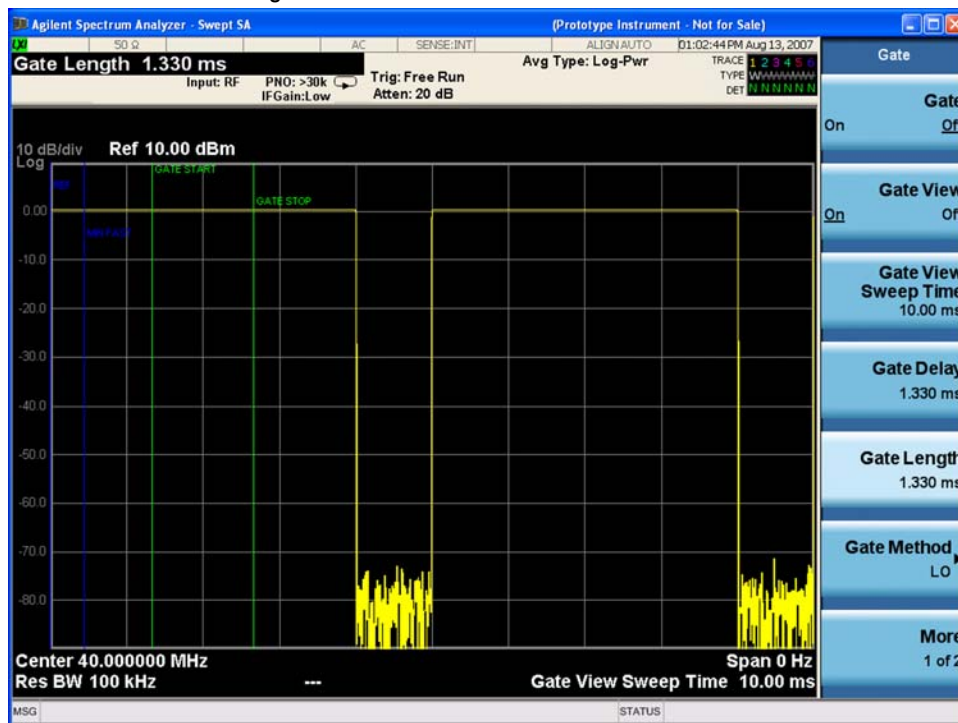
Step	Action	Notes
1 Select Spectrum Analyzer mode and Preset.	<ul style="list-style-type: none"> <li>Press <b>Mode, Spectrum Analyzer, Mode Preset.</b></li> </ul>	
2 Set the analyzer center frequency, span and reference level.	<ul style="list-style-type: none"> <li>a. Press <b>FREQ Channel, Center Freq, 40, MHz.</b></li> <li>b. Press <b>SPAN X Scale, Span, 500, kHz.</b></li> <li>c. Press <b>AMPTD Y Scale, Ref Level, 10, dBm.</b></li> </ul>	
3 Set the analyzer bandwidth.	<ul style="list-style-type: none"> <li>Press <b>BW, Res BW (Man), 100, kHz.</b></li> </ul>	

## Making Time-Gated Measurements

### Generating a Pulsed-RF FM Signal

Step	Action	Notes
4	Set the gate source to the rear external trigger input.	• Press <b>Sweep/Control, Gate, More, Gate Source, External 1</b> .
5	Enable Gate View and Gate.	a. Press <b>Sweep/Control, Gate, Gate View (On)</b> . b. Press <b>Gate View Sweep Time, 10, ms</b> .
6	Set the gate delay and gate length so that the gate will open during the middle third of the pulse.	a. Press <b>Sweep/Control, Gate, Gate Delay, 1.33, ms</b> . b. Press <b>Gate Length, 1.33, ms</b> . c. Press <b>More, Control (Edge)</b> . See <a href="#">Figure 8-1</a> below. For this example, this would result in a Gate Delay of approximately 1.33 ms and a Gate Length of approximately 1.33 ms. Also, check that the gate trigger is set to edge.

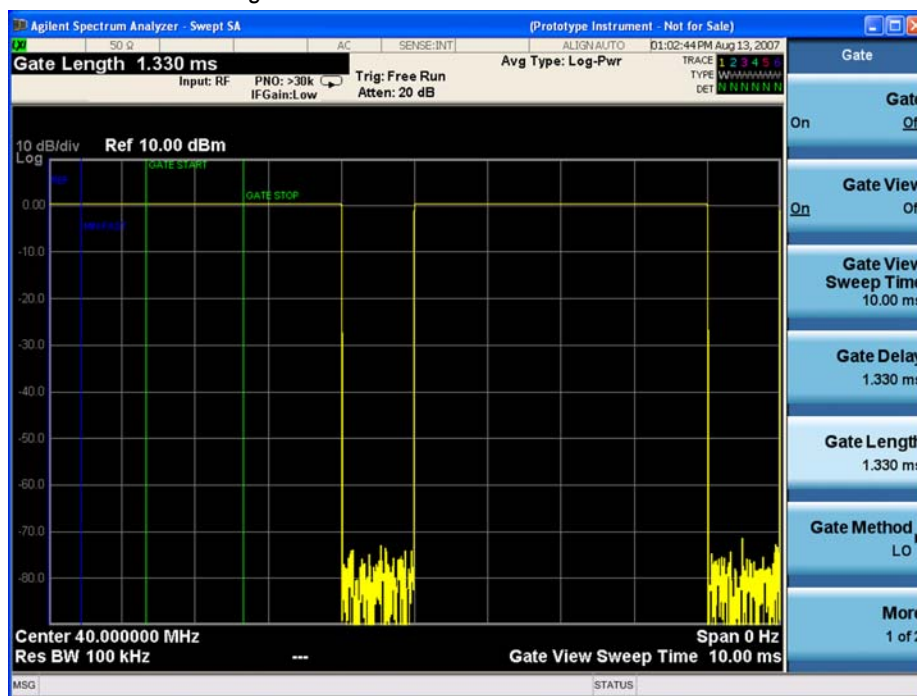
Figure 8-1 Gated RF Signal





Step	Action	Notes
7	Set the RBW to auto, gate view to off, gate method to LO, and gate to on. <ol style="list-style-type: none"> <li>Press <b>Sweep/Control, Gate, Gate View (Off)</b>.</li> <li>Press <b>BW, Res BW (Auto)</b>.</li> <li>Press <b>Sweep/Control, Gate, Gate Method, LO</b>.</li> <li>Press <b>Gate (On)</b>.</li> </ol>	

**Figure 8-2** *Gated RF Signal with Auto RBW*



## Digitizing oscilloscope setup

If you are using a digitizing oscilloscope, set up the oscilloscope to view the trigger, gate and RF signals (see [Figure 8-3](#) for an example of the oscilloscope display):

Table 8-4

### Keysight Infiniium Oscilloscope with 3 or more input channels: Instrument Connections

Timebase	1 ms/div
Channel 1	ON, 2 V/div, OFFSET = 2 V, DC coupled, 1 M $\Omega$ input, connect to the pulse signal (ESG LF OUTPUT or pulse generator OUTPUT). Adjust channel 1 settings as necessary.

## Making Time-Gated Measurements

### Generating a Pulsed-RF FM Signal

Table 8-4

*Keysight Infiniium Oscilloscope with 3 or more input channels: Instrument Connections*

Channel 2	ON, 500 mV/div, OFFSET = 2 V, DC coupled, 1 M $\Omega$ input, connect to the signal analyzer TRIGGER 2 OUT connector. Adjust channel 2 settings as needed when gate is active.
Channel 3	ON, 500 mV/div, OFFSET = 0 V, Timebase = 20 ns/div, DC coupled, 50 $\Omega$ input, connect to the ESG RF OUTPUT pulsed-RF signal. Adjust channel 3 settings as necessary.
Channel 4	OFF
Trigger	Edge, channel 1, level = 1.5 V, or as needed

Figure 8-3

*Viewing the Gate Timing with an Oscilloscope*

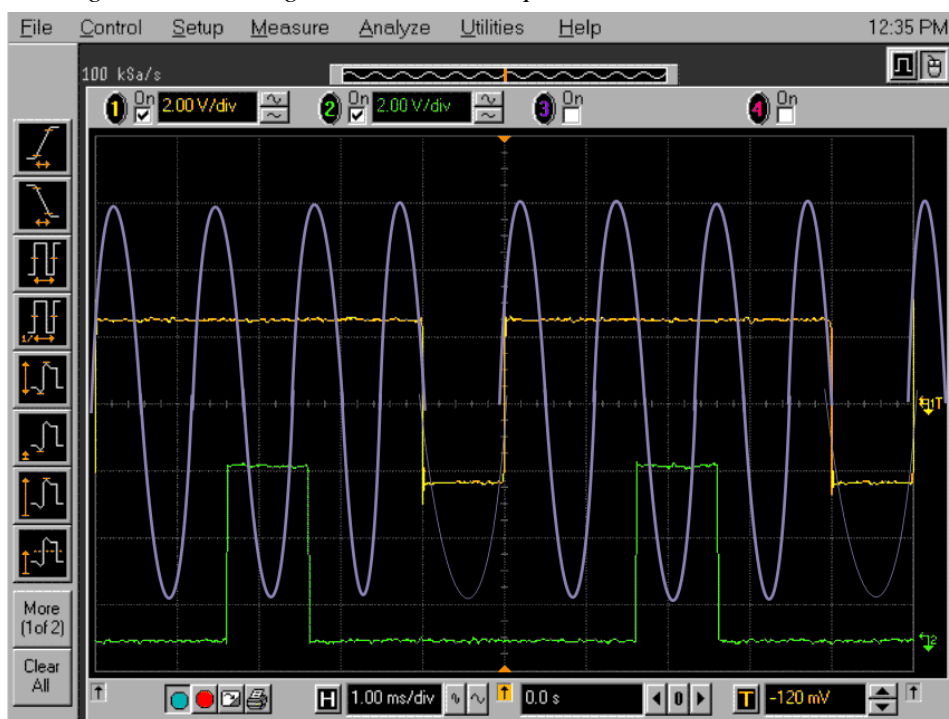


Figure 8-3 oscilloscope channels:

1. Channel 1 (yellow trace) - the trigger signal.
2. Channel 2 (green trace) - the gate signal (gate signal is not active until the gate is on in the spectrum analyzer).
3. Channel 3 (purple) - the RF output of the signal generator.

## Connecting the Instruments to Make Time-Gated Measurements

Figure 8-4 shows a diagram of the test setup. ESG #1 produces a pulsed FM signal by using an external pulse signal. The external pulse signal is connected to the front of the ESG #1 to the EXT 2 INPUT to control the pulsing. The pulse signal is also used as the trigger signal. The oscilloscope is useful for illustrating timing interactions between the trigger signal and the gate. The Gate View feature of the X-Series signal analyzer could be used in place of the oscilloscope.

Using this measurement setup allows you to view all signal spectra on the spectrum analyzer and all timing signals on the oscilloscope. This setup is helpful when you perform gated measurements on unknown signals. If an oscilloscope is not available, begin by using the Gate View feature to set up the gate parameters and then turn Gate View Off to view the signal spectra, refer to Figure 8-5

Figure 8-4

Instrument Connection Diagram with Oscilloscope

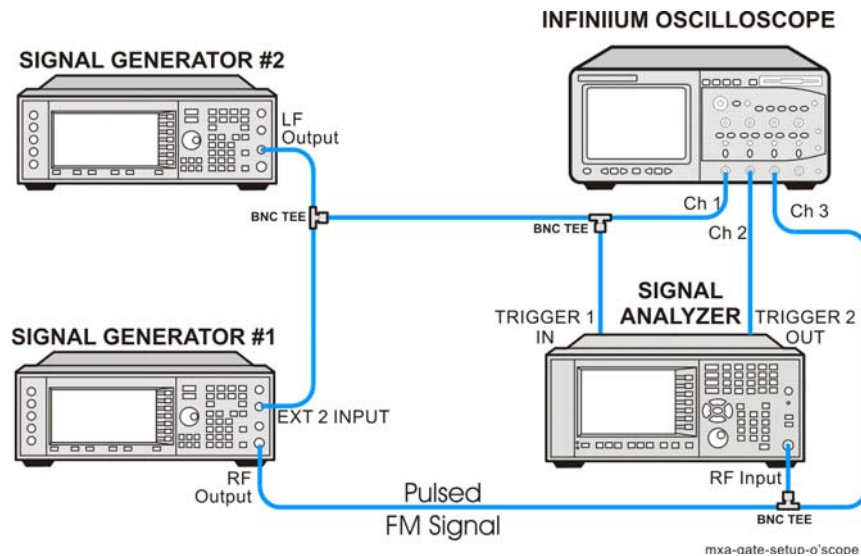
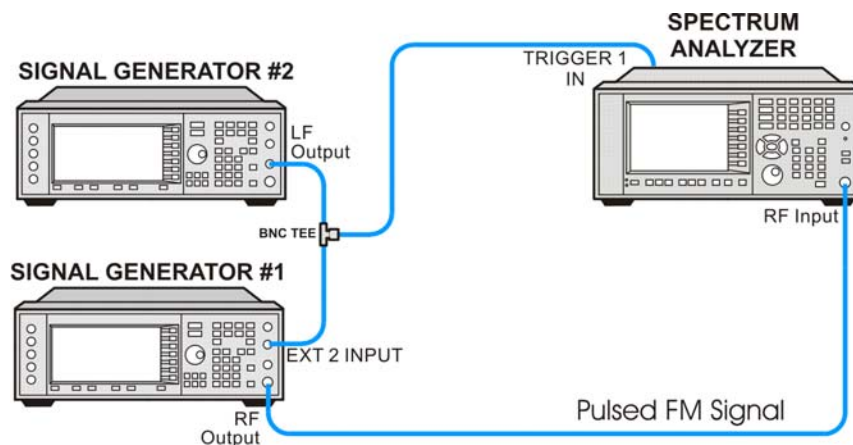


Figure 8-5

Instrument Connection Diagram without Oscilloscope



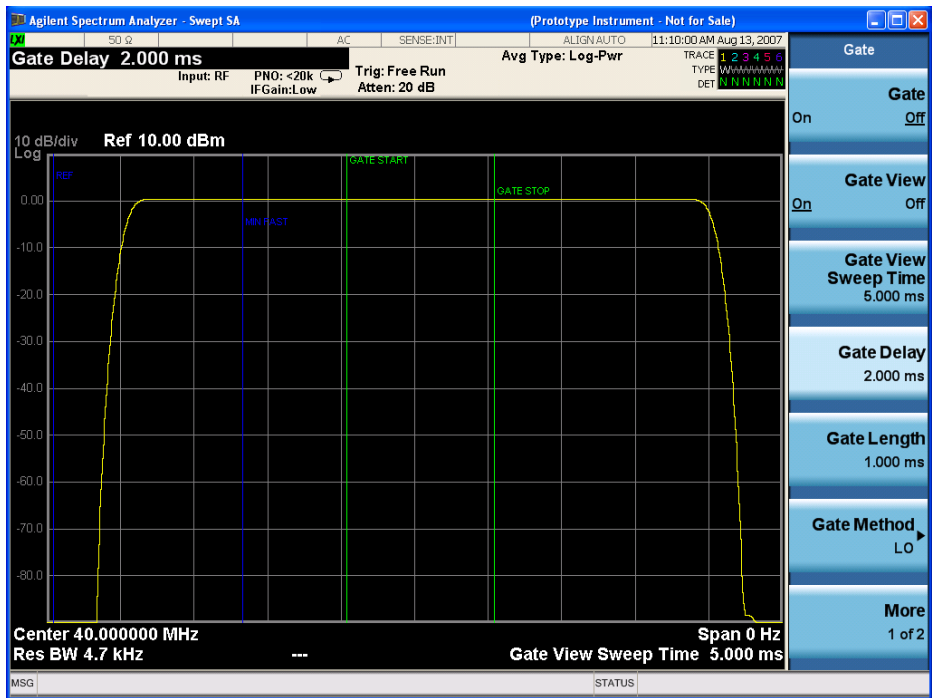
## Gated LO Measurement

This procedure utilizes gated LO to gate the FM signal. For concept and theory information about gated LO see [“How time gating works” on page 199](#).

Step	Action	Notes
1 Set the analyzer to the Spectrum Analyzer mode.	▪ Press <b>Mode, Spectrum Analyzer</b> .	This enables the spectrum analyzer measurements.
2 Preset the analyzer.	▪ Press <b>Mode Preset</b> .	
3 Set the center frequency, span, reference level and attenuation.	a. Press <b>FREQ Channel, Center Freq, 40, MHz</b> . b. Press <b>SPAN X Scale, Span, 500, kHz</b> . c. Press <b>AMPTD Y Scale, Ref Level, 10, dBm</b> .	
4 Set the gate source to the rear external trigger input.	▪ Press <b>Sweep/Control, Gate, More, Gate Source, External 1</b> .	
5 Set the gate delay, gate length, gate sweep time, and gate trigger.	a. Press <b>Sweep/Control, Gate, Gate Delay, 2, ms</b> . b. Press <b>Gate Length, 1, ms</b> . c. Press <b>Gate View Sweep Time, 5, ms</b> . d. Press <b>More1 of 2, Control (Edge)</b> .	
6 Access the analyzer gate view display.	▪ Press <b>Sweep/Control, Gate, Gate View (On)</b> .	Use this function to confirm the gate “on” time during the RF burst interval (alternatively you could also use the oscilloscope to view the gate settings).

Step	Action	Notes
------	--------	-------

Figure 8-6 Viewing the Gate Settings with Gated LO



The blue vertical line (the far left line outside of the RF envelope) represents the location equivalent to a zero gate delay.

The vertical green parallel bars represent the gate settings. The first (left) bar (GATE START) is set at the delay time while the second (right) bar (GATE STOP) is set at the gate length, measured from the first bar. The trace of the signal in this time-domain view is the RF envelope. The gate signal is triggered off of the positive edge of the trigger signal.

When positioning the gate, a good starting point is to have it extend from 20% to 80% of the way through the pulse.

While gate view mode is on, move the gate delay, length and polarity around. Notice the changes in the vertical gate bars while making your changes. Set the gate delay, length and polarity back to the step 3 settings.

**NOTE** The analyzer time gate triggering mode uses positive edge, negative edge, and level triggering.

- |   |                         |  |                                  |
|---|-------------------------|--|----------------------------------|
| 7 | Turn the gate view off. | • Press <b>Sweep/Control</b> ,<br><b>Gate</b> , <b>Gate View (Off)</b> . | See <a href="#">Figure 8-7</a> . |
|---|-------------------------|--|----------------------------------|

## Making Time-Gated Measurements

### Gated LO Measurement

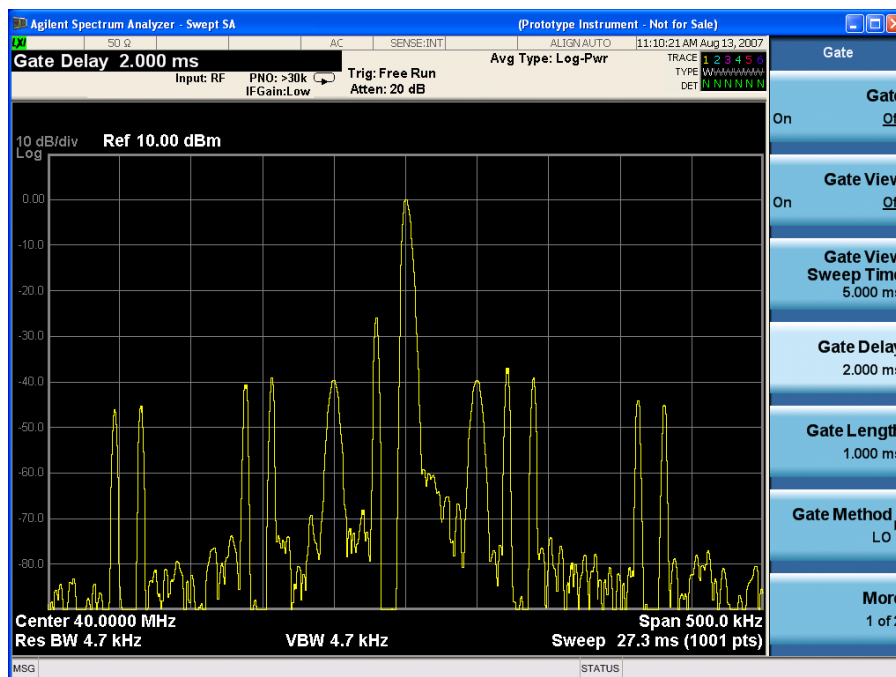
Step

Action

Notes

Figure 8-7

Pulsed RF FM Signal



The moving signals are a result of the pulsed signal. Using delta markers with a time readout, notice that the period of the spikes is at 5 ms (the same period as the pulse signal). Using time gating, these signals will be blocked out, leaving the original FM signal.

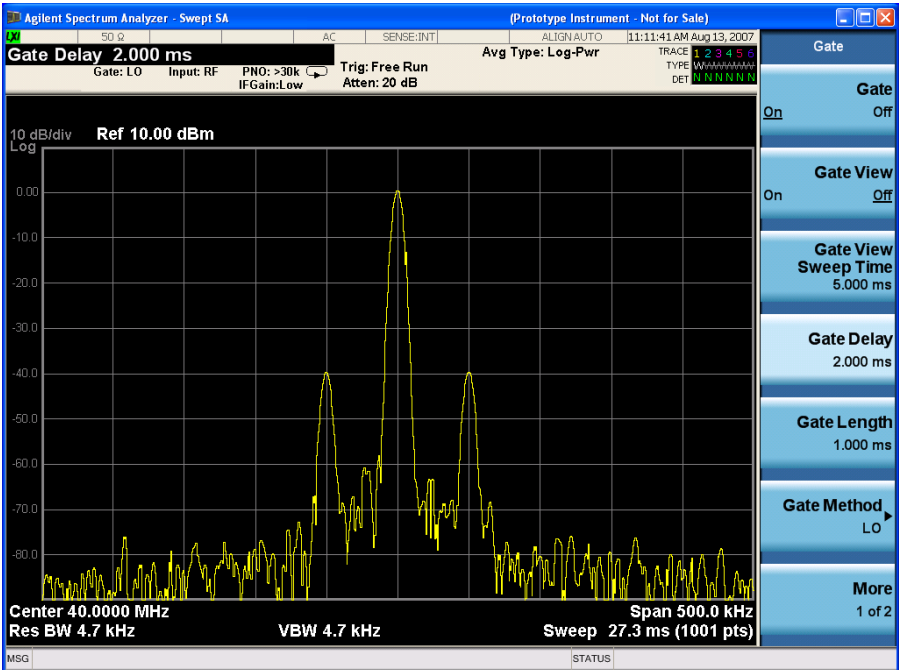
8 Enable the gate settings.

▪ Press **Gate (On)**.

See [Figure 8-8](#).

Step	Action	Notes
------	--------	-------

Figure 8-8 Pulsed and Gated Signal



- |   |  |   |
|---|--|---|
| <p>9 Turn off the pulse modulation on ESG #1.</p> | <ul style="list-style-type: none"><li>Press <b>Pulse, Pulse</b> so that Off is selected.</li></ul> | <p>Notice that the gated spectrum is much cleaner than the ungated spectrum (as seen in the <b>Pulsed-RF FM Signal</b> above). The spectrum you see with the gate on is the same as a frequency modulated signal without being pulsed. The displayed spectrum does not change and in both cases, you can see the two low-level modulation sidebands caused by the narrow-band FM.</p> |
|---|--|---|

## Gated Video Measurement

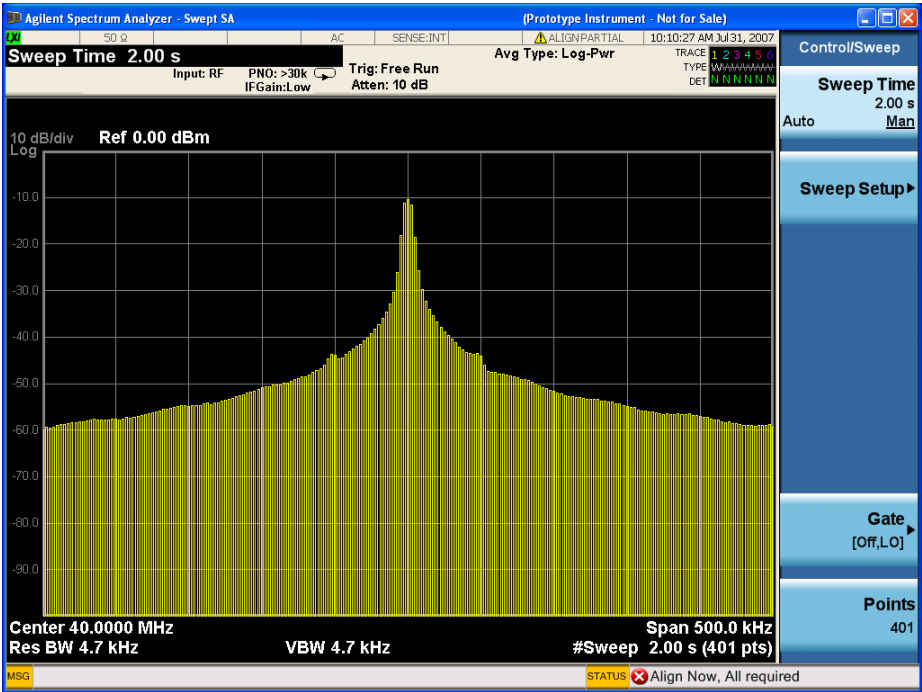
This procedure utilizes gated video to gate the FM signal. For concept and theory information about gated video see [“How time gating works” on page 199](#).

Step	Action	Notes
1 Set the analyzer to the Spectrum Analyzer mode.	<ul style="list-style-type: none"> <li>Press <b>Mode, Spectrum Analyzer</b>.</li> </ul>	This enables the spectrum analyzer measurements.
2 Preset the analyzer	<ul style="list-style-type: none"> <li>Press <b>Mode Preset</b>.</li> </ul>	
3 Set the center frequency, span, reference level and attenuation.	<ul style="list-style-type: none"> <li>a. Press <b>FREQ Channel, Center Freq, 40, MHz</b>.</li> <li>b. Press <b>SPAN X Scale, Span, 500, kHz</b>.</li> <li>c. Press <b>AMPTD Y Scale, Ref Level, 10, dBm</b>.</li> </ul>	
4 Set analyzer points to 401 and sweep time to 2000 ms.	<ul style="list-style-type: none"> <li>a. Press <b>Sweep/Control, Points, 401, Enter</b>.</li> <li>c. Press <b>Sweep Time, 2000, ms</b>.</li> </ul>	<p>For gated video, the calculated sweep time should be set to at least</p> $(\# \text{ sweep points} - 1) \times PRI (\text{pulse repetition interval})$ <p>to ensure that the gate is on at least once during each of the 401 sweep points. In this example, the PRI is 5 ms, so you should set the sweep time to 401 minus 1 times 5 ms, or 2 s. If the sweep time is set too fast, some trace points may show values of zero power or other incorrect low readings. If the trace seems incomplete or erratic, try a longer sweep time.</p>
<b>NOTE</b>	<p><b>Good practices for determining the minimum sweep time for gated video:</b></p> <p>In the event that the signal is not noisy, the sweep time can be set to less than <math>(\# \text{ sweep points} - 1) \times PRI (\text{pulse repetition interval})</math> (as calculated above). Instead of using PRI in the previous sweep time calculation, we can use the “gate off time” where sweep time equals <math>(\# \text{ sweep points} - 1) \times \text{gate off time}</math>. (Gate off time is defined as <math>PRI - GL</math>, where <math>GL = \text{Gate Length}</math>.) In our example we could use a sweep time of 400 points times 1 ms or 400 ms – <math>(401 - 1) \times (5\text{ms} - 4\text{ms}) = 400\text{ms}</math>. Increase the video band width to improve the probability of capturing the pulse using “gate off time”. If trace points are still showing values of zero power, increase the sweep time by small increments until there are no more dropouts.</p>	
5 Set the Gate source to the external trigger input on the rear panel:	<ul style="list-style-type: none"> <li>Press <b>Sweep/Control, Gate, More, Gate Source, External 1</b>.</li> </ul>	



Step	Action	Notes
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Figure 8-9 Viewing a Pulsed RF FM Signal (without gating)



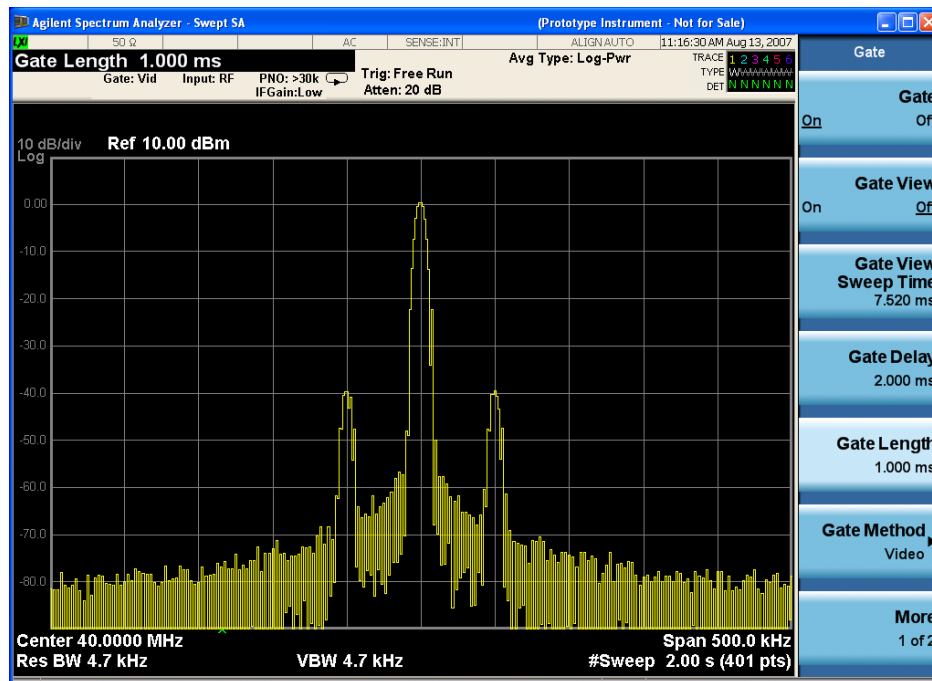
- |   |                                     |   |  |
|---|-------------------------------------|---|--|
| 6 | Set the gate delay and gate length. | <ul style="list-style-type: none"><li>a. Press <b>Sweep/Control, Gate, More, Control (Edge)</b>.</li><li>b. Press <b>More, Gate Delay, 2, ms</b>.</li><li>c. Press <b>Gate Length, 1, ms</b>.</li></ul> | Ensure that the gate control is set to Edge. |
| 7 | Turn the gate on.                   | <ul style="list-style-type: none"><li>a. Press <b>Sweep/Control, Gate, Gate Method, Video</b>.</li><li>b. Press <b>Gate (On)</b>.</li></ul>   |  |

## Making Time-Gated Measurements

### Gated Video Measurement

Step	Action	Notes
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Figure 8-10 Viewing the FR Signal of a Pulsed RF Signal using Gated Video

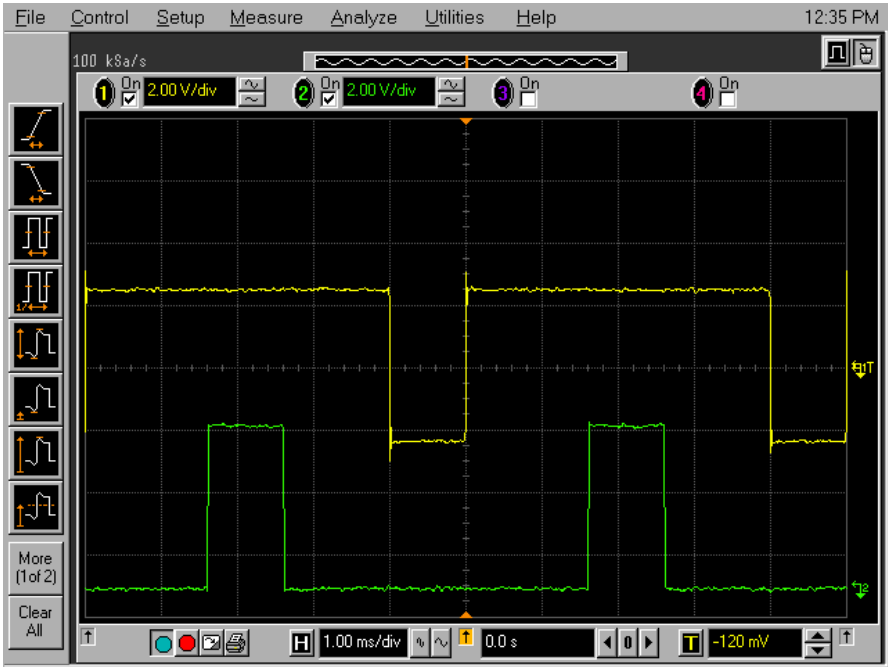


Notice that the gated spectrum is much cleaner than the ungated spectrum (as seen in Figure 8-9). The spectrum you see is the same as a frequency modulated signal without being pulsed. To prove this, turn off the pulse modulation on ESG #1 by pressing **Pulse, Pulse** so that Off is selected. The displayed spectrum does not change.

If you have used an oscilloscope, check the oscilloscope display and ensure that the gate is positioned under the pulse. The gate should be set so that it is on somewhere between 20% to 80% of the pulse. If necessary, adjust gate length and gate delay. Figure 8-11 shows the oscilloscope display when the gate is positioned correctly (the bottom trace).

Step	Action	Notes
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Figure 8-11      The Oscilloscope Display

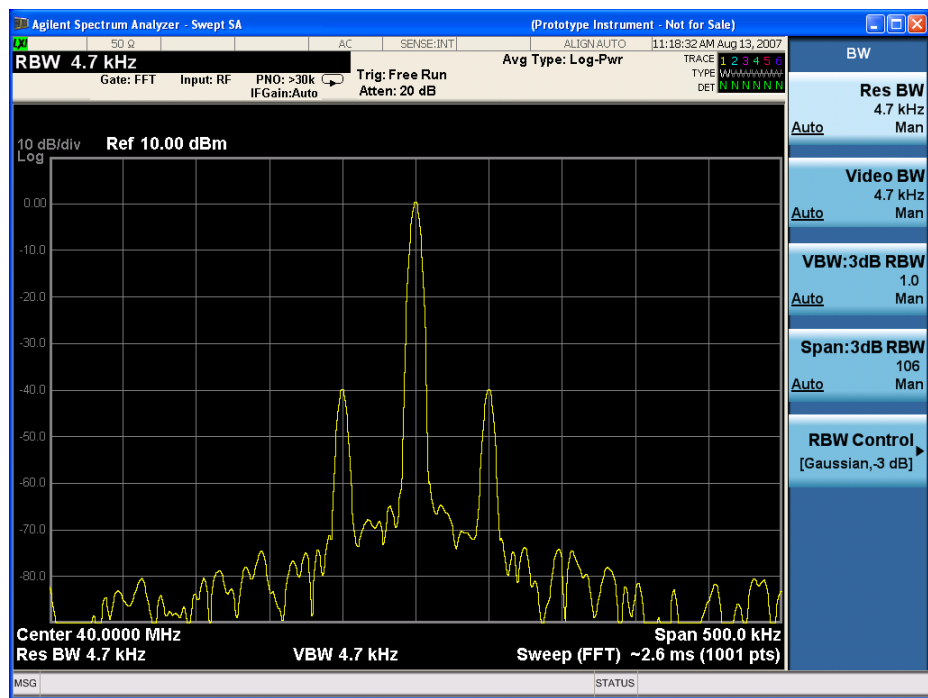


## Gated FFT Measurement

This procedure utilizes gated FFT to gate the FM signal. For concept and theory information about gated FFT see [“How time gating works” on page 199](#).

Step	Action	Notes
<b>1</b> Set the analyzer to the Spectrum Analyzer mode.	▪ Press <b>Mode, Spectrum Analyzer</b> .	This enables the spectrum analyzer measurements.
<b>2</b> Preset the analyzer	▪ Press <b>Mode Preset</b> .	
<b>3</b> Set the center frequency, span, reference level and attenuation.	a. Press <b>FREQ Channel, Center Freq, 40, MHz</b> . b. Press <b>SPAN X Scale, Span, 500, kHz</b> . c. Press <b>AMPTD Y Scale, Ref Level, 10, dBm</b> .	
<b>4</b> Set the Gate source to the external trigger input on the rear panel.	▪ Press <b>Sweep/Control, Gate, More, Gate Source, External 1</b> .	
<b>5</b> Set the gate method and turn gate on.	a. Press <b>Sweep/Control, Gate, Gate Method, FFT</b> . b. Press <b>Gate (On)</b> .	
<b>6</b> Select the minimum resolution bandwidth required.	▪ Press <b>BW, Res BW (Auto)</b> .	See <a href="#">Figure 8-12</a> .

Step	Action	Notes
Figure 8-12	Viewing the Gated FFT Measurement results	



The duration of the analysis required is determined by the RBW. Divide 1.83 by 4 ms to calculate the minimum RBW. The pulse width in our case is 4 ms so we need a minimum RBW of 458 Hz. In this case because the RBW is so narrow let the analyzer choose the RBW for the current analyzer settings (span). Check that the RBW is greater than 458 Hz. Vary the RBW settings and note the signal changes shape as the RBW transitions from 1 kHz to 300 Hz.

**NOTE** If the trigger event needs to be delayed use the **Trig Delay** function under the **Trigger** menu. Apply some small amount of trigger delay to allow time for the device under test to settle.

Making Time-Gated Measurements  
Gated FFT Measurement

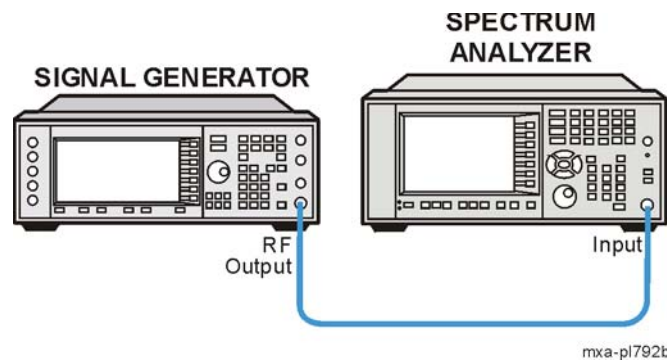
## 9 Measuring Digital Communications Signals

The Signal Analyzer makes power measurements on digital communication signals fast and repeatable by providing a comprehensive suite of power-based one-button automated measurements with pre-set standards-based format setups. The automated measurements also include pass/fail functionality that allow the user to quickly check if the signal passed the measurement.

Channel Power Measurements

This section explains how to make a channel power measurement on a W-CDMA (3GPP) mobile station. (A signal generator is used to simulate a base station.) This test measures the total RF power present in the channel. The results are displayed graphically as well as in total power (dB) and power spectral density (dBm/Hz).

Step	Action	Notes
1	Set up the signal generator. <div>a. Set the mode to W-CDMA. b. Set the frequency to 1.920 GHz. c. Set the amplitude to -20 dBm.</div>	
2	Connect the source RF OUTPUT to the analyzer RF INPUT as shown.	



3	Select the mode.	▪ Press <b>Mode, Spectrum Analyzer</b> .	
4	Preset the analyzer.	▪ Press <b>Mode Preset</b> .	
5	Set the radio standard and toggle the device to mobile station.	▪ Press <b>Mode Setup, Radio Std, 3GPP W-CDMA, 3GPP W-CDMA, Device (MS)</b> .	
6	Set the center frequency.	▪ Press <b>FREQ Channel, 1.920, GHz</b> .	
7	Initiate the channel power measurement.	▪ Press <b>Meas, Channel Power</b> .	The Channel Power measurement result should look like “Channel Power Measurement Result.” on page 113.



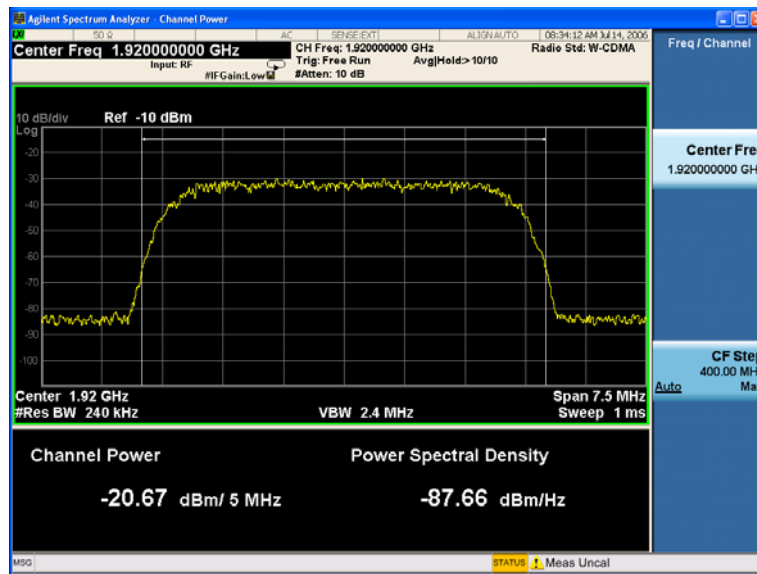
Step

Action

Notes

Figure 9-1

Channel Power Measurement Result.



The graph window and the text window showing the absolute power and its mean power spectral density values over 5 MHz are displayed.

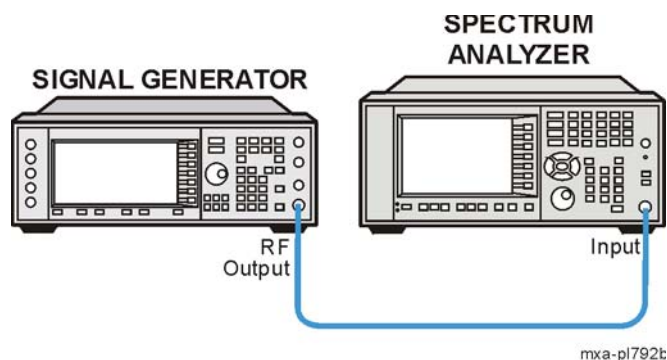
To change the measurement parameters from their default condition:

Press **Meas Setup**.

## Occupied Bandwidth Measurements

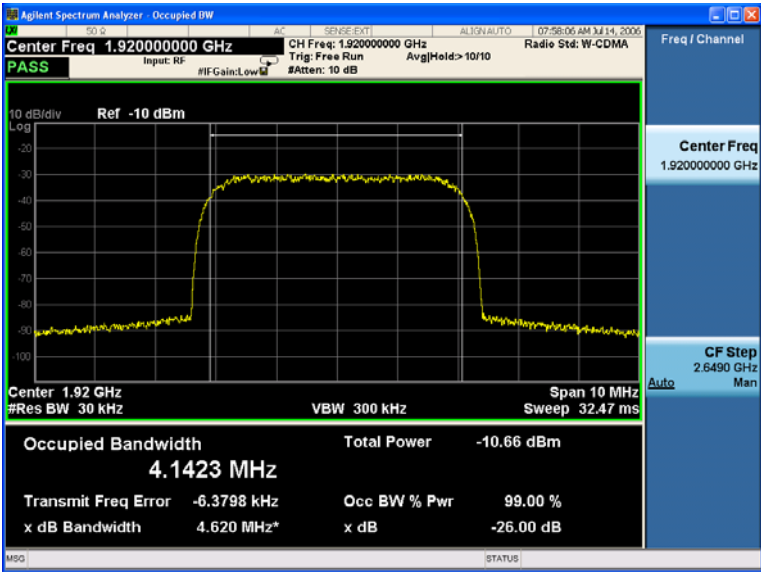
This section explains how to make the occupied bandwidth measurement on a W-CDMA (3GPP) mobile station. (A signal generator is used to simulate a base station.) The instrument measures power across the band, and then calculates its 99.0% power bandwidth.

Step	Action	Notes
1	Set up the signal generator. <ol style="list-style-type: none"> <li>Set the mode to W-CDMA.</li> <li>Set the frequency to 1.920 GHz.</li> <li>Set the amplitude to -20 dBm.</li> </ol>	
2	Connect the source RF OUTPUT to the analyzer RF INPUT as shown.	



3	Select the mode.	<ul style="list-style-type: none"> <li>Press <b>Mode, Spectrum Analyzer</b>.</li> </ul>	
4	Preset the analyzer.	<ul style="list-style-type: none"> <li>Press <b>Mode Preset</b>.</li> </ul>	
5	Set the radio standard and toggle the device to mobile station.	<ul style="list-style-type: none"> <li>Press <b>Mode Setup, Radio Std, 3GPP W-CDMA, 3GPP W-CDMA, Device (MS)</b>.</li> </ul>	
6	Set the center frequency.	<ul style="list-style-type: none"> <li>Press <b>FREQ Channel, 1.920, GHz</b>.</li> </ul>	
7	Initiate the occupied bandwidth measurement.	<ul style="list-style-type: none"> <li>Press <b>Meas, Occupied BW</b>.</li> </ul>	The Occupied BW measurement result should look like "Occupied BW Measurement Result" on page 115.

Step	Action	Notes
Figure 9-2	Occupied BW Measurement Result	



Troubleshooting hints

Any distortion such as harmonics or intermodulation, for example, produces undesirable power outside the specified bandwidth.

Shoulders on either side of the spectrum shape indicate spectral regrowth and intermodulation. Rounding or sloping of the top shape can indicate filter shape problems.

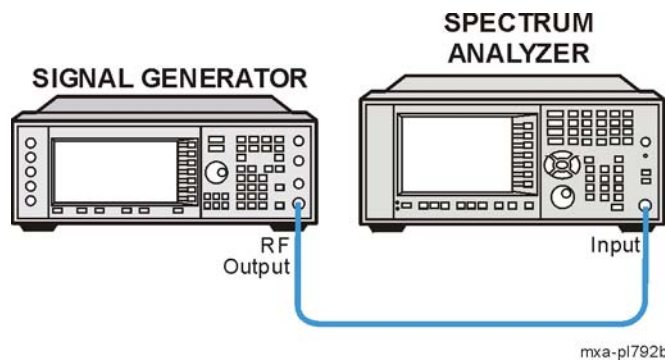
## Making Adjacent Channel Power (ACP) Measurements

The adjacent channel power (ACP) measurement is also referred to as the adjacent channel power ratio (ACPR) and adjacent channel leakage ratio (ACLR). We use the term ACP to refer to this measurement.

ACP measures the total power (rms voltage) in the specified channel and up to six pairs of offset frequencies. The measurement result reports the ratios of the offset powers to the main channel power.

The following example shows how to make an ACP measurement on a W-CDMA base station signal broadcasting at 1.96 GHz. (A signal generator is used to simulate a base station.)

Step	Action	Notes
1 Set up the signal generator.	a. Set the mode to W-CDMA. b. Set the frequency to 1.920 GHz. c. Set the amplitude to -10 dBm.	
2 Connect the source RF OUTPUT to the analyzer RF INPUT as shown.		



3 Select the mode.	▪ Press <b>Mode, Spectrum Analyzer.</b>
4 Preset the analyzer.	▪ Press <b>Mode Preset.</b>
5 Set the analyzer radio mode to W-CDMA as a base station device.	a. Press <b>Mode Setup, Radio Std, 3GPP W-CDMA, 3GPP W-CDMA,</b> b. Press <b>Mode Setup, Radio Std Setup, Device (BTS).</b>

Step	Action	Notes
6 Set the center frequency.	▪ Press <b>FREQ Channel, 1.920, GHz.</b>	
7 Initiate the adjacent channel power measurement.	▪ Press <b>Meas, ACP.</b>	The Occupied BW measurement result should look like the following graphic.
8 Optimize the attenuation setting.	▪ Press <b>AMPTD, Attenuation, Adjust Atten for Min Clip.</b>	Adjust Atten for Min Clip protects against input signal overloads, but does not necessarily set the input attenuation and reference level for optimum measurement dynamic range.  To improve the measurement repeatability, increase the sweep time to smooth out the trace (average detector must be selected). Measurement repeatability can be traded off with sweep time.
9 To increase dynamic range, <b>Noise Correction</b> can be used to factor out the added power of the noise floor effects.	▪ Press <b>Meas Setup, More, More, Noise Correction (On).</b>	

# Measuring Digital Communications Signals

## Making Adjacent Channel Power (ACP) Measurements

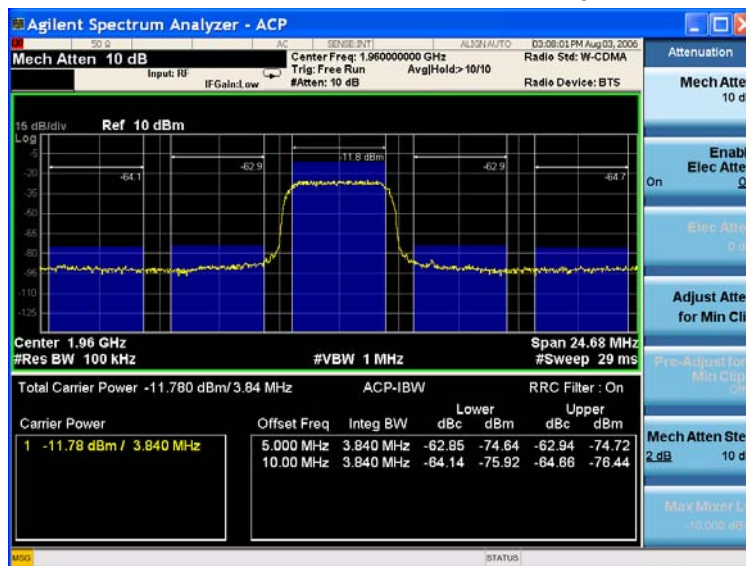
Step

Action

Notes

Figure 9-3

ACP Measurement on a Base Station W-CDMA Signal



Two vertical white lines, in the center of the screen, indicate the band width limits of the central channel being measured.

The frequency offsets, channel integration band widths, and span settings can all be modified from the default settings.

Offsets A and B are designated by the adjacent pairs of white lines, in this case: 5 MHz and 10 MHz from the center frequency respectively.

**10** View the results using the full screen.

▪ Press **Full Screen**.

Press the **Full Screen** key again to exit the full screen display without changing any parameter values.

**11** Define a new third pair of offset frequencies.

▪ Press **Meas Setup**, **Offset/Limits**, **Offset**, **C**, **Offset Freq (On)**, **15**, **MHz**.

This third pair of offset frequencies is offset by 15.0 MHz from the center frequency (the outside offset pair) as shown in Figure 9-4. Three further pairs of offset frequencies (D, E and F) are also available.

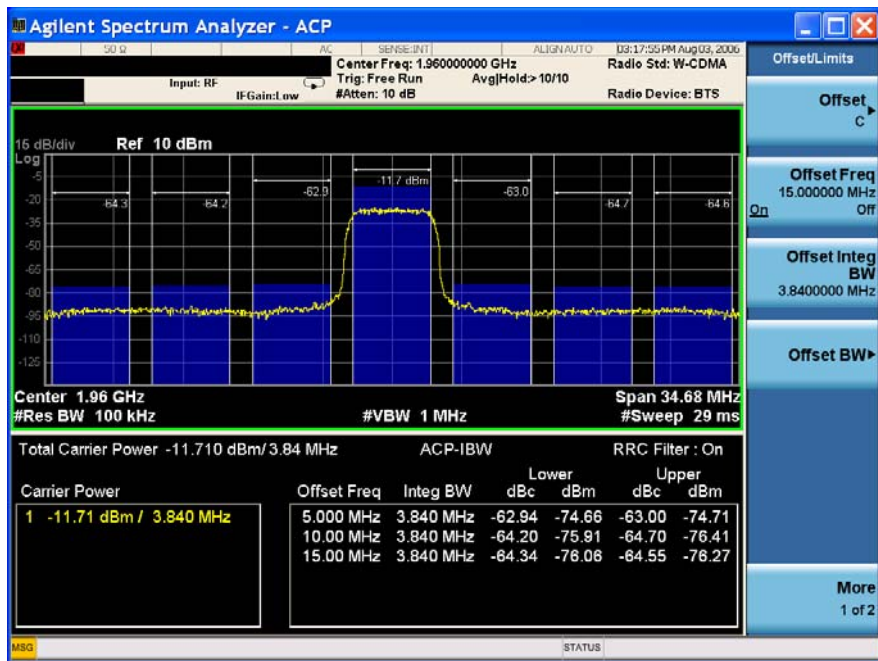
Step

Action

Notes

Figure 9-4

Measuring a Third Adjacent Channel



12 Set pass/fail limits for each offset.

- Press Meas Setup, Offset/Limits, Offset, A, More, Rel Limit (Car), -55, dB, Offset, B, Rel Limit (Car), -75, dB, Offset, C, Rel Limit (Car), -60, dB.

13 Turn the limit test on.

- Press Meas Setup, More, Limit Test (On).

In Figure 9-5 notice that offsets A and C have passed, however offset B has failed. Power levels that fall above our specified -75 dB for offset B, fail. The offset bar graph and the associated power level value are shaded red to identify a failure. The offset limits are shown as dashed lines.

# Measuring Digital Communications Signals Making Adjacent Channel Power (ACP) Measurements

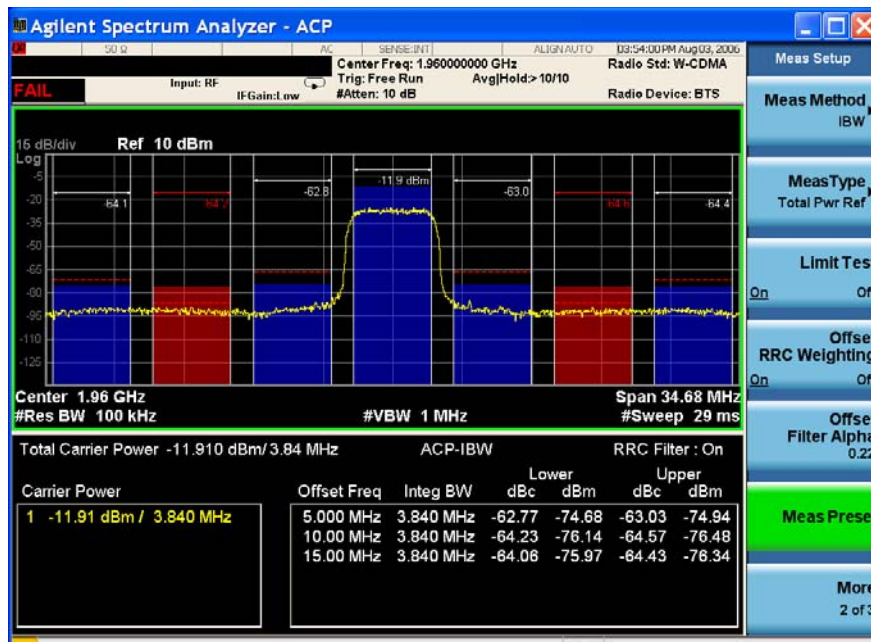
Step

Action

Notes

Figure 9-5

Setting Offset Limits



**NOTE** You may increase the repeatability by increasing the sweep time.



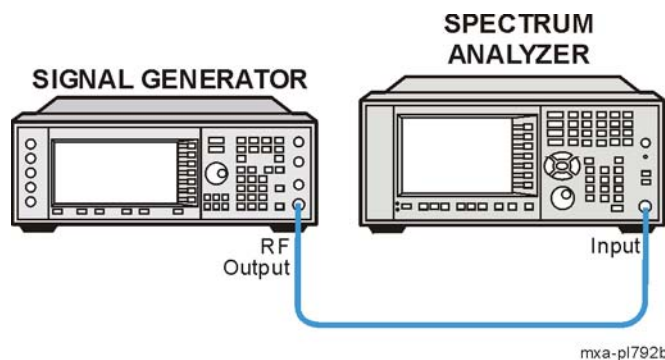
## Making Statistical Power Measurements (CCDF)

Complementary cumulative distribution function (CCDF) curves characterize a signal by providing information about how much time the signal spends at or above a given power level. The CCDF measurement shows the percentage of time a signal spends at a particular power level. Percentage is on the vertical axis and power (in dB) is on the horizontal axis.

All CDMA signals, and W-CDMA signals in particular, are characterized by high power peaks that occur infrequently. It is important that these peaks are preserved otherwise separate data channels can not be received properly. Too many peak signals can also cause spectral regrowth. If a CDMA system works well most of the time and only fails occasionally, this can often be caused by compression of the higher peak signals.

The following example shows how to make a CCDF measurement on a W-CDMA signal broadcasting at 1.96 GHz. (A signal generator is used to simulate a base station.)

Step	Action	Notes
1 Set up the signal generator.	a. Setup a W-CDMA down link signal. b. Set the frequency to 1.96 GHz. c. Set the amplitude to -10 dBm.	
2 Connect the source RF OUTPUT to the analyzer RF INPUT as shown.		



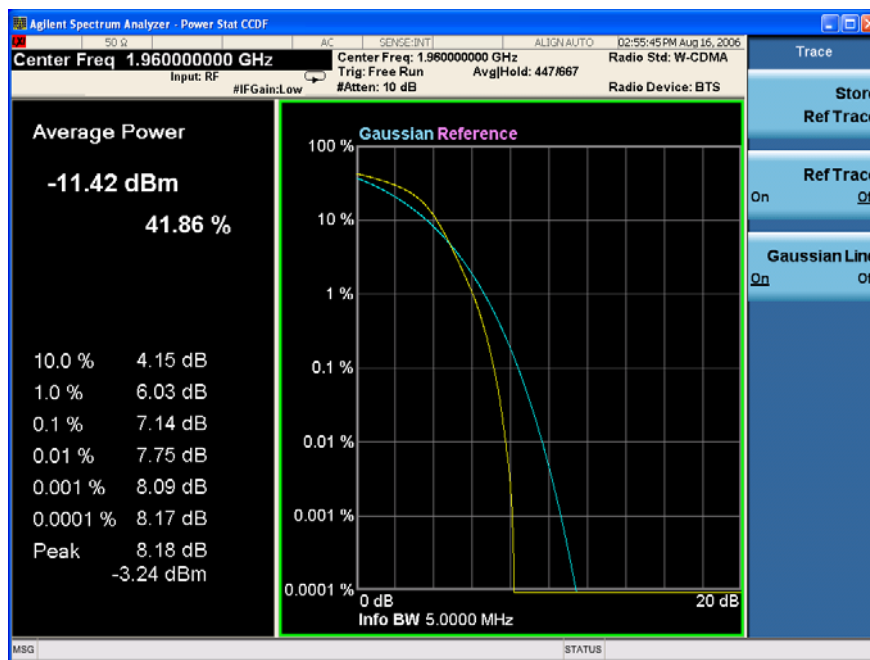
3 Select the mode.	<ul style="list-style-type: none"> <li>Press <b>Mode, Spectrum Analyzer</b>.</li> </ul>
4 Preset the analyzer.	<ul style="list-style-type: none"> <li>Press <b>Mode Preset</b>.</li> </ul>

# Measuring Digital Communications Signals

## Making Statistical Power Measurements (CCDF)

Step	Action	Notes
5	Set the analyzer radio mode to W-CDMA as a base station device.	<ul style="list-style-type: none"> <li>Press <b>Mode Setup, Radio Std, 3GPP W-CDMA, 3GPP W-CDMA, Device (BTS).</b></li> </ul>
6	Set the center frequency.	<ul style="list-style-type: none"> <li>Press <b>FREQ Channel, 1.98, GHz</b></li> </ul>
7	Select the CCDF measurement and optimize the attenuation level and attenuation settings suitable for the CCDF measurement.	<ul style="list-style-type: none"> <li>a. Press <b>Meas, Power Stat CCDF.</b></li> <li>b. Press <b>AMPTD, Attenuation, Adjust Atten for Min Clip.</b></li> </ul>

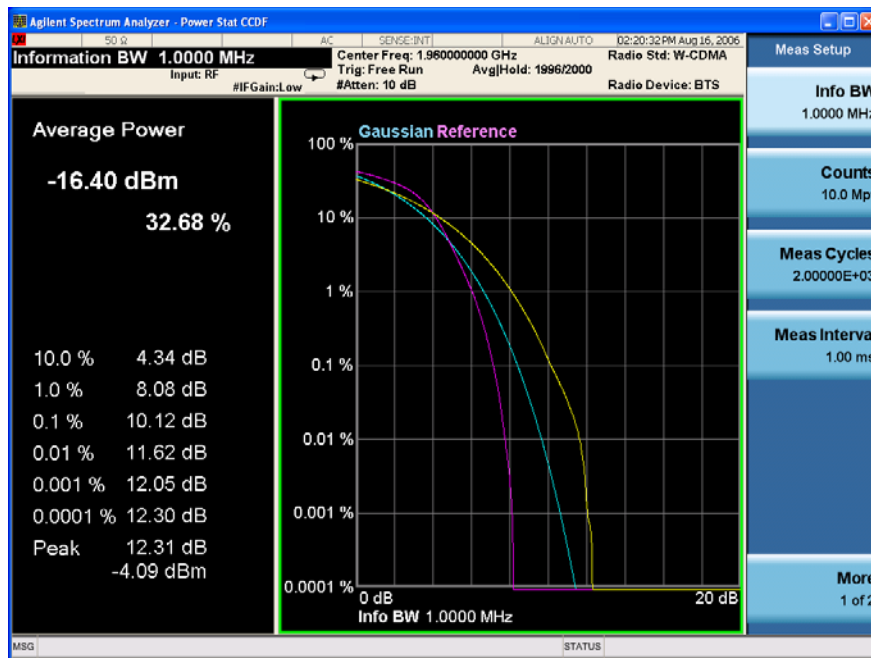
Figure 9-6 Power Statistics CCDF Measurement on a W-CDMA Signal



8	Store your current measurement trace for future reference.	<ul style="list-style-type: none"> <li>Press <b>Trace/Detector, Store Ref Trace.</b></li> </ul>	<p>When the power stat CCDF measurement is first made, the graphical display should show a signal typical of pure noise. This is labeled Gaussian, and is shown in aqua. Your CCDF measurement is displayed as a yellow plot. You have stored this measurement plot to make for easy comparison with subsequent measurements. Refer to <a href="#">Figure 9-6</a>.</p>
---	--	---	--

Step	Action	Notes
9 Display the stored trace.	<ul style="list-style-type: none"> <li>Press <b>Trace/Detector, Ref Trace (On)</b>.</li> </ul>	Press the <b>Full Screen</b> key again to exit the full screen display without changing any parameter values.
10 Change the measurement bandwidth to 1 MHz.	<ul style="list-style-type: none"> <li>Press <b>BW, Info BW, 1, MHz</b>.</li> </ul>	The stored trace from your last measurement is displayed as a magenta plot (as shown in Figure 9-7), and allows direct comparison with your current measurement (yellow trace).

Figure 9-7 Storing and Displaying a Power Stat CCDF Measurement



**NOTE** If you choose a measurement band width setting that the analyzer cannot display, it automatically sets itself to the closest available band width setting.

11 Change the number of measured points from 10,000,000 (10.0Mpt) to 1,000 (1kpt).	<ul style="list-style-type: none"> <li>Press <b>Meas Setup, Counts, 1, kpt</b>.</li> </ul>	Reducing the number of points decreases the measurement time, however the number of points is a factor in determining measurement uncertainty and repeatability. Notice how the displayed plot loses a lot of its smoothness. You are gaining speed but reducing repeatability and increasing measurement uncertainty. refer to Figure 9-8.
--	--	---

## Measuring Digital Communications Signals Making Statistical Power Measurements (CCDF)

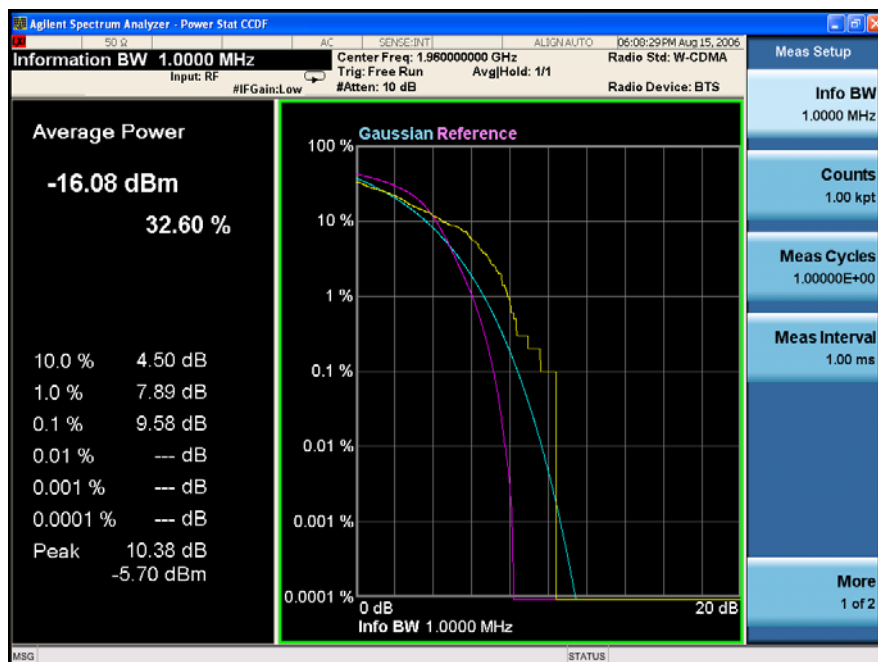
### Step

### Action

### Notes

Figure 9-8

Reducing the Measurement Points to 1 kpt



**NOTE** The number of points collected per sweep is dependent on the sampling rate and the measurement interval. The number of samples that have been processed are indicated at the top of the screen. The graphical plot is continuously updated so you can see it getting smoother as measurement uncertainty is reduced and repeatability improves.

**12** Change the scaling of the X-axis to 1 dB per division to optimize your particular measurement.

- Press **SPAN X Scale, Scale/Div, 1, dB**.

Refer to [Figure 9-9](#).

Step

Action

Notes

Figure 9-9

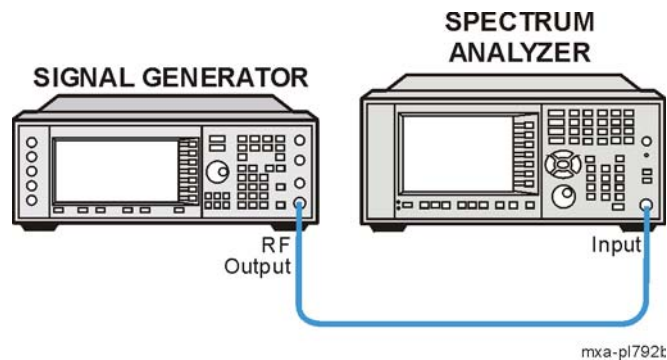
Reducing the X Scale to 1 dB



Making Burst Power Measurements

The following example demonstrates how to make a burst power measurement on a Bluetooth signal broadcasting at 2.402 GHz. (A signal generator is used to simulate a Bluetooth signal.)

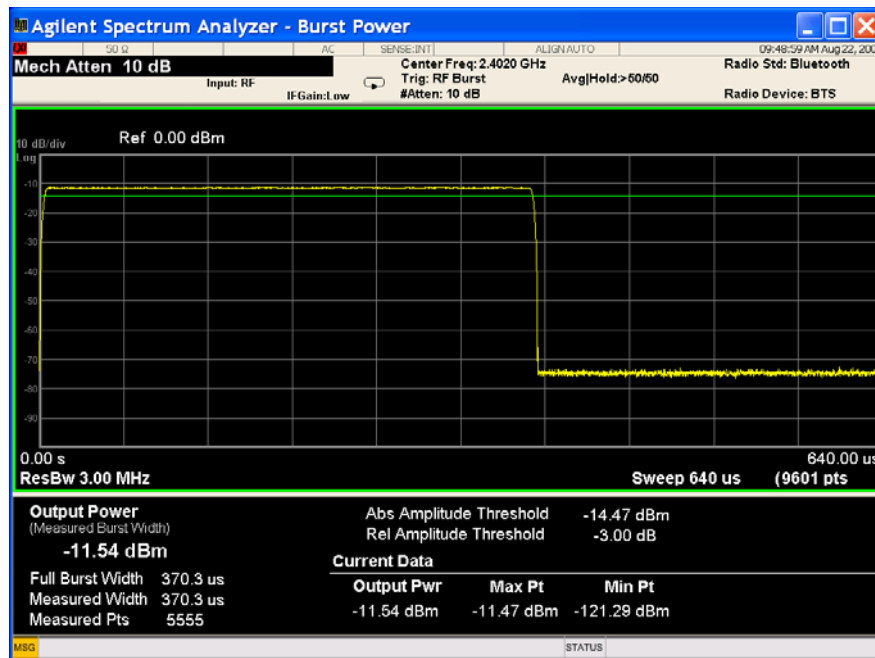
Step	Action	Notes
1	Set up the signal source. <div>a. Setup a Bluetooth signal transmitting DH1 packets. b. Set the source frequency to 2.402 GHz. c. Set the source amplitudes to -10 dBm. d. Set the source amplitudes to -10 dBm.</div>	
2	Connect the source RF OUTPUT to the analyzer RF INPUT as shown.	



3	Set the analyzer to the Spectrum Analyzer mode.	<div>▪ Press <b>Mode, Spectrum Analyzer</b>.</div>	
4	Preset the analyzer.	<div>▪ Press <b>Mode Preset</b>.</div>	
5	Set the analyzer center frequency.	<div>▪ Press <b>FREQ Channel, Center Freq, 2.402, GHz</b>.</div>	
6	Set the analyzer radio mode to Bluetooth .	<div>▪ Press <b>Mode Setup, Radio Std, More, Bluetooth, Bluetooth, DH1</b>.</div>	Check to make sure packet type DH1 is selected.

Step	Action	Notes
7	Select the burst power measurement and optimize the attenuation level.	<ul style="list-style-type: none"> <li>a. Press <b>Meas, Burst Power</b>.</li> <li>b. Press <b>AMPTD, Attenuation, Adjust Atten for Min Clip</b>.</li> </ul>
8	View the results of the burst power measurement using the full screen).	<ul style="list-style-type: none"> <li>• Press <b>Full Screen</b>.</li> </ul> <p>See <a href="#">Figure 9-10</a>.</p>

Figure 9-10 Full Screen Display of Burst Power Measurement Results



**NOTE** Press the **Full Screen** key again to exit the full screen display without changing any parameter values. Refer to [Figure 9-11](#)

## Measuring Digital Communications Signals

### Making Burst Power Measurements

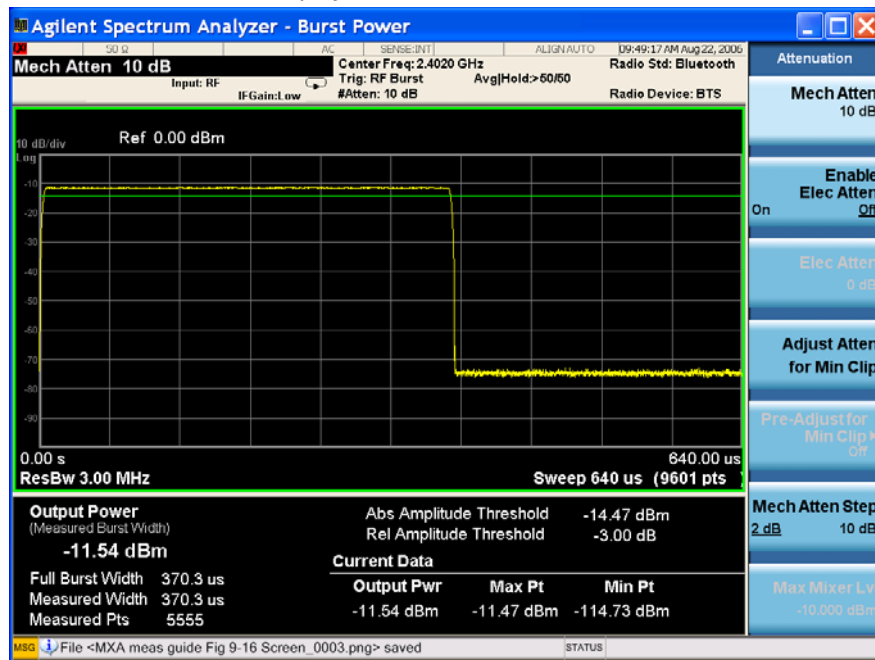
#### Step

#### Action

#### Notes

Figure 9-11

Normal Screen Display of Burst Power Measurement Results



- 9 Select one of the following three trigger methods to capture the bursted signal:
- Periodic Timer Triggering
  - Video
  - RF Burst Wideband Triggering (RF burst is recommended, if available).

- Press **Trigger, RF Burst**.

For more information on trigger selections see [“Trigger Concepts” on page 194](#).

Although the trigger level allows the analyzer to detect the presence of a burst, the time samples contributing to the burst power measurement are determined by the threshold level, as described next.

- 10 Set the relative threshold level above which the burst power measurement is calculated.

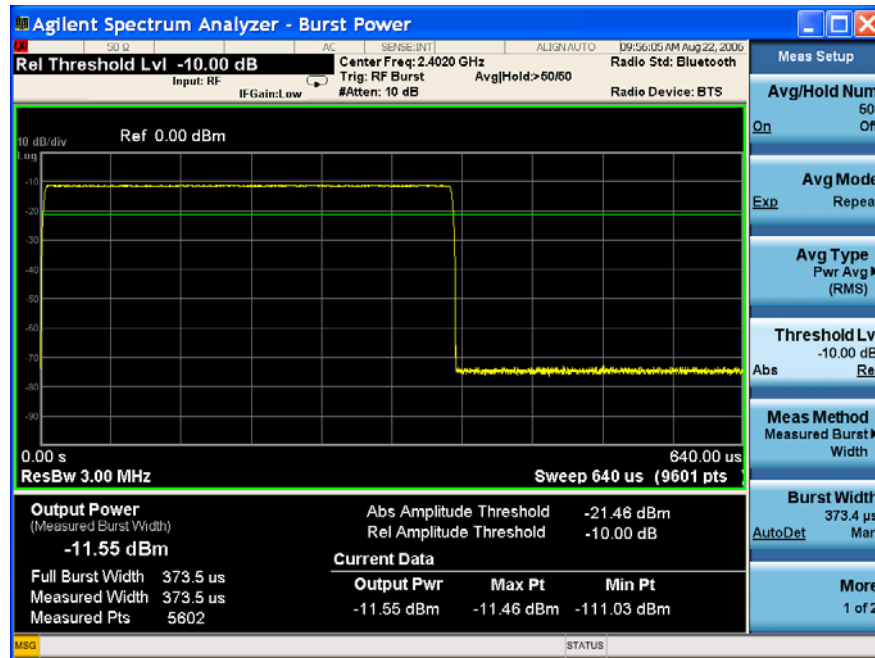
- Press **Meas Setup, Threshold Lvl (Rel), -10, dB**.

The burst power measurement includes all points above the threshold and no points below. The threshold level is indicated on the display by the green horizontal line. In this example, the threshold level has been set to be 10 dB below the relative level of the burst. The mean power of the burst is measured from all data above the threshold level. Refer to [Figure 9-12](#).



Step	Action	Notes
------	--------	-------

Figure 9-12 Burst Power Measurement Results with Threshold Level Set



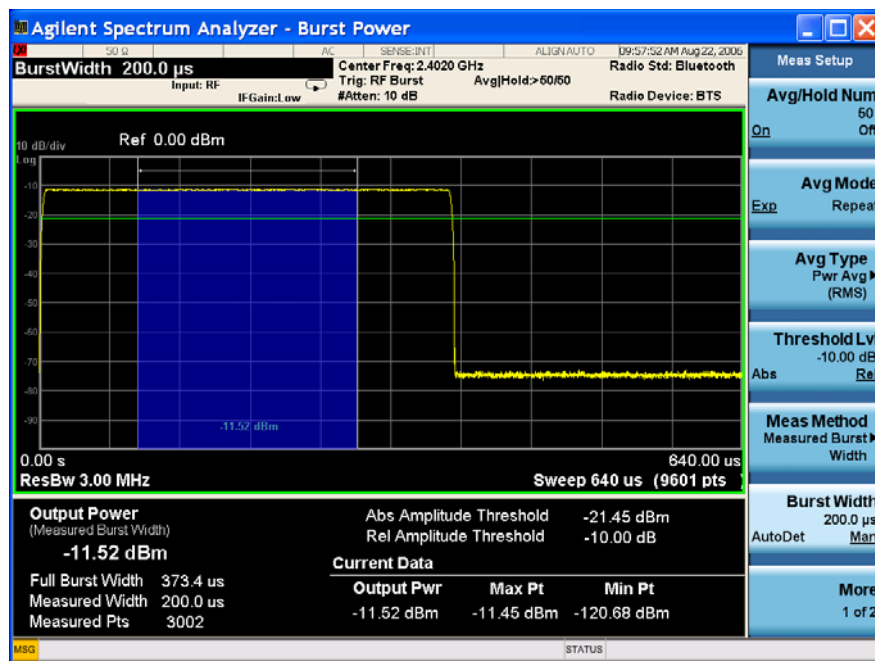
- |  |  |   |
|--|--|---|
| 11 Set the burst width to measure the central 200 $\mu$ s of the burst and enable bar graph. | <ol style="list-style-type: none"> <li>Press <b>View/Display, Bar Graph (On)</b>.</li> <li>Press <b>Meas Setup, Meas Method, Measured Burst Width, Burst Width (Man), 200, <math>\mu</math>s</b>.</li> </ol> | <p>The burst width is indicated on the screen by two vertical white lines and a blue power bar. Manually setting the burst width allows you to make it a long time interval (to include the rising and falling edges of the burst) or to make it a short time interval, measuring a small central section of the burst. Refer to <a href="#">Figure 9-13</a>.</p> |
|--|--|---|

# Measuring Digital Communications Signals

## Making Burst Power Measurements

Step	Action	Notes
------	--------	-------

Figure 9-13 Bar Graph Results with Measured Burst Width Set



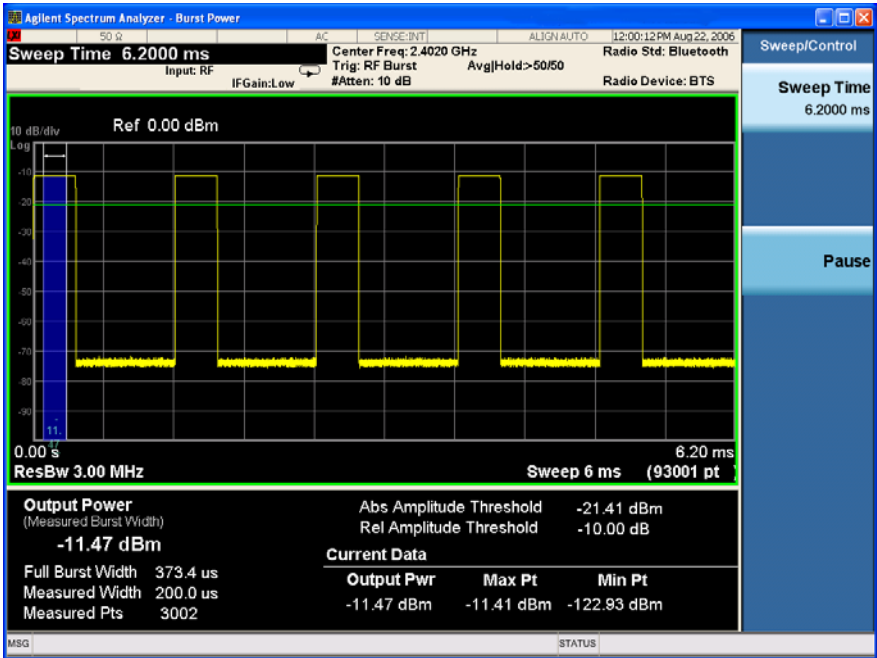
**NOTE** If you set the burst width manually to be wider than the screen's display, the vertical white lines move off the edges of the screen. This could give misleading results as only the data on the screen can be measured.

The Bluetooth standard states that power measurements should be taken over at least 20% to 80% of the duration of the burst.

- |  |  |   |
|--|--|---|
| <p><b>12</b> Increase the sweep time to display more than one burst at a time.</p> | <ul style="list-style-type: none"> <li>Press <b>Sweep/Control</b>, <b>Sweep Time</b>, <b>6200, <math>\mu</math>s</b> (or <b>6.2, ms</b>).</li> </ul> | <p>The screen display shows several bursts in a single sweep as in <a href="#">Figure 9-14</a>. The burst power measurement measures the mean power of the first burst, indicated by the vertical white lines and blue power bar.</p> |
|--|--|---|

Step	Action	Notes
------	--------	-------

Figure 9-14      *Displaying Multiple Bursts*

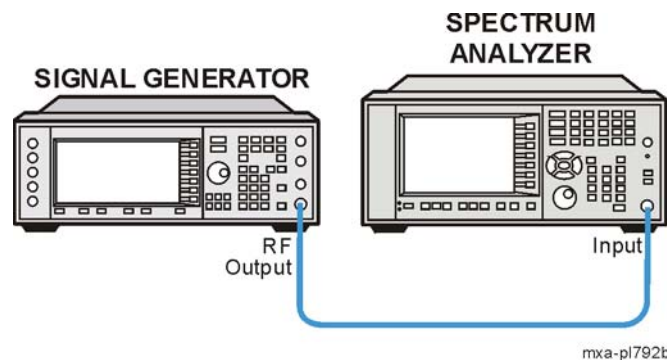


**NOTE**      Although the burst power measurement still runs correctly when several bursts are displayed simultaneously, the timing accuracy of the measurement is degraded. For the best results (including the best trade-off between measurement variations and averaging time), it is recommended that the measurement be performed on a single burst.

Spurious Emissions Measurements

The following example demonstrates how to make a spurious emissions measurement on a multitone signal used to simulate a spurious emission in a measured spectrum.

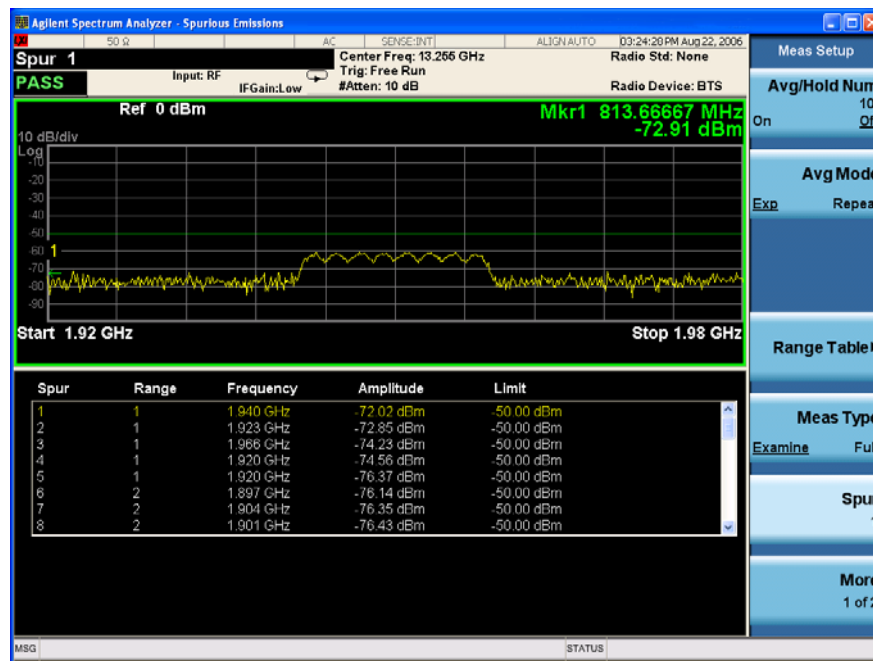
Step	Action	Notes
1	Setup the signal source. <div>a. Setup a multitone signal with 8 tones with a 2.0 MHz frequency spacing. b. Set the source frequency to 1.950 GHz. c. Set the source amplitudes to -50 dBm.</div>	
2	Connect the source RF OUTPUT to the analyzer RF INPUT as shown.	



3	Set the analyzer to the Spectrum Analyzer mode.	▪ Press <b>Mode, Spectrum Analyzer</b> .
4	Preset the analyzer.	▪ Press <b>Mode Preset</b> .
5	Set the analyzer center frequency.	▪ Press <b>FREQ Channel, Center Freq, 1.950, GHz</b> .
6	Select the spurious emissions measurement.	▪ Press <b>Meas, More, Spurious Emissions</b> .

Step	Action	Notes
7	<p>You may Focus the display on a specific spurious emissions signal.</p> <p>a. Press <b>Meas Setup, Spur, 1</b>, Enter (or enter the number of the spur of interest)</p> <p>b. Press <b>Meas Type</b> to highlight <b>Examine</b></p>	<p>The Spurious Emission result should look like <a href="#">Figure 9-15</a>. The graph window and a text window are displayed. The text window shows the list of detected spurs. Each line item includes the spur number, the range in which the spur was detected, the power of the spur, and the limit value against which the spur amplitude is tested.</p>

Figure 9-15 Spurious Emission Measurement Result



- 8 You may customize the tested ranges for spurious emissions (initially 5 default ranges and parameters are loaded into the range table).
- Press **Meas Setup, Range Table**, then select and edit the available parameters.

### Troubleshooting hints

Spurious emissions measurements can reveal the presence of degraded or defective parts in the transmitter section of the UUT. The following are examples of problems which, once indicated by testing, may require further attention:

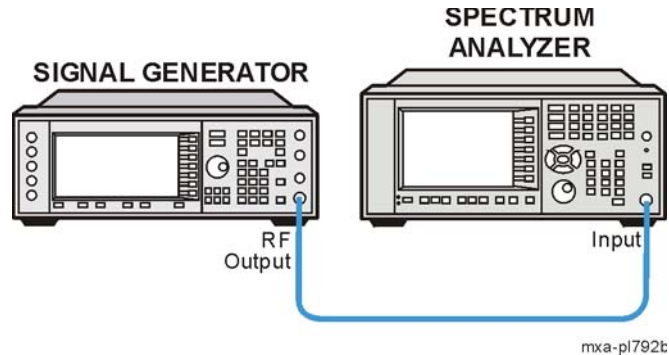
- Faulty DC power supply control of the transmitter power amplifier
- RF power controller of the pre-power amplifier stage
- I/Q control of the baseband stage
- Reduction in the gain and output power level of the amplifier due to a degraded gain control and/or increased distortion
- Degradation of amplifier linearity and other performance characteristics

Power amplifiers are one of the final stage elements of a base transmitter and play a critical part in meeting the important power and spectral efficiency specifications. Measuring the spectral response of these amplifiers to complex wideband signals is crucial to linking amplifier linearity and other performance characteristics to the stringent system specifications.

## Spectrum Emission Mask Measurements

This section explains how to make the spectrum emission mask measurement on a W-CDMA (3GPP) mobile station. (A signal generator is used to simulate a mobile station.) SEM compares the total power level within the defined carrier bandwidth and the given offset channels on both sides of the carrier frequency, to levels allowed by the standard. Results of the measurement of each offset segment can be viewed separately.

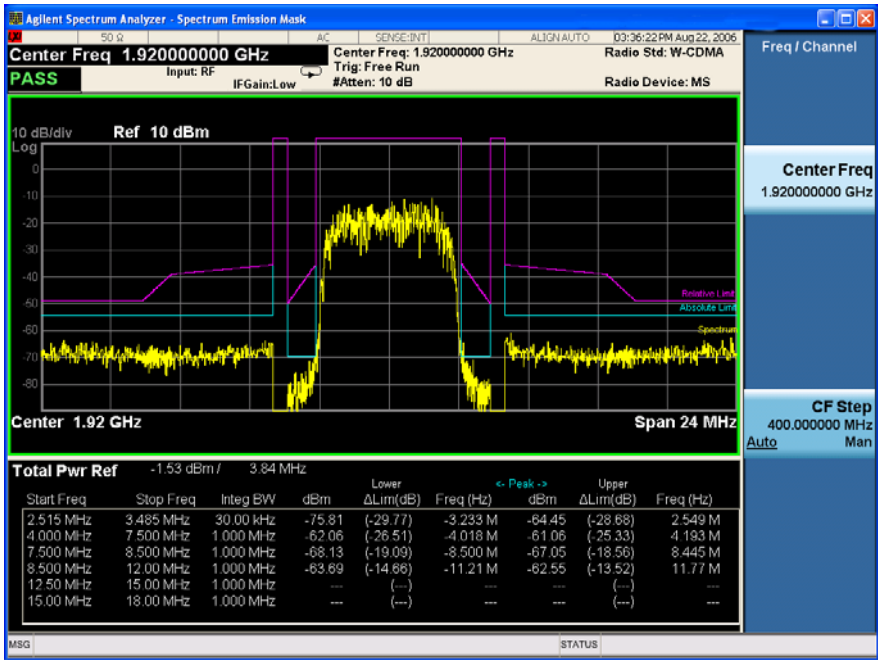
Step	Action	Notes
1	Set up the signal source.	<ol style="list-style-type: none"> <li>Setup a W-CDMA uplink signal.</li> <li>Set the source frequency to 1,920 MHz (Channel Number: <math>5 \times 1,920 = 9,600</math>).</li> <li>Set the source amplitudes to 0 dBm.</li> </ol>
2	Connect the source RF OUTPUT to the analyzer RF INPUT as shown.	



3	Select the mode.	<ul style="list-style-type: none"> <li>Press <b>Mode, Spectrum Analyzer</b>.</li> </ul>
4	Preset the analyzer.	<ul style="list-style-type: none"> <li>Press <b>Mode Preset</b>.</li> </ul>
5	Set the radio standard and toggle the device to mobile station.	<ul style="list-style-type: none"> <li>Press <b>Mode Setup, Radio Std, 3GPP W-CDMA, 3GPP W-CDMA, Device (MS)</b>.</li> </ul>
6	Set the center frequency.	<ul style="list-style-type: none"> <li>Press <b>FREQ Channel, 1.920, GHz</b>.</li> </ul>

Step	Action	Notes
7	Initiate the spectrum emission mask measurement.	<ul style="list-style-type: none"><li>Press <b>Meas, More, Spectrum Emission Mask</b>.</li></ul> The Spectrum Emission Mask measurement result should look like <a href="#">Figure 9-16</a> . The text window shows the reference total power and the absolute peak power levels which correspond to the frequency bands on both sides of the reference channel.

Figure 9-16                      Spectrum Emission Mask Measurement Result - (Default) View



Troubleshooting hints

- This spectrum emission mask measurement can reveal degraded or defective parts in the transmitter section of the UUT. The following examples are those areas to be checked further.
- Faulty DC power supply control of the transmitter power amplifier.
  - RF power controller of the pre-power amplifier stage.
  - I/Q control of the baseband stage.
  - Some degradation in the gain and output power level of the amplifier due to the degraded gain control and/or increased distortion.
  - Some degradation of the amplifier linearity or other performance characteristics.



Power amplifiers are one of the final stage elements of a base or mobile transmitter and are a critical part of meeting the important power and spectral efficiency specifications. Since spectrum emission mask measures the spectral response of the amplifier to a complex wideband signal, it is a key measurement linking amplifier linearity and other performance characteristics to the stringent system specifications.



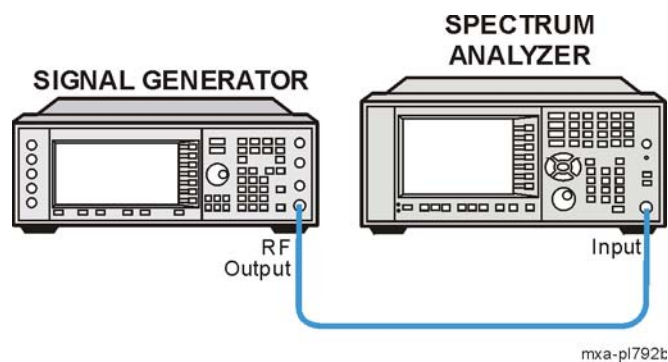
## 10 Demodulating AM Signals

Measuring the Modulation Rate of an AM Signal

This section demonstrates how to determine parameters of an AM signal, such as modulation rate and modulation index (depth) by using frequency and time domain measurements (see the concepts chapter “AM and FM Demodulation Concepts” on page 215 for more information).

To obtain an AM signal, you can either connect a source transmitting an AM signal, or connect an antenna to the analyzer input and tune to a commercial AM broadcast station. For this demonstration an RF source is used to generate an AM signal.

Step	Action	Notes
1	Set up the signal source.	<div>a. Set the source frequency to 300 MHz.</div> <div>b. Set the source amplitudes to -10 dBm.</div> <div>c. Set the AM depth to 80%.</div> <div>d. Set the AM rate to 1 kHz.</div> <div>e. Turn AM on.</div>
2	Connect an Keysight ESG RF signal source to the analyzer RF INPUT as shown.	



3	Select the mode.	<div>▪ Press <b>Mode, Spectrum Analyzer</b>.</div>
4	Preset the analyzer.	<div>▪ Press <b>Mode Preset</b>.</div>

Step	Action	Notes
5 Set the center frequency, span, RBW and the sweep time.	a. Press <b>FREQ Channel, Center Freq, 300, MHz.</b> b. Press <b>SPAN X Scale, Span, 500, kHz.</b> c. Press <b>BW, Res BW, 30, kHz.</b> d. Press <b>Sweep/Control, Sweep Time, 20, ms.</b>	
6 Change the y-scale type to linear.	▪ Press <b>AMPTD Y Scale, Scale Type (Lin).</b>	The y-axis units will automatically set to volts.
7 Position the signal peak near the first graticule below the reference level.	▪ Press <b>AMPTD Y Scale, Ref Level,</b> (rotate front-panel knob).	
8 Set the analyzer in zero span to make time-domain measurements	a. Press <b>SPAN X Scale, Zero Span</b> b. Press <b>Sweep/Control, Sweep Time, 5, ms</b>	
9 Use the video trigger to stabilize the trace.	▪ Press <b>Trigger, Video.</b>	<p>Since the modulation is a steady tone, you can use video trigger to trigger the analyzer sweep on the waveform and stabilize the trace, much like an oscilloscope. See <a href="#">Figure 10-1</a></p> <p>If the trigger level is set too high or too low when video trigger mode is activated, the sweep stops. You need to adjust the trigger level up or down with the front-panel knob until the sweep begins again.</p>
10 Measure the AM rate using delta markers.	▪ Press <b>Peak Search, Marker Delta, Next Right or Next Left.</b>	Use markers and delta markers to measure the AM rate. Place the marker on a peak and then use a delta marker to measure the time difference between the peaks (this is the AM rate of the signal)

## Demodulating AM Signals

### Measuring the Modulation Rate of an AM Signal

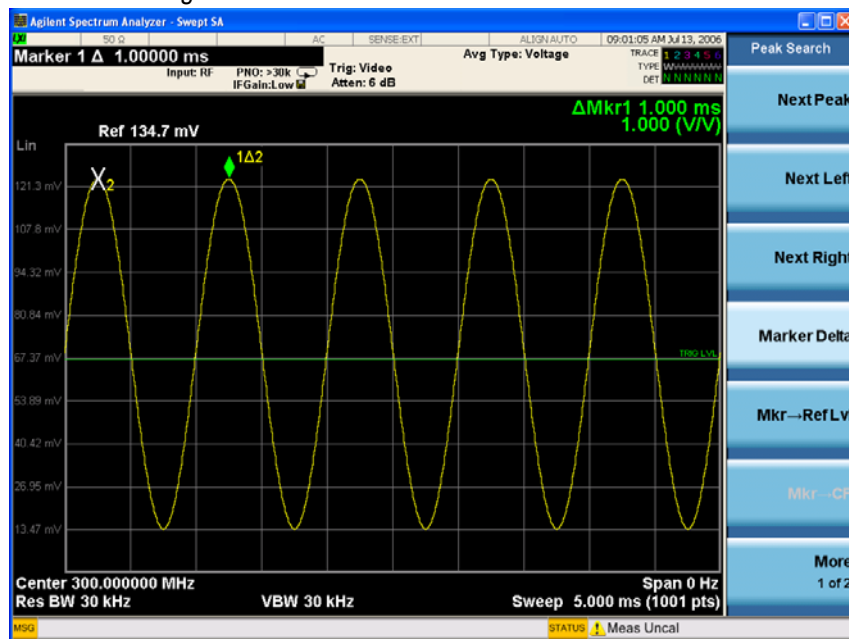
Step

Action

Notes

Figure 10-1

Measuring Time Parameters



**NOTE** Make sure the delta markers above are placed on adjacent peaks. See Figure 10-1 The frequency or the AM rate is 1 divided by the time between adjacent peaks:

$$\text{AM Rate} = 1/1.0 \text{ ms} = 1 \text{ kHz}$$

The signal analyzer can also make this rate calculation by changing the marker readout to inverse time.

Press **Marker, Properties, X Axis Scale, Inverse Time**.

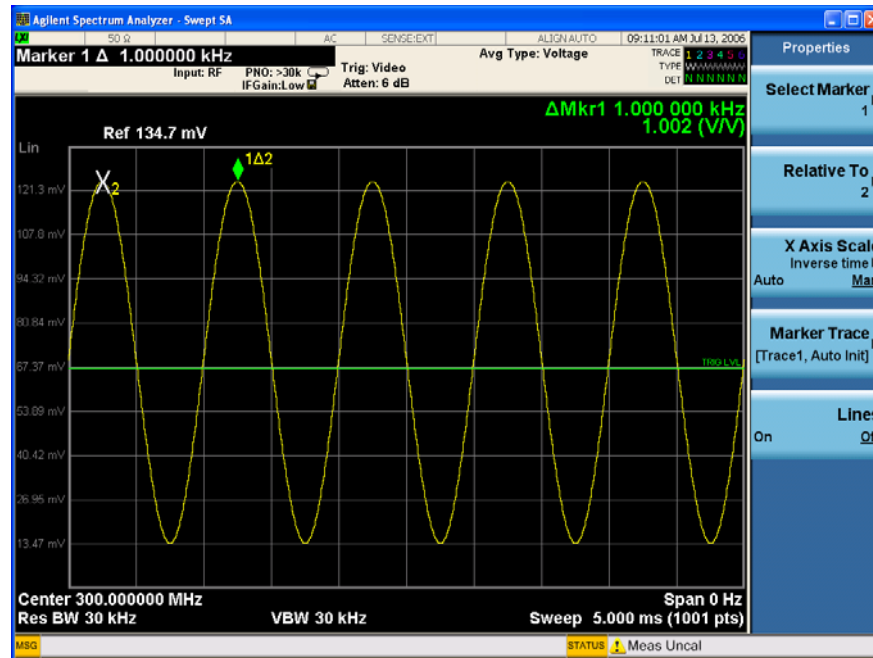
Step

Action

Notes

Figure 10-2

Measuring Time Parameters with Inverse Time Readout

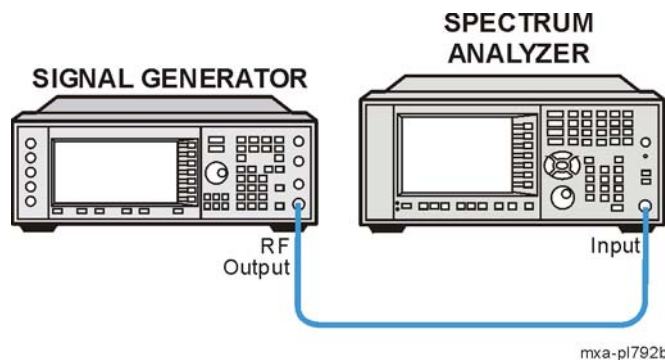


Another way to calculate the modulation rate would be to view the signal in the frequency domain and measure the delta frequency between the peak of the carrier and the first sideband.

Measuring the Modulation Index of an AM Signal

This procedure demonstrates how to use the signal analyzer as a fixed-tuned (time-domain) receiver to measure the modulation index as a percent AM value of an AM signal.

Step	Action	Notes
1	Set up the signal source. <div>a. Set the source frequency to 300 MHz. b. Set the source amplitudes to -10 dBm. c. Set the AM depth to 80%. d. Set the AM rate to 1 kHz. e. Turn AM on.</div>	
2	Connect an Keysight ESG RF signal source to the analyzer RF INPUT as shown.	



3	Select the mode.	▪ Press <b>Mode, Spectrum Analyzer.</b>
4	Preset the analyzer.	▪ Press <b>Mode Preset.</b>
5	Set the center frequency, span, RBW and the sweep time.	<div>a. Press <b>FREQ Channel, Center Freq, 300, MHz.</b> b. Press <b>SPAN X Scale, Span, 500, kHz.</b> c. Press <b>BW, Res BW, 30, kHz.</b> d. Press <b>Sweep/Control, Sweep Time, 20, ms.</b></div>



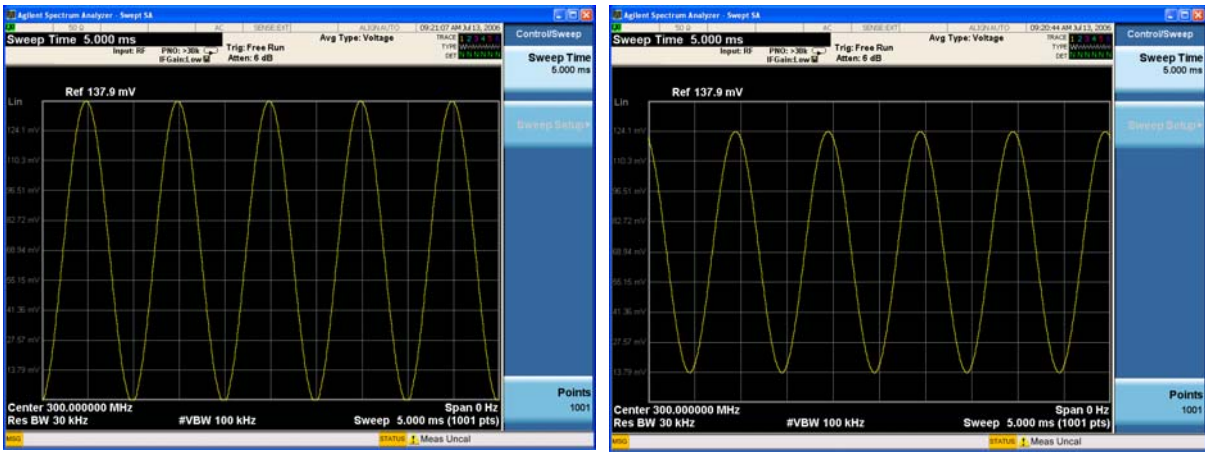
Step	Action	Notes
6 Set the y-axis units to volts.	▪ Press <b>AMPTD Y Scale, More, Y-Axis Units, V</b> (Volts).	
7 Position the signal peak near the reference level.	▪ Press <b>AMPTD Y Scale, Ref Level</b> , (rotate front-panel knob).	
8 Change the y-scale type to linear.	▪ Press <b>AMPTD Y Scale, Scale Type (Lin)</b> .	
9 Set the analyzer in zero span to make time-domain measurements.	a. Press <b>SPAN X Scale, Zero Span</b> . b. Press <b>Sweep/Control, Sweep Time, 5, ms</b>	
10 Place the analyzer in free run trigger mode.	▪ Press <b>Trigger, Free Run</b> .	
11 Increase the sweep time and decrease the VBW.	a. Press <b>Sweep/Control, Sweep Time, 5, s</b> . b. Press <b>BW, Video BW, 30, Hz</b> .	The waveform is displayed as a flat horizontal signal.
12 Center the flat waveform at the mid-point of the y-axis and then widen the VBW and decrease the sweep time to display the waveform as a sine wave.	a. Press <b>AMPTD Y Scale, Ref Level</b> , (rotate front-panel knob). b. Press <b>BW, Video BW, 100, kHz</b> . c. Press <b>Sweep/Control, Sweep Time, 5, ms</b> .	
13 Measure the modulation index of the AM signal.	To measure the modulation index as % AM, read the trace as follows (see <a href="#">Figure 10-3</a> for display examples): 100% AM extends from the top graticule down to the bottom graticule. 80% AM (as in this example) is when the top of the signal is at 1 division below the top graticule and 1 division above the bottom graticule. To determine % AM of your signal count each y-axis division as 10%.	

Demodulating AM Signals

Measuring the Modulation Index of an AM Signal

Step	Action	Notes
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Figure 10-3 AM Signal Measured in the Time Domain



LEFT: 100% AM Signal (Modulation Index = 1)      RIGHT: 80% AM Signal (Modulation Index = 0.8)

## 11 IQ Analyzer Measurement

## Capturing Wideband Signals for Further Analysis

This section demonstrates how to capture complex time domain data from wide bandwidth RF signals. This mode preserves the instantaneous vector relationships of time, frequency, phase and amplitude contained within the selected digitizer span or analysis BW, at the analyzer's center frequency, for output as IQ data. This IQ data can then be utilized internally or output over LAN, USB or GPIB for use with external analysis tools. Each measurement description specifies the types of data available remotely for that measurement.

The standard 10 MHz Analysis BW and optional 25 MHz Analysis BW digitizers used to capture the wide bandwidth RF signals can be accessed from the front panel in IQ Analyzer (Basic) mode. This IQ Analyzer mode provides basic setup, RF (FFT based) and IQ analysis tools

Within the IQ Analyzer mode, basic frequency domain, time domain and IQ measurements are available as initial signal and data verification tools in preparation for deriving the IQ data output.

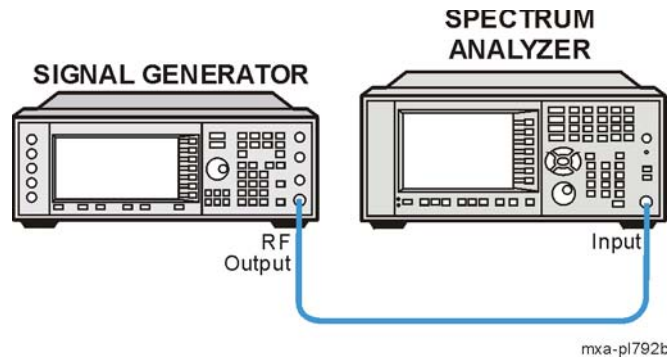
The Complex Spectrum measurement provides a display in the upper window of power versus frequency with current (yellow trace) and average (blue trace) data. In addition, an IQ waveform of voltage versus time is provided in the lower window.

The IQ Waveform measurement provides a time domain view of the RF signal envelope with power versus time or an IQ waveform of voltage versus time.

## Complex Spectrum Measurement

This section explains how to make a waveform (time domain) measurement on a W-CDMA signal. (A signal generator is used to simulate a base station.) The measurement of I and Q modulated waveforms in the time domain disclose the voltages which comprise the complex modulated waveform of a digital signal.

Step	Action	Notes
1	Set up the signal source. <ol style="list-style-type: none"> <li>Set the mode to W-CDMA 3GPP with 4 carriers.</li> <li>Set the frequency of the signal source to 1.0 GHz.</li> <li>Set the source amplitude to -10 dBm.</li> </ol>	
2	Connect the source RF OUTPUT to the analyzer RF INPUT as shown.	



3	Select the mode.	<ul style="list-style-type: none"> <li>Press <b>Mode, IQ Analyzer (Basic)</b>.</li> </ul>	
4	Preset the analyzer.	<ul style="list-style-type: none"> <li>Press <b>Mode Preset</b></li> </ul>	
5	Set the measurement center frequency.	<ul style="list-style-type: none"> <li>Press <b>Freq Channel, 1, GHz</b>.</li> </ul>	
6	Set the measurement span/analysis bandwidth.	<ul style="list-style-type: none"> <li>Press <b>Span X Scale, 10, MHz</b> (25 MHz if option B25 installed).</li> </ul>	
7	Enable the Complex Spectrum measurement.	<ul style="list-style-type: none"> <li>Press <b>Meas, Complex Spectrum</b>.</li> </ul>	Refer to the default view in <a href="#">Figure 11-1</a> or <a href="#">Figure 11-2</a> .

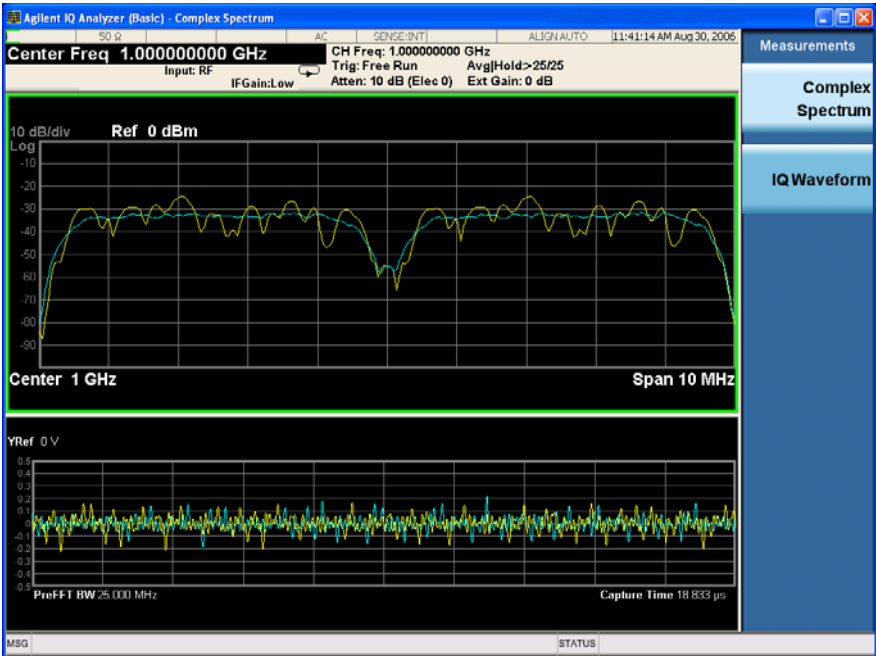
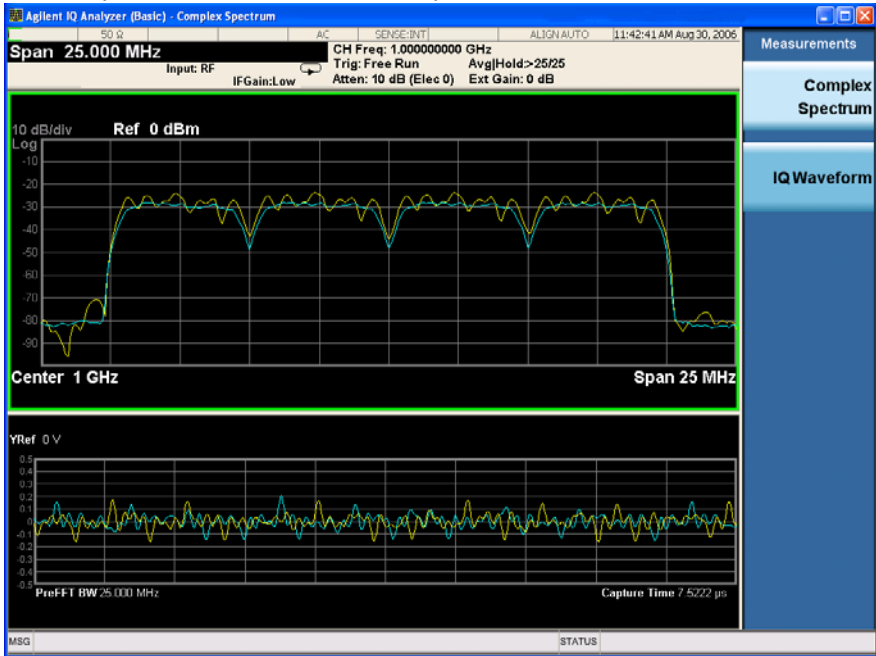
Step	Action	Notes
Figure 11-1	Spectrum and I/Q Waveform (Span 10 MHz)	

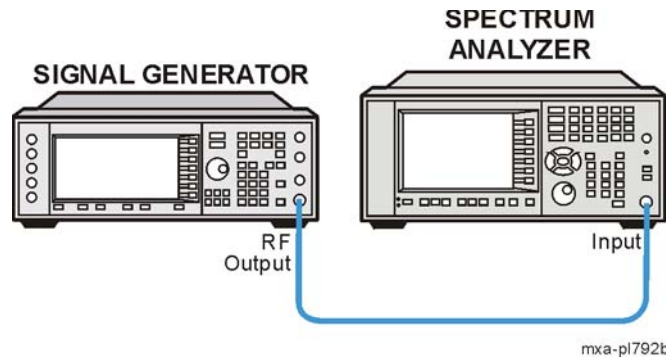
Figure 11-2	Spectrum and I/Q Waveform (Span 25 MHz)	
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**NOTE** A display with both an FFT derived spectrum in the upper window and an IQ Waveform in the lower window will appear when you activate a Complex Spectrum measurement. The active window is outlined in green. Changes to Frequency, Span or Amplitude will affect only the active window. Use the Next Window key to select a different window, and Zoom key to enlarge the window.

## IQ Waveform (Time Domain) Measurement

This section explains how to make a waveform (time domain) measurement on a W-CDMA signal. (A signal generator is used to simulate a base station.) The measurement of I and Q modulated waveforms in the time domain disclose the voltages which comprise the complex modulated waveform of a digital signal.

Step	Action	Notes
1	Set up the signal source.	<ol style="list-style-type: none"> <li>Set the mode to W-CDMA 3GPP with 4 carriers.</li> <li>Set the frequency of the signal source to 1.0 GHz.</li> <li>Set the source amplitude to -10 dBm.</li> </ol>
2	Connect the source RF OUTPUT to the analyzer RF INPUT as shown.	



3	Select the mode.	<ul style="list-style-type: none"> <li>Press <b>Mode, IQ Analyzer (Basic)</b>.</li> </ul>
4	Preset the analyzer.	<ul style="list-style-type: none"> <li>Press <b>Mode Preset</b>.</li> </ul>
5	Set the measurement center frequency.	<ul style="list-style-type: none"> <li>Press <b>Freq Channel, 1, GHz</b>.</li> </ul>
6	Set the measurement span/analysis bandwidth.	<ul style="list-style-type: none"> <li>Press <b>Span X Scale, 10, MHz</b> (25 MHz if option B25 installed).</li> </ul>
7	Enable the IQ Waveform measurement.	<ul style="list-style-type: none"> <li>Press <b>Meas, IQ Waveform</b>.</li> </ul>
8	View the RF envelope.	<ul style="list-style-type: none"> <li>Press <b>View/Display, RF Envelope</b>.</li> </ul>

IQ Analyzer Measurement

IQ Waveform (Time Domain) Measurement

Step	Action	Notes
9 Set the analysis bandwidth.	<ul style="list-style-type: none"><li>Press <b>BW, Info BW, 10, MHz</b> (25 MHz if option B25 installed).</li></ul>	This view provides a waveform display of power versus time of the RF signal in the upper window with metrics for mean and peak-to-mean in the lower window. Refer to <a href="#">Figure 11-3</a> or <a href="#">Figure 11-4</a> .

Figure 11-3 IQ Waveform Measurement - Time domain View (10 MHz BW)

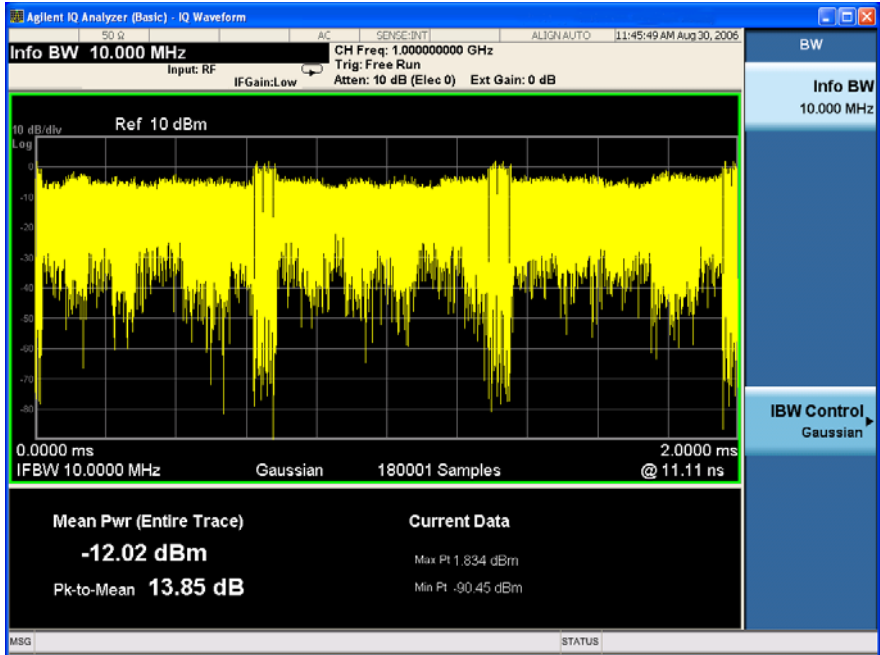
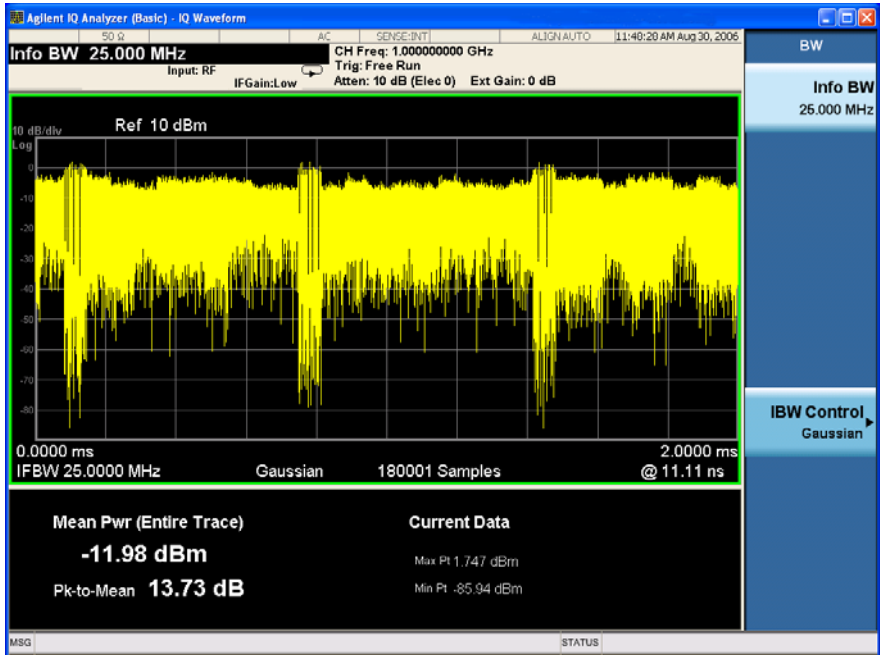


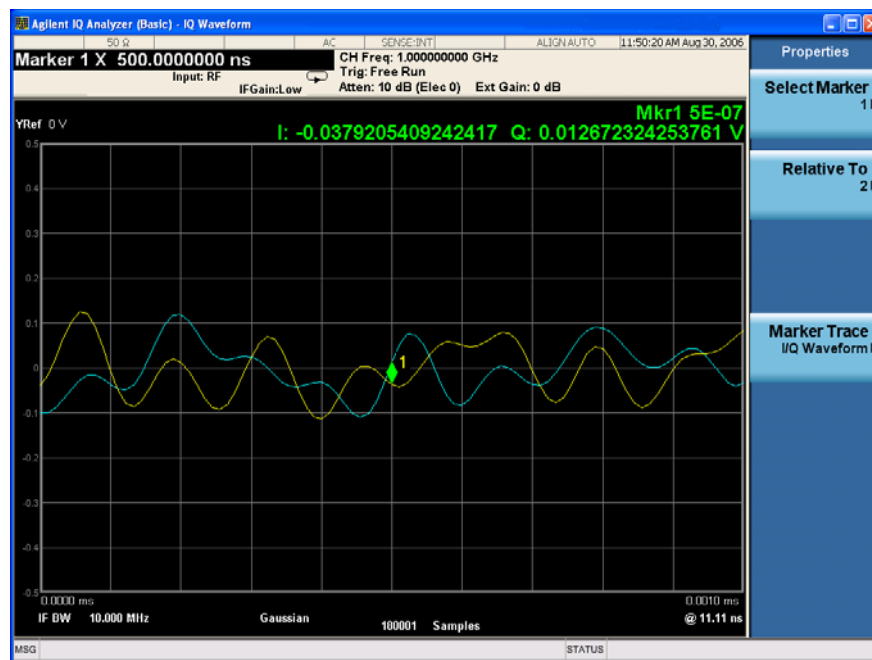
Figure 11-4 IQ Waveform Measurement - Time domain View (25 MHz BW)





Step	Action	Notes
10 View the IQ Waveform.	<ul style="list-style-type: none"> <li>Press <b>View/Display, IQ Waveform.</b></li> </ul>	
11 Set the time scale.	<ul style="list-style-type: none"> <li>Press <b>Span X Scale, Scale/Div, 100, ns.</b></li> </ul>	
12 Enable markers.	<ul style="list-style-type: none"> <li>Press <b>Marker, Properties, Marker Trace, IQ Waveform, 500, ns.</b></li> </ul>	<p>This view provides a display of voltage versus time for the I and Q waveforms. Markers enable measurement of the individual values of I and Q. Refer to <a href="#">Figure 11-5</a>.</p>

Figure 11-5 IQ Waveform Measurement - with Markers



IQ Analyzer Measurement  
IQ Waveform (Time Domain) Measurement

## 12 Using Option BBA Baseband I/Q Inputs

## Baseband I/Q measurements available for X-Series Signal Analyzers

The following table shows the measurements that can be made using Baseband I/Q inputs:

Table 12-1

*BBIQ Supported Measurements vs. Mode*

Mode	Measurements
GSM	IQ Waveform
	GMSK Phase & Freq
	EDGE EVM
802.16 OFDMA	IQ Waveform
	Power Stat CCDF
	Modulation Analysis
TD-SCDMA	IQ Waveform
	Power Stat CCDF
	Code Domain
	Mod Accuracy
Cdma2000	IQ Waveform
	Power Stat CCDF
	Code Domain
	Mod Accuracy
	QPSK EVM
IQ Analyzer (Basic)	IQ Waveform
	Complex Spectrum

## Baseband I/Q measurement overview

The Baseband I/Q functionality is a hardware option, Option BBA. If the option is not installed in the instrument, the I/Q functionality cannot be enabled.

The Baseband I/Q option provides four input ports and one Calibration Output port. The input ports are I, I-bar, Q, and Q-bar. The I and I-bar together compose the I channel and the Q and Q-bar together compose the Q channel. Each channel has two modes of operation:

Mode	Description
Single Ended (unbalanced)	In this mode, only the main port (I or Q) is used and the complementary ports (I-bar or Q-bar) is ignored. The I and Q ports are in single-ended mode when Differential "Off" is selected.
Differential (balanced)	In this mode, both main and complementary ports are used. To activate this mode, select Differential "On" from the I and Q Setup softkey menus.

The system supports a variety of input passive probes as well as the Keysight 1153A active differential probe using the InfiniMax probe interface.

<b>NOTE</b>	To avoid duplication, this section describes only the details unique to using the baseband I/Q inputs. For generic measurement details, refer to the previous "Making Measurements" sections.
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To make measurements using baseband I/Q Inputs, make the following selections:

Step	Notes
<b>1</b> Select measurement.	Select a measurement that supports baseband I/Q inputs.
<b>2</b> Select the I/Q Path	Press <b>Input/Output, I/Q, I/Q Path</b> .  Select from the choices present on the screen. The path selected is shown at the top of the measurement screen.
<b>3</b> Select the appropriate circuit location and probe(s) for measurements.	For details see <a href="#">"Selecting input probes for baseband measurements" on page 223</a> in the Concepts chapter.
<b>4</b> Select baseband I/Q input connectors.	

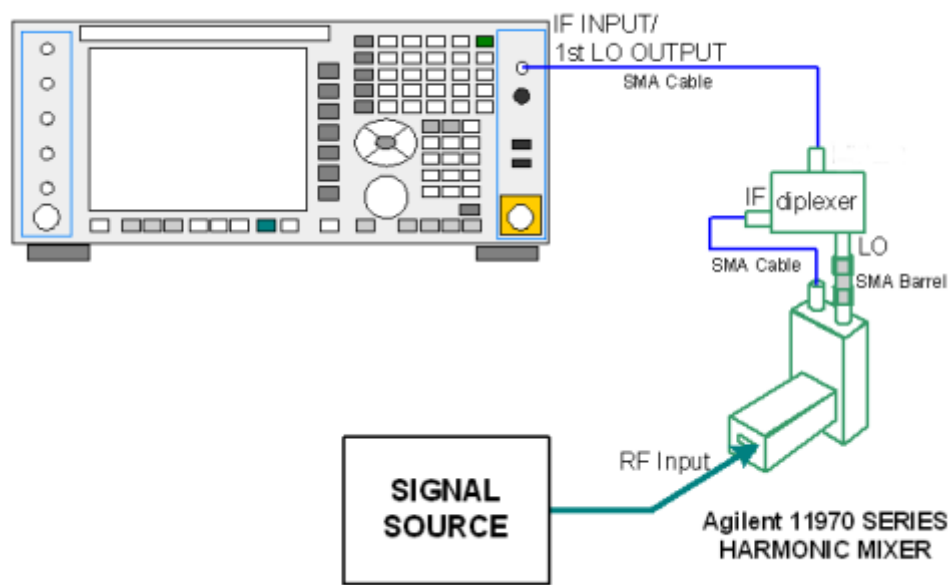
Step	Notes
5 Set up the I Path (if required).	<p>If you have set the I/Q Path to <b>I+jQ</b> or to <b>I Only</b>, press <b>I Setup</b>.</p> <ol style="list-style-type: none"> <li>Select whether <b>Differential (Balanced)</b> inputs is <b>On</b> or <b>Off</b>.</li> <li>Select the input impedance, <b>Input Z</b>.</li> <li>Input a <b>Skew</b> value in seconds.</li> <li>Set up the I Probe by pressing <b>I Probe</b> <ol style="list-style-type: none"> <li>Select probe <b>Attenuation</b></li> <li>Calibrate the probe. Press <b>Calibrate...</b> to start the calibration procedure. Follow the calibration procedure, clicking <b>Next</b> at the end of each step.</li> </ol> </li> </ol>
6 Set up the Q Path (if required).	<p>If you have set the I/Q Path to <b>I+jQ</b> or to <b>Q Only</b>, press <b>Q Setup</b>.</p> <ol style="list-style-type: none"> <li>Select whether <b>Differential (Balanced)</b> inputs is <b>On</b> or <b>Off</b>.</li> <li>Select the input impedance, <b>Input Z</b>.</li> <li>Input a <b>Skew</b> value in seconds.</li> <li>Set up the Q Probe by pressing <b>Q Probe</b> <ol style="list-style-type: none"> <li>Select probe <b>Attenuation</b></li> <li>Calibrate the probe. Press <b>Calibrate...</b> to start the calibration procedure. Follow the calibration procedure, clicking <b>Next</b> at the end of each step.</li> </ol> </li> </ol>
7 Select the reference impedance.	<p>Press <b>Reference Z</b>, then input a value from one ohm to one megohm.</p> <p>The impedance selected is shown at the top of the measurement screen.</p>
8 Calibrate the cable (if required).	<p>If you using cables that were not calibrated in the probe calibration step, press <b>I/Q Cable Calibrate...</b></p> <p>Follow the calibration procedure, clicking <b>Next</b> at the end of each step.</p>
9 Make the desired measurement.	

## 13 Option EXM External Mixing

Using Option EXM with the Keysight 11970 Series Mixers.

The following examples explain how to, connect the external mixers to the signal analyzer using a diplexer, choose the band of interest, activate conversion loss correction data, and how to use the signal-identification functions.

Step	Action	Notes
1 Set up the equipment	<ul style="list-style-type: none"><li>Connect the signal source, diplexer, and harmonic mixer to the signal analyzer as shown:</li></ul>	



2 Set the analyzer to the Spectrum Analyzer mode	<ul style="list-style-type: none"><li>Press <b>Mode, Spectrum Analyzer</b></li></ul>	
3 Preset the analyzer	<ul style="list-style-type: none"><li>Press <b>Mode Preset</b>.</li></ul>	
4 Select external mixing.	<ul style="list-style-type: none"><li>Press <b>Input/Output, External Mixer, External Mixer, External Mixer Setup</b></li></ul>	The default is 11970A
5 To select Q, U, V or W bands	<ul style="list-style-type: none"><li>a. Press <b>Mixer Presets, Keysight 11970</b>.</li><li>b. Select the appropriate key corresponding to 11970 frequency band.</li></ul>	
6 View the spectrum display	<ul style="list-style-type: none"><li>Press <b>Return</b> twice.</li></ul>	



Step	Action	Notes
7 Tune the analyzer to the input signal frequency	a. Press <b>FREQ Channel</b> . b. Enter a center frequency or a start and stop frequency	
8 Turn on the Signal ID function	• Press <b>Input Output, External Mixing, Signal ID Mode, Image Suppress, Signal ID On</b> .	This enables you to identify true signals from images and harmonics.  See “Signal ID” on page 166 for more information.

### Amplitude calibration

See “Loading conversion loss data for the PXA Signal Analyzer” on page 161. This will guide you through entering the conversion loss data provided with the mixer, into a corrections file that can be activated to provide amplitude corrected measurements.

Action	Notes
1 To access corrections, press <b>Input/Output, More, Corrections, Select Correction</b> .	
2 Choose a correction from the list.	Note that you used one of the Corrections numbered 1-6 when you entered the conversion loss data into the instrument.
3 Press <b>Correction On</b> .	This applies the corrections to the measurement.

<b>NOTE</b>	Assure only ONE correction file is turned on because it is possible to turn on multiple correction files, and if some of the files share the same frequency points, the correction that results for those shared frequency points will cause measurement errors. Therefore assure that only the correction file required for the measurement is turned on, and turn off all other corrections.
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### Loading conversion loss data for the PXA Signal Analyzer

The conversion loss data supplied with your mixer can be loaded into your signal analyzer from one of two sources:

- By downloading the 70xxxxxx\_X.csv file located on the CD ROM disk that is provided with your mixer. The 70xxxxxx\_X.csv file is transferred from the CD to the USB memory stick (also provided), and then the USB memory stick inserted into the PXA, and the file transferred to one of the analyzer corrections array locations.
- The mixer ships with a printed copy of the conversion loss data. Find the printed copy conversion loss data that has the text "For Use with Keysight X-Series analyzers only". The conversion loss data will need to be manually entered as frequency and amplitude pairs into the analyzer corrections file. An example of calibration data is shown in [Figure 13-1 on page 167](#).

The CD also contains 70xxxxxx\_X.pdf files of the conversion loss data that can be printed, and then manually entered into a Correction array location. You will need to enter the frequency and amplitude pairs into the analyzer corrections file. An example of calibration data is shown in [Figure 13-1 on page 167](#).

### Down loading the conversion loss .csv files to the analyzer corrections array

Action	Notes
<b>1</b> Install the CD ROM provided with the mixer, into a PC.	You can view the contents of the CD.
<b>2</b> Locate the 70xxxxxx_X.csv file.	
<b>3</b> Copy the .csv file to the USB memory stick provided with the mixer.	
<b>4</b> Insert the USB memory stick into one of the USB ports on the signal analyzer.	It is recommended that you connect a mouse and keyboard to the signal analyzer.
<b>5</b> Press <b>Input/Output, More, Corrections, Select Correction.</b>	
<b>6</b> Choose a correction array from the list of Correction 1 through Correction 6.	Correction 1 has a provision to store antenna corrections, so if antenna corrections are required, reserve this array for that use.
<b>7</b> To see if anything is already stored in a particular correction, press <b>Correction, Edit.</b>	Selecting Edit turns the correction ON. Be sure to turn the correction OFF after determining the contents of the correction array.
<b>8</b> To delete a correction table, press <b>Return</b> , assure the <b>Select Correction</b> key corresponds to the correction you want to delete, and press <b>Delete Correction.</b>	
<b>9</b> Once a correction array number is selected, press <b>Recall, Data (Import), Amplitude Correction</b> , and choose one of the correction array numbers.	
<b>10</b> Press <b>Open</b> , use the pull down arrow in the "look in" box to navigate to the USB memory stick, and locate the 70xxxxxx_X.csv file.	
<b>11</b> Select the 70xxxxxx_X.csv file and click Open.	The conversion loss data will now load into the specified corrections array.

Action	Notes
<b>12</b> To view the contents of the corrections array in the conversion loss table, press <b>Input/Output, More, Corrections</b> , select the corrections array number, and press <b>Edit</b> .	
<b>13</b> Press <b>Return</b> to go back to the measurement screen.	
<b>NOTE</b>	Loading the .csv file automatically populates the Description and Comment fields found under the Corrections, Properties key. To edit these fields, press <b>Input/Output, More, Corrections, Select Correction</b> , select the correction number, press <b>Properties, Description</b> or <b>Comment</b> .

## Manually entering conversion loss data

Action	Notes
<p><b>1</b> Locate the printed copy of the conversion loss data that has the text "For use with Keysight X-Series analyzers only". Or Insert the CD provided with the mixer into a PC and navigate to the 70xxxxxx_X.pdf file.</p>	<p>The file contains tabular and graphic conversion loss data. Be careful to select the correct file since there are three files provided for the 11970A, Q and V band mixers. Print the 70xxxxxx_X.pdf file to create a printed copy.</p>
<p><b>2</b> Press <b>Input/Output, More, Corrections, Select Correction.</b></p>	
<p><b>3</b> Choose a correction array from the list of Correction 1 through Correction 6.</p>	<p>Correction 1 has a provision to store antenna corrections, so if antenna corrections are required, reserve this array for that use.</p>
<p><b>4</b> To see if anything is already stored in a particular correction, press <b>Correction, Edit.</b></p>	<p>Selecting Edit turns the correction ON. Be sure to turn the correction OFF after determining the contents of the correction array.</p>
<p><b>5</b> To delete a correction table, press <b>Return</b>, assure the <b>Select Correction</b> key corresponds to the correction you want to delete, and press <b>Delete Correction.</b></p>	
<p><b>6</b> Select the correction number and press <b>Edit.</b> When finished press <b>Return.</b></p>	<p>Use the keys provided to enter the frequency and amplitude (conversion loss) points from the calibration data table. Conversion loss values are entered as positive numbers.</p>

---

**NOTE** It is possible to add a description and a comment of what the selected correction is, and have this description appear on the Description or Comment key. Press **Properties**, and connect a keyboard to the instrument. For example, press **Comment** and type 11970V Serial XXxxxxxxxx. Press **Done**.

---

## Signal ID

### Image Suppress

The Image Suppress mode of Signal ID mathematically removes all image and multiple responses of signals present at the mixer input. Two hidden sweeps are taken in succession. The second sweep is offset in LO frequency by  $2*IF/N$ . For each point in each trace, the smaller amplitude from the two traces is taken and placed in that point in Trace 1. Responses of each trace that lie on top of one another will remain and are valid signals, others are images and are suppressed.

---

<b>NOTE</b>	This function takes control of and uses Trace 1. Any data in this trace prior to activating Image Suppress will be lost.
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In Image Suppress Mode, synchronization is ensured by first turning off Signal ID, initiating a single sweep, then turning on Signal ID followed by two single sweeps.

### Image shift

Like the Image Suppress mode, Image Shift is a two sweep sequence. The data from the first sweep is placed in Trace 1 and the data from the second (LO frequency shifted by  $2*IF/N$ ) sweep is placed in Trace 2. Signal responses of Trace 1 and Trace 2 that have the same horizontal position are considered to be in the current band and therefore can be analyzed with the amplitude and frequency measurement systems of the SA. All other responses are invalid and should be ignored.

---

<b>NOTE</b>	This function takes control of and uses Trace 1 and Trace 2. Any data in these traces prior to activating Image Shift will be lost.
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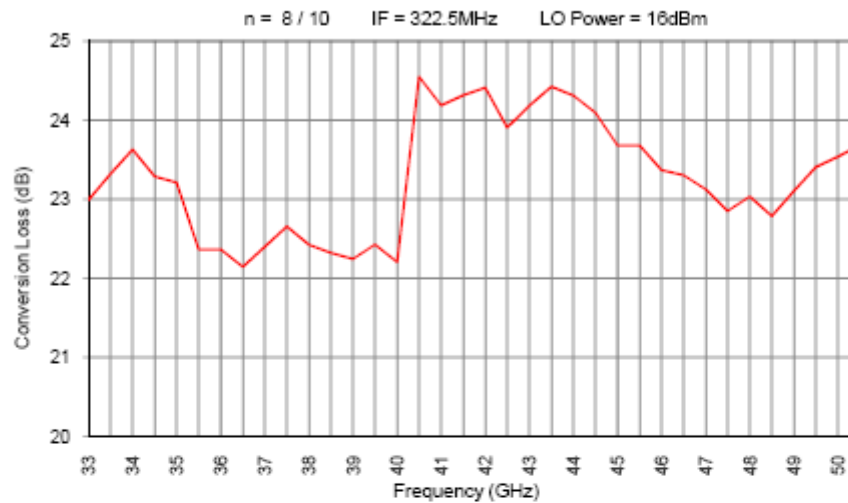
---

To synchronize in Image Shift Mode, turn off Signal ID and then initiate a single sweep. Then turn on Signal ID and initiate two single sweeps. The results of the first sweep after Signal ID is turned on are available in Trace 1. The next sweep is shifted and the data from that sweep is available in Trace 2. The unshifted and shifted data can then be compared.

Figure 13-1

MODEL: 11970Q SER: MY30033018 DATE: 15 Mar 2011

For use with Agilent X-Series signal analyzers only. See other documents/files for other spectrum analyzers.



Freq. (GHz)	Conv. Loss (dB)	Freq. (GHz)	Conv. Loss (dB)
33.0	23.0	42.0	23.9
33.5	23.3	42.5	24.2
34.0	23.6	43.0	24.4
34.5	23.3	43.5	24.3
35.0	23.2	44.0	24.1
35.5	22.4	44.5	23.7
36.0	22.4	45.0	23.7
36.5	22.1	45.5	23.4
37.0	22.4	46.0	23.3
37.5	22.7	46.5	23.1
38.0	22.4	47.0	22.8
38.5	22.3	47.5	23.0
39.0	22.2	48.0	22.8
39.5	22.4	48.5	23.1
40.0	22.2	49.0	23.4
40.0	24.5	49.5	23.5
40.5	24.2	50.0	23.7
41.0	24.3		
41.5	24.4		

Print Date: 15-Mar-11

RECOMMENDED CALIBRATION CYCLE: THREE YEARS

## Using the M1970 Series Mixers with X-Series Signal Analyzers (Option EXM)

### Operating precautions

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**WARNING**

**Do not exceed the maximum ratings listed below or permanent damage to the mixer will result.**

---

#### **RF input power**

Use the following parameters:

CW                      No greater than 20 dBm

Peak Pulse            No greater than 24 dBm at <1  $\mu$ sec

See the gain compression values for each model mixer. Use an appropriate waveguide attenuator if the output power of the unit under test exceeds the gain compression value.

#### **LO input power**

LO input power is set by the internal signal analyzer LO alignment. However, the LO input must not exceed 20 dBm.

Always use a high quality low loss SMA cable since this will allow the longest cable length, and prevent damage to the mixer SMA female connector.

#### **Electrostatic discharge**

When installing the mixer, always connect the LO/IF SMA cable to the signal analyzer BEFORE connecting to the mixer. This will minimize the danger of an electrostatic discharge damaging the mixer diodes.

#### **Connect only one mixer at a time**

The automatic LO adjustment and mixer ID process assumes only one mixer is connected to the analyzer's USB and SMA EXT MIXER connections.

#### **Waveguide protection foam**

Do not remove, displace or damage the nonconductive foam installed in the open end of the waveguide. This foam keeps small objects from entering the waveguide.

#### **Provide mechanical support for the mixer**

Assure the mixer body is properly supported so it does not present any stress on the waveguide connection. Instrument option 301 provides a jackstand that allows a stable support and height adjustment.



### Avoiding waveguide flange damage

Install the waveguide flange cap whenever the mixer is not connected to a device under test. This will protect the waveguide flange mating surface.

### Mixer waveguide connections

Assure the shoulder of the mixer waveguide flange is properly aligned with the flange of the device under test. To ensure proper mating, it is important to tighten all screws equally. To do this, tighten opposed screws in pairs by a small amount until all are snug. Final torque must not exceed 7 in pounds.

For additional information regarding use with a particular X-Series analyzer, refer to that analyzer's User's and Programmer's Reference Guide.

## Equipment set up

The following examples explain how to connect the external mixers to the signal analyzer, and how to use the signal-identification functions.

Step	Action	Notes
1 SMA connection	a. Connect an SMA cable from the mixer to the spectrum analyzer EXT MIXER front panel SMA.	<p>The torque for the SMA cables and adapters should not exceed 8 in-lbs.</p> <p>The LO/IF connection between the mixer and the signal analyzer must be in place before the USB cable from the mixer is connected. Connecting the USB cable automatically triggers the LO adjustment, and if the LO/IF cable is not connected the adjustment will not complete and an error will occur.</p>
2 USB connection	a. Connect a USB cable from the mixer to the spectrum analyzer.	<p>When a connection is made, the green LED on the mixer lights up indicating that the mixer has power and the processor inside the mixer is running. The spectrum analyzer is automatically switched to external mixing mode, and the mixer model number and mixer option are used to set the start and stop frequencies for the mixing band.</p>



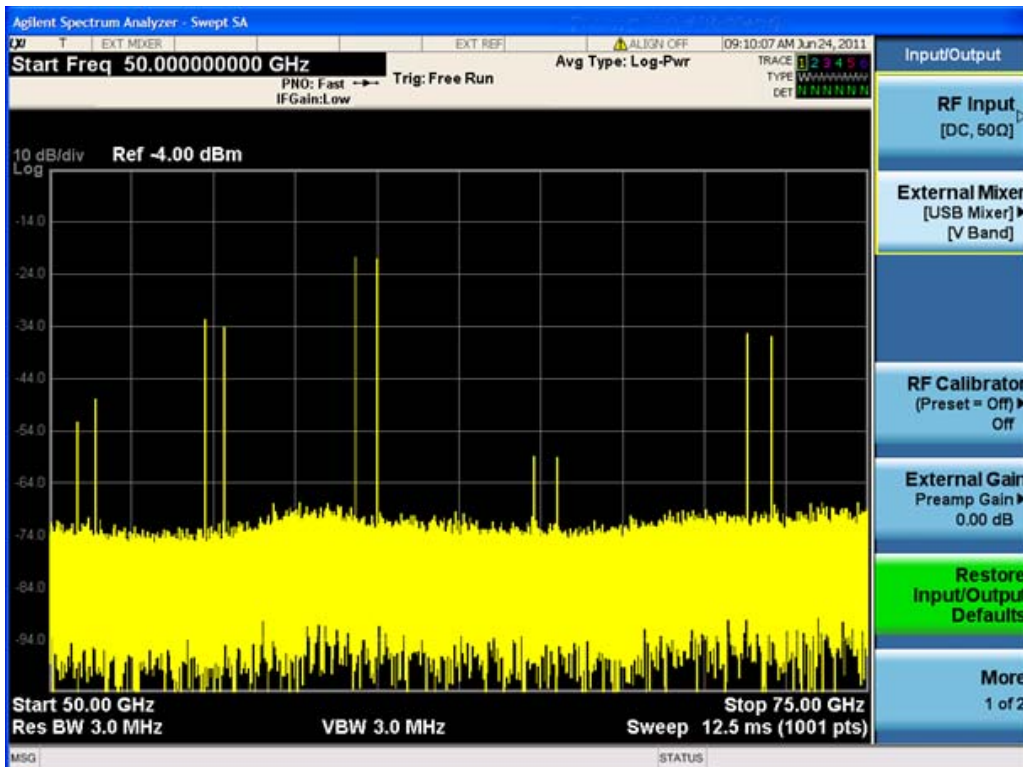
## Option EXM External Mixing

### Using the M1970 Series Mixers with X-Series Signal Analyzers (Option EXM)

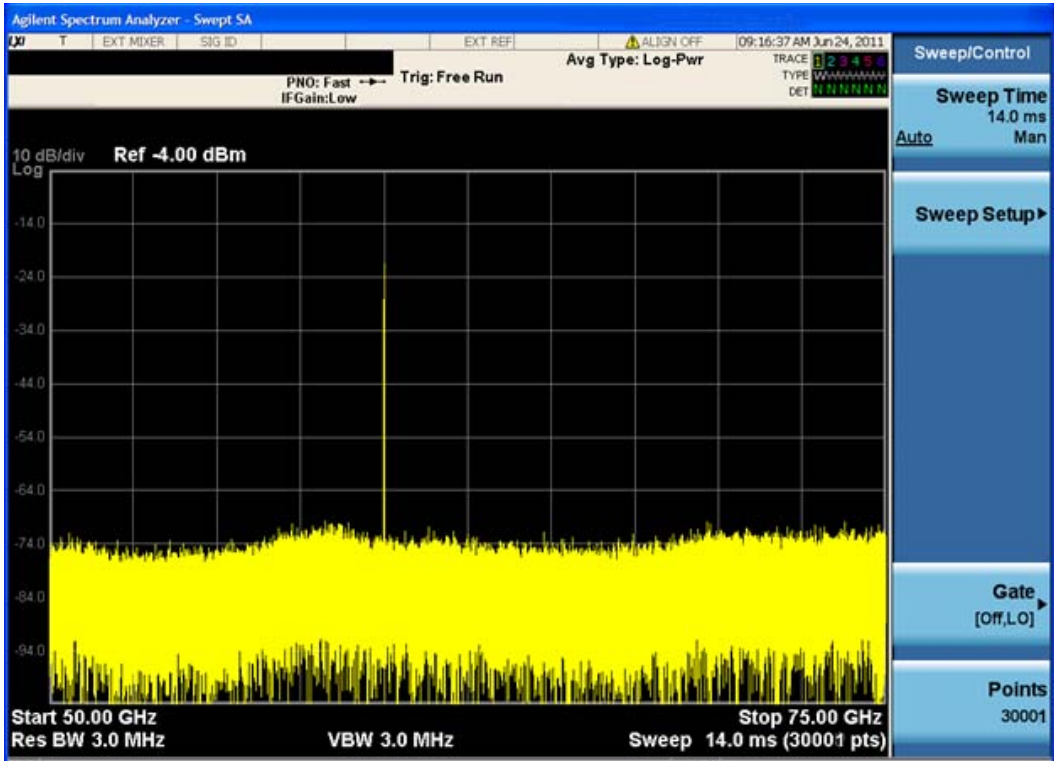
The spectrum analyzer performs an LO alignment using a detector in the mixer to set the LO Power. During the alignment the yellow Busy LED turns on. Once the alignment completes, the mixer is ready to make calibrated measurements since the conversion loss values stored in the mixer are automatically loaded to the signal analyzer.

## Operation

Step	Action	Notes
1 Tune the analyzer	<p>a. Apply a signal to the mixer input.</p> <p>b. Press <b>FREQ Channel</b> and enter a center frequency or a start and stop frequency</p>	<p>Multiple responses may appear on screen. Most of these responses are images or multiples of the mixing process and not true signals.</p>



2 Turn on the signal identification function.	<p>a. Press <b>Input/Output, External Mixer, Signal ID to On, Signal ID Mode, Image Suppress.</b></p>	<p>This enables you to identify true signals from images and harmonics. Refer to the following graphic.</p>
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Step	Action	Notes
		
3	With wide spans, increasing the number of sweep points may improve the effectiveness of image suppressing.	a. Press <b>Sweep/Control</b> , <b>Points</b> , enter the number, and press <b>Enter</b> .

### Amplitude calibration

The M1970 Series mixers automatically download a conversion loss file to the signal analyzer, and this conversion loss table is used to correct the measured amplitude. It is not possible to view or edit the conversion loss file. The Certificate of Calibration that is provided with each mixer lists the conversion loss measured at the factory.

### LO adjustment

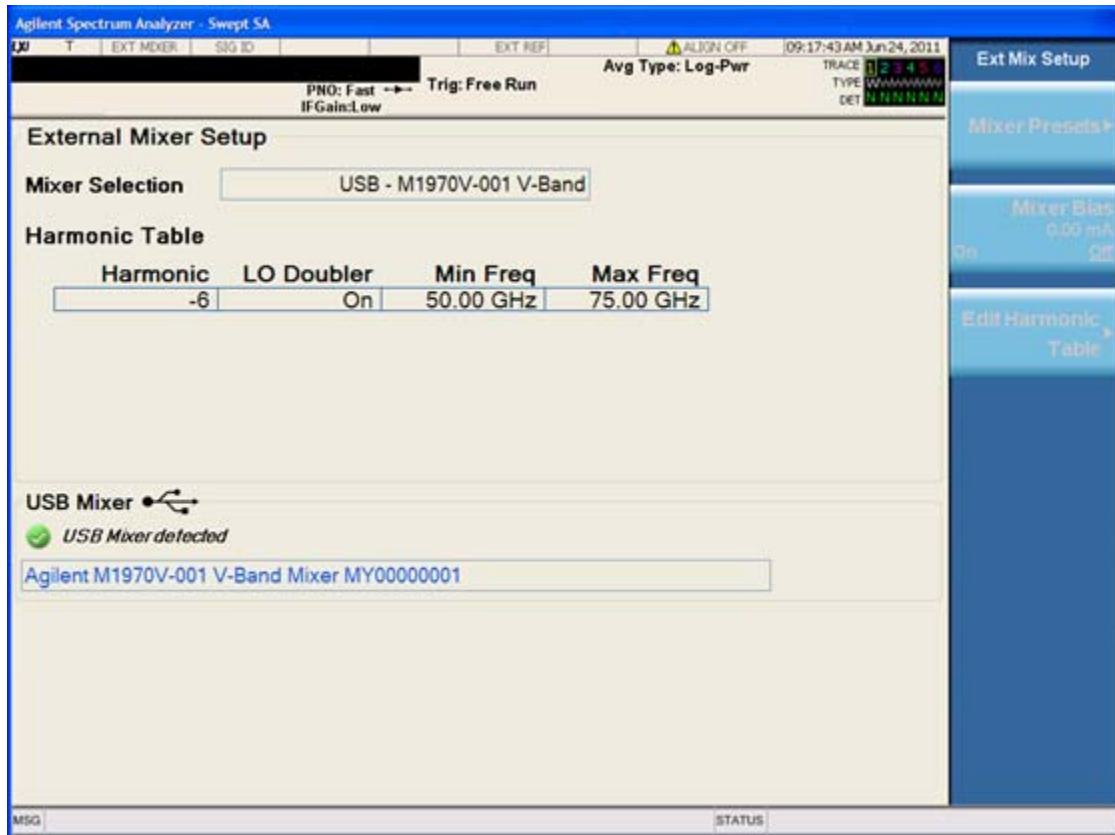
The LO adjustment will run each time the USB connection is made, and if the signal analyzer Alignments are set to Normal, the LO adjustment will be performed based on time and temperature rules similar to the other signal analyzer alignments. Both the mixer and the spectrum analyzer temperature sensors are monitored by the alignment algorithm. If the Alignment is set to OFF, the LO Alignment will not be performed based on time and temperature, and it will be necessary for the user to determine when to perform alignments.

To manually trigger an LO alignment from the front panel, press **System**, **Alignments**, **Align Now**, **External Mixer**.

## Viewing the external mixer setup screen

The mixer setup screen contains information such as mixer serial and model number, harmonic mixing used, and the status of the mixer connection. When the USB mixer is connected, the Mixer Preset, Mixer Bias and Edit Harmonic Table keys are grayed out since these keys do not apply. However, if you unplug the USB cable, the Mixer Presets key will become functional and the connection status will show USB Mixer not connected.

To view the setup screen, press **Input /Output, External Mixer, Ext Mix Setup**.



## Option EXM External Mixing

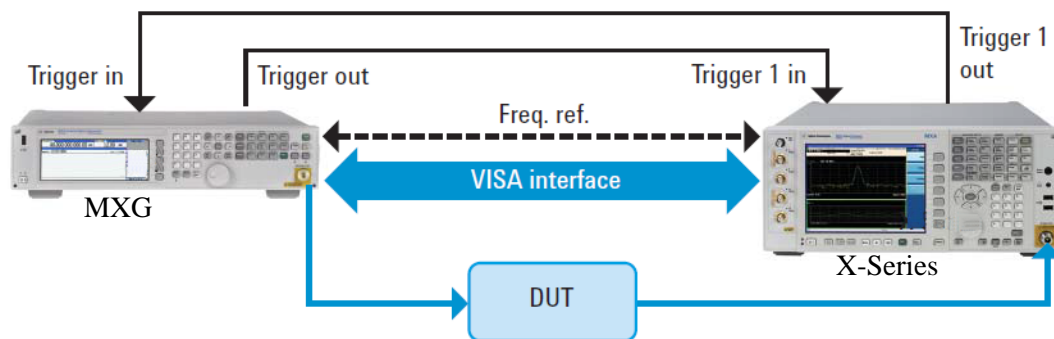
Using the M1970 Series Mixers with X-Series Signal Analyzers (Option EXM)

## 14 Option Esc External Source Control

## Using Option ESC with the Keysight MXG Signal Sources.

The following examples explain how to connect the MXG signal source to the signal analyzer.

Step	Action	Notes
1 Set up the equipment	<ul style="list-style-type: none"> <li>Connect the signal source to the signal analyzer as shown:</li> </ul>	The X-Series controls the MXG via the virtual instrument software architecture interface (VISA), which uses a connection of “Lan” on page 177, GPIB, or USB.



2 Set the analyzer to the Spectrum Analyzer mode	<ul style="list-style-type: none"> <li>Press <b>Mode, Spectrum Analyzer</b></li> </ul>	
3 Preset the analyzer	<ul style="list-style-type: none"> <li>Press <b>Mode Preset</b>.</li> </ul>	
4 Select external mixing.	<ul style="list-style-type: none"> <li>Press <b>Input/Output, External Mixer, External Mixer, External Mixer Setup</b></li> </ul>	The default is 11970A
5 To select Q, U, V or W bands	<ol style="list-style-type: none"> <li>Press <b>Mixer Presets, Keysight 11970</b>.</li> <li>Select the appropriate key corresponding to 11970 frequency band.</li> </ol>	
6 View the spectrum display	<ul style="list-style-type: none"> <li>Press <b>Return</b> twice.</li> </ul>	
7 Tune the analyzer to the input signal frequency	<ol style="list-style-type: none"> <li>Press <b>FREQ Channel</b>.</li> <li>Enter a center frequency or a start and stop frequency</li> </ol>	



Step	Action	Notes
8 Turn on the Signal ID function	<ul style="list-style-type: none"> <li>Press <b>Input Output, External Mixing, Signal ID Mode, Image Suppress, Signal ID On.</b></li> </ul>	<p>This enables you to identify true signals from images and harmonics.</p> <p>See <a href="#">“Signal ID” on page 182</a> for more information.</p>

## Lan

The X-Series with Option ESC controls the MXG through a LAN connection based on TCP/IP protocol. The TCP/IP protocol can only be established with correct IP addressing.

<b>NOTE</b>	You must be logged in as an Administrator to change the TCP/IP properties. This requires the use of a USB mouse and keyboard.
-------------	---

## X-Series Instrument

Step	Action
1 Log off as default user.	<ul style="list-style-type: none"> <li>Click <b>Start, Log Off, Log Off</b></li> </ul>
2 Log on as an administrator.	<ul style="list-style-type: none"> <li>At the log in prompt enter: User name: administrator Password: agilent4u</li> </ul>
3 Assign an IP adress and a subnet mask.	

<b>NOTE</b>	Assure only ONE correction file is turned on because it is possible to turn on multiple correction files, and if some of the files share the same frequency points, the correction that results for those shared frequency points will cause measurement errors. Therefore assure that only the correction file required for the measurement is turned on, and turn off all other corrections.
-------------	--

## Loading conversion loss data for the PXA Signal Analyzer

The conversion loss data supplied with your mixer can be loaded into your signal analyzer from one of two sources:

- By downloading the 70xxxxxx\_X.csv file located on the CD ROM disk that is provided with your mixer. The 70xxxxxx\_X.csv file is transferred from the CD to the USB memory stick (also provided), and then the USB memory stick inserted into the PXA, and the file transferred to one of the analyzer corrections array locations.
- The mixer ships with a printed copy of the conversion loss data. Find the printed copy conversion loss data that has the text "For Use with Keysight X-Series analyzers only". The conversion loss data will need to be manually entered as frequency and amplitude pairs into the analyzer corrections file. An example of calibration data is shown in [Figure 14-1 on page 183](#).

The CD also contains 70xxxxxx\_X.pdf files of the conversion loss data that can be printed, and then manually entered into a Correction array location. You will need to enter the frequency and amplitude pairs into the analyzer corrections file. An example of calibration data is shown in [Figure 14-1 on page 183](#).

**Down loading the conversion loss .csv files to the analyzer corrections array**

Action	Notes
<b>1</b> Install the CD ROM provided with the mixer, into a PC.	You can view the contents of the CD.
<b>2</b> Locate the 70xxxxxx_X.csv file.	
<b>3</b> Copy the .csv file to the USB memory stick provided with the mixer.	
<b>4</b> Insert the USB memory stick into one of the USB ports on the signal analyzer.	It is recommended that you connect a mouse and keyboard to the signal analyzer.
<b>5</b> Press <b>Input/Output, More, Corrections, Select Correction.</b>	
<b>6</b> Choose a correction array from the list of Correction 1 through Correction 6.	Correction 1 has a provision to store antenna corrections, so if antenna corrections are required, reserve this array for that use.
<b>7</b> To see if anything is already stored in a particular correction, press <b>Correction, Edit.</b>	Selecting Edit turns the correction ON. Be sure to turn the correction OFF after determining the contents of the correction array.
<b>8</b> To delete a correction table, press <b>Return</b> , assure the <b>Select Correction</b> key corresponds to the correction you want to delete, and press <b>Delete Correction.</b>	
<b>9</b> Once a correction array number is selected, press <b>Recall, Data (Import), Amplitude Correction</b> , and choose one of the correction array numbers.	
<b>10</b> Press <b>Open</b> , use the pull down arrow in the "look in" box to navigate to the USB memory stick, and locate the 70xxxxxx_X.csv file.	
<b>11</b> Select the 70xxxxxx_X.csv file and click Open.	The conversion loss data will now load into the specified corrections array.

Option Esc External Source Control  
Using Option ESC with the Keysight MXG Signal Sources.

Action	Notes
<b>12</b> To view the contents of the corrections array in the conversion loss table, press <b>Input/Output, More, Corrections</b> , select the corrections array number, and press <b>Edit</b> .	
<b>13</b> Press <b>Return</b> to go back to the measurement screen.	
<b>NOTE</b>	Loading the .csv file automatically populates the Description and Comment fields found under the Corrections, Properties key. To edit these fields, press <b>Input/Output, More, Corrections, Select Correction</b> , select the correction number, press <b>Properties, Description</b> or <b>Comment</b> .

## Manually entering conversion loss data

Action	Notes
<b>1</b> Locate the printed copy of the conversion loss data that has the text "For use with Keysight X-Series analyzers only". Or Insert the CD provided with the mixer into a PC and navigate to the 70xxxxxx_X.pdf file.	The file contains tabular and graphic conversion loss data. Be careful to select the correct file since there are three files provided for the 11970A, Q and V band mixers. Print the 70xxxxxx_X.pdf file to create a printed copy.
<b>2</b> Press <b>Input/Output, More, Corrections, Select Correction.</b>	
<b>3</b> Choose a correction array from the list of Correction 1 through Correction 6.	Correction 1 has a provision to store antenna corrections, so if antenna corrections are required, reserve this array for that use.
<b>4</b> To see if anything is already stored in a particular correction, press <b>Correction, Edit.</b>	Selecting Edit turns the correction ON. Be sure to turn the correction OFF after determining the contents of the correction array.
<b>5</b> To delete a correction table, press <b>Return</b> , assure the <b>Select Correction</b> key corresponds to the correction you want to delete, and press <b>Delete Correction.</b>	
<b>6</b> Select the correction number and press <b>Edit.</b> When finished press <b>Return.</b>	Use the keys provided to enter the frequency and amplitude (conversion loss) points from the calibration data table. Conversion loss values are entered as positive numbers.

---

**NOTE** It is possible to add a description and a comment of what the selected correction is, and have this description appear on the Description or Comment key. Press **Properties**, and connect a keyboard to the instrument. For example, press **Comment** and type 11970V Serial XXxxxxxxxx. Press **Done**.

---

## Signal ID

### Image Suppress

The Image Suppress mode of Signal ID mathematically removes all image and multiple responses of signals present at the mixer input. Two hidden sweeps are taken in succession. The second sweep is offset in LO frequency by  $2*IF/N$ . For each point in each trace, the smaller amplitude from the two traces is taken and placed in that point in Trace 1. Responses of each trace that lie on top of one another will remain and are valid signals, others are images and are suppressed.

---

<b>NOTE</b>	This function takes control of and uses Trace 1. Any data in this trace prior to activating Image Suppress will be lost.
-------------	--

---

In Image Suppress Mode, synchronization is ensured by first turning off Signal ID, initiating a single sweep, then turning on Signal ID followed by two single sweeps.

### Image shift

Like the Image Suppress mode, Image Shift is a two sweep sequence. The data from the first sweep is placed in Trace 1 and the data from the second (LO frequency shifted by  $2*IF/N$ ) sweep is placed in Trace 2. Signal responses of Trace 1 and Trace 2 that have the same horizontal position are considered to be in the current band and therefore can be analyzed with the amplitude and frequency measurement systems of the SA. All other responses are invalid and should be ignored.

---

<b>NOTE</b>	This function takes control of and uses Trace 1 and Trace 2. Any data in these traces prior to activating Image Shift will be lost.
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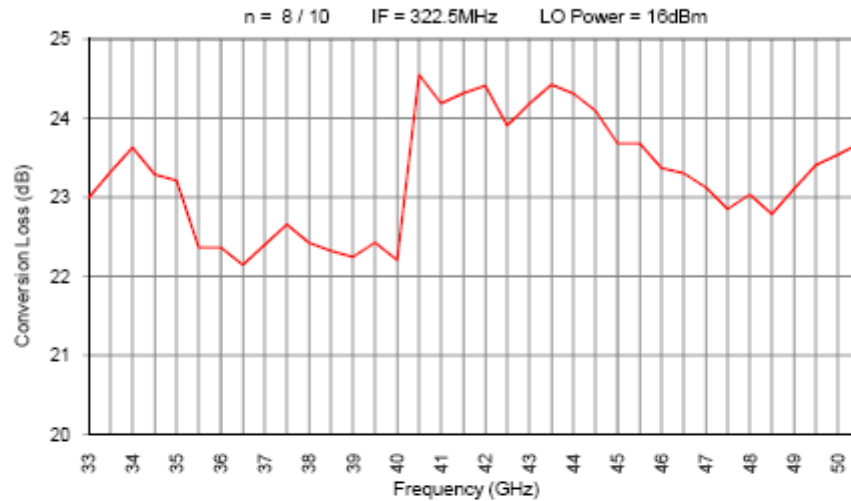
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To synchronize in Image Shift Mode, turn off Signal ID and then initiate a single sweep. Then turn on Signal ID and initiate two single sweeps. The results of the first sweep after Signal ID is turned on are available in Trace 1. The next sweep is shifted and the data from that sweep is available in Trace 2. The unshifted and shifted data can then be compared.

Figure 14-1

MODEL: 11970Q SER: MY30033018 DATE: 15 Mar 2011

For use with Agilent X-Series signal analyzers only. See other documents/files for other spectrum analyzers.



Freq. (GHz)	Conv. Loss (dB)	Freq. (GHz)	Conv. Loss (dB)
33.0	23.0	42.0	23.9
33.5	23.3	42.5	24.2
34.0	23.6	43.0	24.4
34.5	23.3	43.5	24.3
35.0	23.2	44.0	24.1
35.5	22.4	44.5	23.7
36.0	22.4	45.0	23.7
36.5	22.1	45.5	23.4
37.0	22.4	46.0	23.3
37.5	22.7	46.5	23.1
38.0	22.4	47.0	22.8
38.5	22.3	47.5	23.0
39.0	22.2	48.0	22.8
39.5	22.4	48.5	23.1
40.0	22.2	49.0	23.4
40.0	24.5	49.5	23.5
40.5	24.2	50.0	23.7
41.0	24.3		
41.5	24.4		

Print Date: 15-Mar-11

RECOMMENDED CALIBRATION CYCLE: THREE YEARS

## Using the M1970 Series Mixers with X-Series Signal Analyzers (Option EXM)

### Operating precautions

---

**WARNING**

**Do not exceed the maximum ratings listed below or permanent damage to the mixer will result.**

---

#### **RF input power**

Use the following parameters:

CW                      No greater than 20 dBm

Peak Pulse            No greater than 24 dBm at <1  $\mu$ sec

See the gain compression values for each model mixer. Use an appropriate waveguide attenuator if the output power of the unit under test exceeds the gain compression value.

#### **LO input power**

LO input power is set by the internal signal analyzer LO alignment. However, the LO input must not exceed 20 dBm.

Always use a high quality low loss SMA cable since this will allow the longest cable length, and prevent damage to the mixer SMA female connector.

#### **Electrostatic discharge**

When installing the mixer, always connect the LO/IF SMA cable to the signal analyzer BEFORE connecting to the mixer. This will minimize the danger of an electrostatic discharge damaging the mixer diodes.

#### **Connect only one mixer at a time**

The automatic LO adjustment and mixer ID process assumes only one mixer is connected to the analyzer's USB and SMA EXT MIXER connections.

#### **Waveguide protection foam**

Do not remove, displace or damage the nonconductive foam installed in the open end of the waveguide. This foam keeps small objects from entering the waveguide.

#### **Provide mechanical support for the mixer**

Assure the mixer body is properly supported so it does not present any stress on the waveguide connection. Instrument option 301 provides a jackstand that allows a stable support and height adjustment.



### Avoiding waveguide flange damage

Install the waveguide flange cap whenever the mixer is not connected to a device under test. This will protect the waveguide flange mating surface.

### Mixer waveguide connections

Assure the shoulder of the mixer waveguide flange is properly aligned with the flange of the device under test. To ensure proper mating, it is important to tighten all screws equally. To do this, tighten opposed screws in pairs by a small amount until all are snug. Final torque must not exceed 7 in pounds.

For additional information regarding use with a particular X-Series analyzer, refer to that analyzer's User's and Programmer's Reference Guide.

## Equipment set up

The following examples explain how to connect the external mixers to the signal analyzer, and how to use the signal-identification functions.

Step	Action	Notes
1 SMA connection	a. Connect an SMA cable from the mixer to the spectrum analyzer EXT MIXER front panel SMA.	<p>The torque for the SMA cables and adapters should not exceed 8 in-lbs.</p> <p>The LO/IF connection between the mixer and the signal analyzer must be in place before the USB cable from the mixer is connected. Connecting the USB cable automatically triggers the LO adjustment, and if the LO/IF cable is not connected the adjustment will not complete and an error will occur.</p>
2 USB connection	a. Connect a USB cable from the mixer to the spectrum analyzer.	<p>When a connection is made, the green LED on the mixer lights up indicating that the mixer has power and the processor inside the mixer is running. The spectrum analyzer is automatically switched to external mixing mode, and the mixer model number and mixer option are used to set the start and stop frequencies for the mixing band.</p>



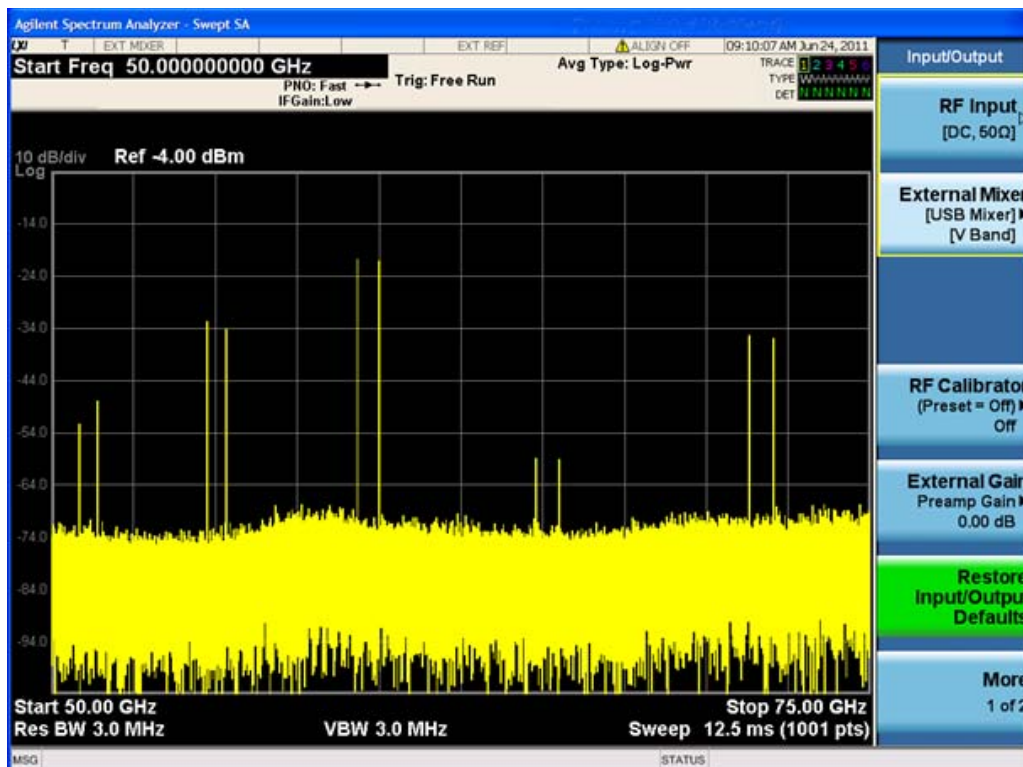
## Option Esc External Source Control

### Using the M1970 Series Mixers with X-Series Signal Analyzers (Option EXM)

The spectrum analyzer performs an LO alignment using a detector in the mixer to set the LO Power. During the alignment the yellow Busy LED turns on. Once the alignment completes, the mixer is ready to make calibrated measurements since the conversion loss values stored in the mixer are automatically loaded to the signal analyzer.

## Operation

Step	Action	Notes
1 Tune the analyzer	<p>a. Apply a signal to the mixer input.</p> <p>b. Press <b>FREQ Channel</b> and enter a center frequency or a start and stop frequency</p>	<p>Multiple responses may appear on screen. Most of these responses are images or multiples of the mixing process and not true signals.</p>



2 Turn on the signal identification function.	<p>a. Press <b>Input/Output, External Mixer, Signal ID to On, Signal ID Mode, Image Suppress.</b></p>	<p>This enables you to identify true signals from images and harmonics. Refer to the following graphic.</p>
---	---	---

Step	Action	Notes
		

- 3 With wide spans, increasing the number of sweep points may improve the effectiveness of image suppressing.
  - a. Press **Sweep/Control**, **Points**, enter the number, and press **Enter**.

### Amplitude calibration

The M1970 Series mixers automatically download a conversion loss file to the signal analyzer, and this conversion loss table is used to correct the measured amplitude. It is not possible to view or edit the conversion loss file. The Certificate of Calibration that is provided with each mixer lists the conversion loss measured at the factory.

### LO adjustment

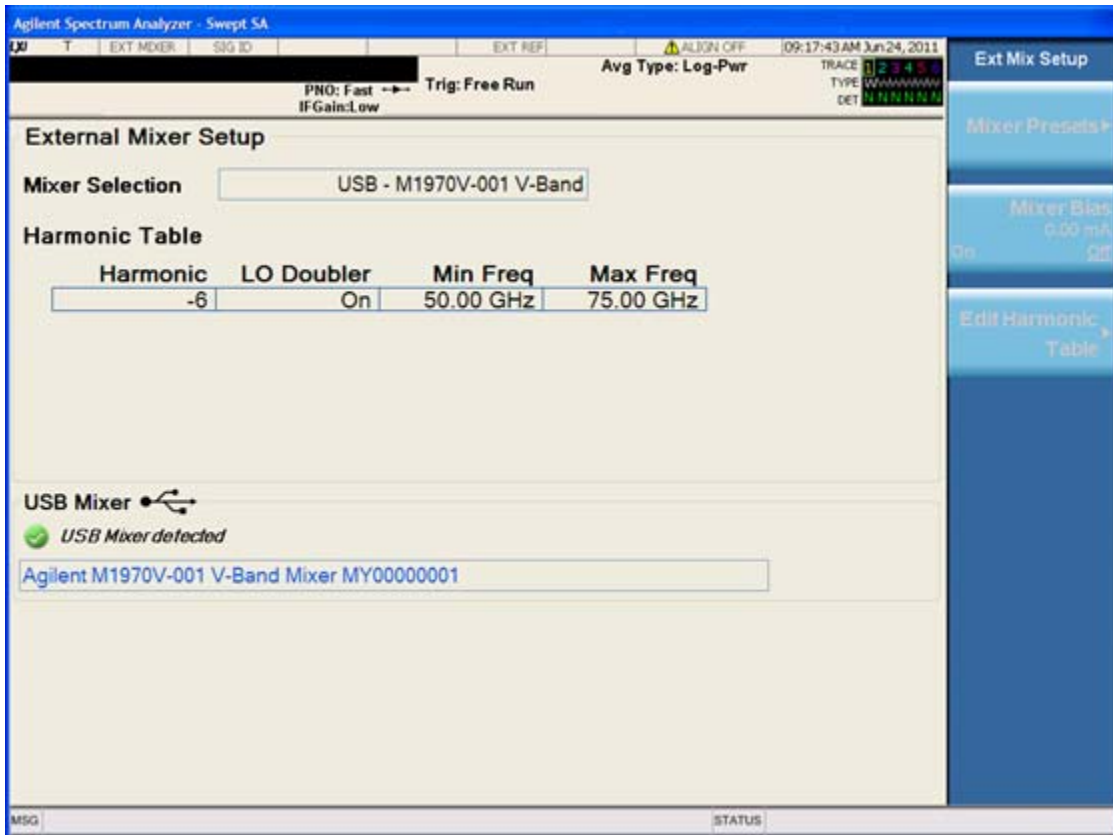
The LO adjustment will run each time the USB connection is made, and if the signal analyzer Alignments are set to Normal, the LO adjustment will be performed based on time and temperature rules similar to the other signal analyzer alignments. Both the mixer and the spectrum analyzer temperature sensors are monitored by the alignment algorithm. If the Alignment is set to OFF, the LO Alignment will not be performed based on time and temperature, and it will be necessary for the user to determine when to perform alignments.

To manually trigger an LO alignment from the front panel, press **System**, **Alignments**, **Align Now**, **External Mixer**.

## Viewing the external mixer setup screen

The mixer setup screen contains information such as mixer serial and model number, harmonic mixing used, and the status of the mixer connection. When the USB mixer is connected, the Mixer Preset, Mixer Bias and Edit Harmonic Table keys are grayed out since these keys do not apply. However, if you unplug the USB cable, the Mixer Presets key will become functional and the connection status will show USB Mixer not connected.

To view the setup screen, press **Input /Output, External Mixer, Ext Mix Setup**.



Option Esc External Source Control

Using the M1970 Series Mixers with X-Series Signal Analyzers (Option EXM)

## 15 Concepts

## Resolving Closely Spaced Signals

### Resolving signals of equal amplitude

Two equal-amplitude input signals that are close in frequency can appear as a single signal trace on the analyzer display. Responding to a single-frequency signal, a swept-tuned analyzer traces out the shape of the selected internal IF (intermediate frequency) filter (typically referred to as the resolution bandwidth or RBW filter). As you change the filter bandwidth, you change the width of the displayed response. If a wide filter is used and two equal-amplitude input signals are close enough in frequency, then the two signals will appear as one signal. If a narrow enough filter is used, the two input signals can be discriminated and appear as separate peaks. Thus, signal resolution is determined by the IF filters inside the analyzer.

The bandwidth of the IF filter tells us how close together equal amplitude signals can be and still be distinguished from each other. The resolution bandwidth function selects an IF filter setting for a measurement. Typically, resolution bandwidth is defined as the 3 dB bandwidth of the filter. However, resolution bandwidth may also be defined as the 6 dB or impulse bandwidth of the filter.

Generally, to resolve two signals of equal amplitude, the resolution bandwidth must be less than or equal to the frequency separation of the two signals. If the bandwidth is equal to the separation and the video bandwidth is less than the resolution bandwidth, a dip of approximately 3 dB is seen between the peaks of the two equal signals, and it is clear that more than one signal is present.

For Signal Analyzers in swept mode, sweep time is automatically set to a value that is inversely proportional to the square of the resolution bandwidth ( $1/BW^2$ ), to keep the analyzer measurement calibrated. So, if the resolution bandwidth is reduced by a factor of 10, the sweep time is increased by a factor of 100 when sweep time and bandwidth settings are coupled. For the shortest measurement times, use the widest resolution bandwidth that still permits discrimination of all desired signals. Sweep time is also a function of which detector is in use, peak and normal detectors sweep as fast or more quickly than sample or average detectors. The analyzer allows RBW selections up to 8 MHz in 1, 3, 10 steps and it has the flexibility to fine tune RBWs in increments of 10% for a total of 160 RBW settings.

For best sweep times and keeping the analyzer calibrated set the sweep time (**Sweep/Control, Sweep Time**) to **Auto**, and the sweep type (**Sweep/Control, Sweep Setup, Sweep Type**) to **Auto**. Use the widest resolution bandwidth and the narrowest span that still permits resolution of all desired signals.

### Resolving small signals hidden by large signals

When dealing with the resolution of signals that are close together and not equal in amplitude, you must consider the shape of the IF filter of the analyzer, as well as its 3 dB bandwidth. (See [“Resolving signals of equal amplitude” on page 192](#) for more information.) The shape of a filter is defined by the selectivity, which is the ratio of the 60 dB bandwidth to the 3 dB bandwidth. If a small signal is too close to a larger signal, the smaller signal can be hidden by the skirt of the larger signal.

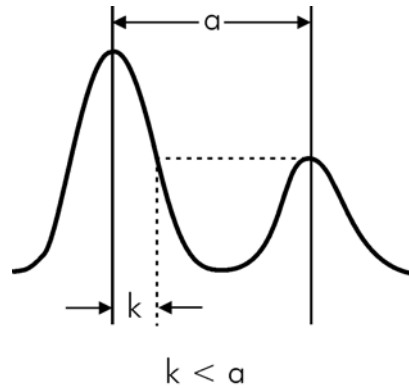


To view the smaller signal, select a resolution bandwidth such that **k** is less than **a** (see Figure 15-1). The separation between the two signals (**a**) must be greater than half the filter width of the larger signal (**k**), measured at the amplitude level of the smaller signal.

The digital filters in the analyzer have filter widths about one-third as wide as typical analog RBW filters. This enables you to resolve close signals with a wider RBW (for a faster sweep time).

Figure 15-1

*RBW Requirements for Resolving Small Signals*



## Trigger Concepts

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<b>NOTE</b>	The trigger functions let you select the trigger settings for a sweep or measurement. When using a trigger source other than Free Run, the analyzer will begin a sweep only with the selected trigger conditions are met. A trigger event is defined as the point at which your trigger source signal meets the specified trigger level and polarity requirements (if any). In FFT measurements, the trigger controls when the data is acquired for FFT conversion.
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### Selecting a trigger

#### 1. Free Run Triggering

Pressing this key, when it is not selected, selects free-run triggering. Free run triggering occurs immediately after the sweep/measurement is initiated.

Press **Trigger, Free Run**

#### 2. Video Triggering

The Video trigger condition is met when the video signal (the filtered and detected version of the input signal, including both RBW and VBW filtering) crosses the video trigger level. Video triggering triggers the measurement at the point at which the rising signal crosses the video trigger horizontal green line on the display:

Press **Trigger, Video, Video, Trigger Level, -30, dBm**. (If Video trigger has not already been selected, you need to press Video a second time to get to the Trigger Level function.)

#### 3. External Triggering

In the event that you have an external trigger available that can be used to synchronize with the burst of interest, connect the trigger signal to the rear of the analyzer using either the Trigger 1 In or Trigger 2 In input connector. It might be necessary to adjust the trigger level by rotating the front panel knob or by entering the numeric value on the keypad.

Press **Trigger, External 1** or **External 2, Trigger Level**, and adjust as necessary.

#### 4. RF Burst Wideband Triggering

RF burst triggering occurs in the IF circuitry chain, as opposed to after the video detection circuitry with video triggering. In the event video triggering is used, the detection filters are limited to the maximum width of the resolution bandwidth filters. Set the analyzer in RF burst trigger mode.

Press **Trigger, RF Burst**.

#### 5. Line Triggering

Line triggering selects the line signal as the trigger. A new sweep/measurement will start synchronized with the next cycle of the line voltage. Pressing this key, when it is already selected, access the line trigger setup menu.

Press **Trigger, Line**.

## 6. Periodic Timer Triggering

This feature selects the internal periodic timer signal as the trigger. Trigger occurrences are set by the **Periodic Timer** parameter, which is modified by the **Sync Source** and **Offset**. [Figure 15-2](#) shows the action of the periodic timer trigger. Before reviewing the figure, we'll explain some uses for the periodic trigger.

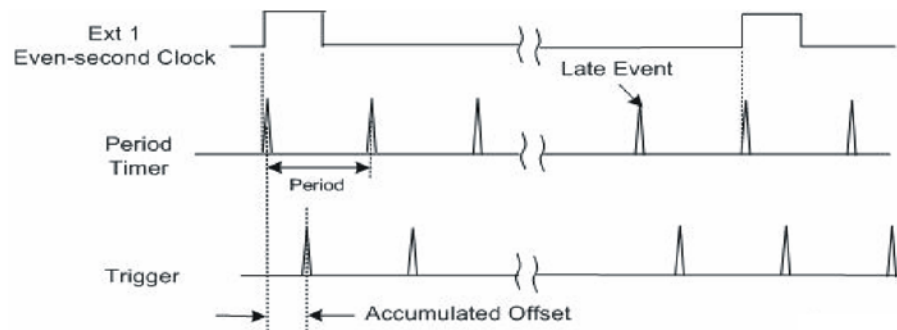
A common application is measuring periodic burst RF signals for which a trigger signal is not easily available. For example, we might be measuring a TDMA radio which bursts every 20 ms. Let's assume that the 20 ms period is very consistent. Let's also assume that we do not have an external trigger source available that is synchronized with the period, and that the signal-to-noise ratio of the signal is not high enough to provide a clean RF burst trigger at all of the analysis frequencies. For example, we might want to measure spurious transmissions at an offset from the carrier that is larger than the bandwidth of the RF burst trigger. In this application, we can set the **Periodic Timer** to a 20.00 ms period and adjust the offset from that timer to position our trigger just where we want it. If we find that the 20.00 ms is not exactly right, we can adjust the period slightly to minimize the drift between the period timer and the signal to be measured.

A second way to use this feature would be to use **Sync Source** temporarily, instead of **Offset**. In this case, we might tune to the signal in a narrow span and use the **RF Burst** trigger to synchronize the periodic timer. Then we would turn the sync source off so that it would not mistrigger. Mistriggering can occur when we are tuned so far away from the RF burst trigger that it is no longer reliable.

A third example would be to synchronize to a signal that has a reference time element of much longer period than the period of interest. In some CDMA applications, it is useful to look at signals with a short periodicity, by synchronizing that periodicity to the “even-second clock” edge that happens every two seconds. Thus, we could connect the even-second clock trigger to Ext1 and use then Ext1 as the sync source for the periodic timer.

The figure below illustrates this third example. The top trace represents the even-second clock. It causes the periodic timer to synchronize with the leading edge shown. The analyzer trigger occurs at a time delayed by the accumulated offset from the period trigger event. The periodic timer continues to run, and triggers continue to occur, with a periodicity determined by the analyzer time base. The timer output (labeled “late event”) will drift away from its ideal time due to imperfect matching between the time base of the signal being measured and the time base of the analyzer, and also because of imperfect setting of the period parameter. But the synchronization is restored on the next even-second clock event. (“Accumulated offset” is described in the **Offset** function section.)

Figure 15-2 Frame Triggering



a. **Period**

Sets the period of the internal periodic timer clock. For digital communications signals, this is usually set to the frame period of your current input signal. In the case that sync source is not set to OFF, and the external sync source rate is changed for some reason, the periodic timer is synchronized at the every external synchronization pulse by resetting the internal state of the timer circuit.

Press **Trigger**, **Periodic Timer**.

b. **Offset**

Adjusts the accumulated offset between the periodic timer events and the trigger event. Adjusting the accumulated offset is different than setting an offset, and requires explanation.

The periodic timer is usually unsynchronized with any external events, so the timing of its output events has no absolute meaning. Since the timing relative to external events (RF signals) is important, you need to be able to adjust (offset) it. However, you have no direct way to see when the periodic timer events occur. All that you can see is the trigger timing. When you want to adjust the trigger timing, you will be changing the internal offset between the periodic timer events and the trigger event. Because the absolute value of that internal offset is unknown, we will just call that the accumulated offset.

Whenever the **Offset** parameter is changed, you are changing that accumulated offset. You can reset the displayed offset using **Reset Offset Display**. Changing the display does not change the value of the accumulated offset, and you can still make additional changes to accumulated offset.

Press **Trigger**, **Periodic Timer**.

c. **Reset Offset Display**

Resets the value of the periodic trigger offset display setting to 0.0 seconds. The current displayed trigger location may include an offset value defined with the **Offset** key. Pressing this key redefines the currently displayed trigger location as the new trigger point that is 0.0 s offset. The **Offset** key can then be used to add offset relative to this new timing

Press **Trigger**, **Periodic Timer**.

## Time Gating Concepts

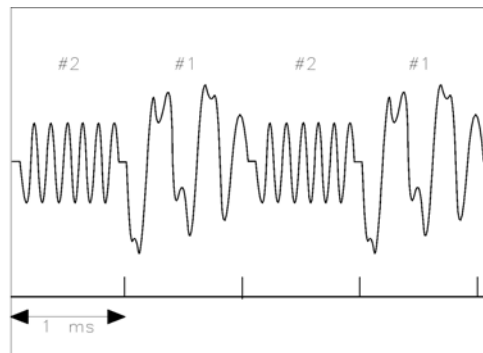
### Introduction: Using Time Gating on a Simplified Digital Radio Signal

This section shows you the concepts of using time gating on a simplified digital radio signal. The section on Making Time-Gated Measurements demonstrates time gating examples.

Figure 15-3 shows a signal with two radios, radio 1 and radio 2, that are time-sharing a single frequency channel. Radio 1 transmits for 1 ms then radio 2 transmits for 1 ms.

Figure 15-3

*Simplified Digital Mobile-Radio Signal in Time Domain*



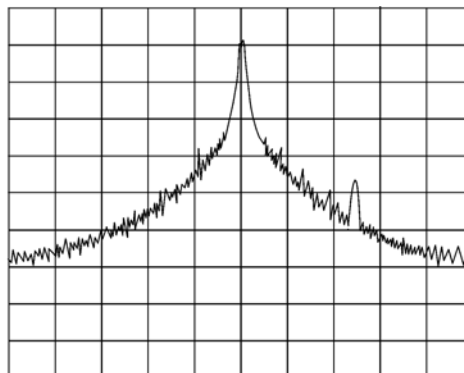
oj154e

We want to measure the unique frequency spectrum of each transmitter.

A signal analyzer without time gating cannot do this. By the time the signal analyzer has completed its measurement sweep, which lasts about 50 ms, the radio transmissions switch back and forth 25 times. Because the radios are both transmitting at the same frequency, their frequency spectra overlap, as shown in Figure 15-4. The signal analyzer shows the combined spectrum; you cannot tell which part of the spectrum results from which signal.

Figure 15-4

*Frequency Spectra of the Combined Radio Signals*



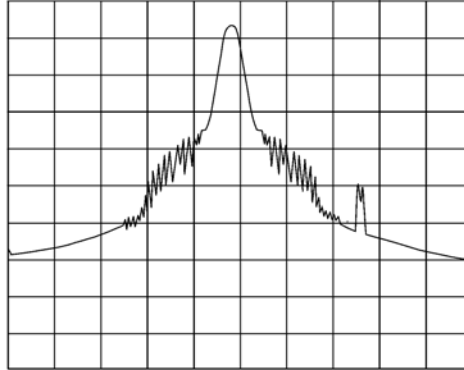
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## Concepts

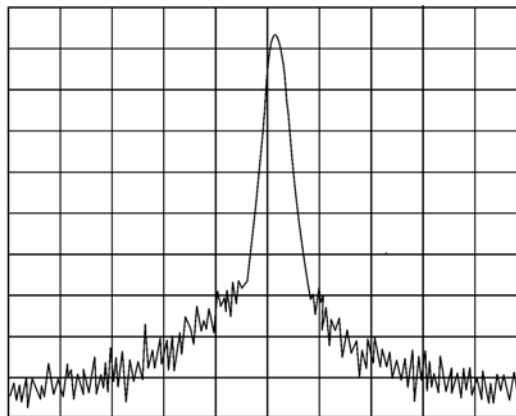
### Time Gating Concepts

Time gating allows you to see the separate spectrum of radio 1 or radio 2 to determine the source of the spurious signal, as shown in [Figure 15-5](#)

*Figure 15-5*      *Time-Gated Spectrum of Radio 1*



*Figure 15-6*      *Time-Gated Spectrum of Radio 2*



Time gating lets you define a time window (or time gate) of when a measurement is performed. This lets you specify the part of a signal that you want to measure, and exclude or mask other signals that might interfere.

## How time gating works

Time gating is achieved by the signal analyzer selectively interrupting the path of the detected signal, with a gate, as shown in Figure 15-9 and Figure 15-8. The gate determines the times at which it captures measurement data (when the gate is turned “on,” under the Gate menu, the signal is being passed, otherwise when the gate is “off,” the signal is being blocked). Under the right conditions, the only signals that the analyzer measures are those present at the input to the analyzer when the gate is on. With the correct signal analyzer settings, all other signals are masked out.

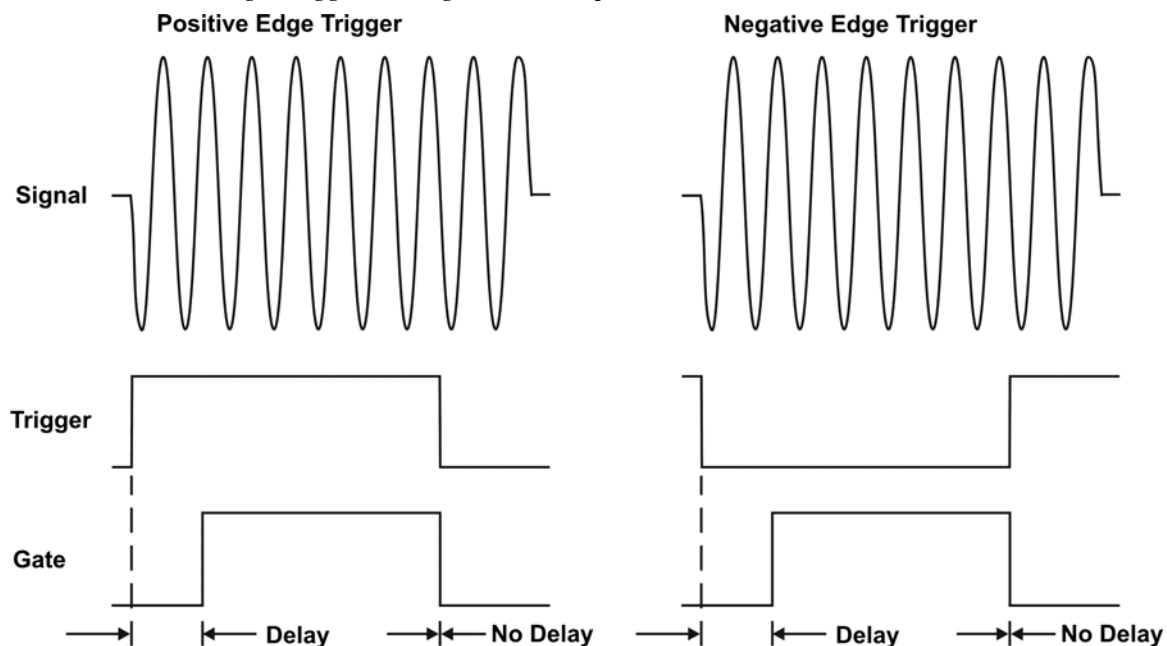
There are typically two main types of gating conditions, **edge** and **level**:

- With edge gating, the gate timing is controlled by user parameters (gate delay and gate length) following the selected (rising or falling) edge of the trigger signal. The gate passes a signal on the edge of the trigger signal (after the gate delay time has been met) and blocks the signal at the end of the gate length.

With edge gating, the gate control signal is usually an external periodic TTL signal that rises and falls in synchronization with the rise and fall of the pulsed radio signal. The gate delay is the time the analyzer waits after the trigger event to enable the gate (see Figure 15-7).

- With level gating, the gate will pass a signal when the gate signal meets the specified level (high or low). The gate blocks the signal when the level conditions are no longer satisfied (level gating does not use gate length or gate delay parameters).

Figure 15-7 Edge Trigger Timing Relationships



With Keysight signal analyzers, there are three different implementations for time gating: gated LO, gated video and gated FFT.

### Gated video concepts

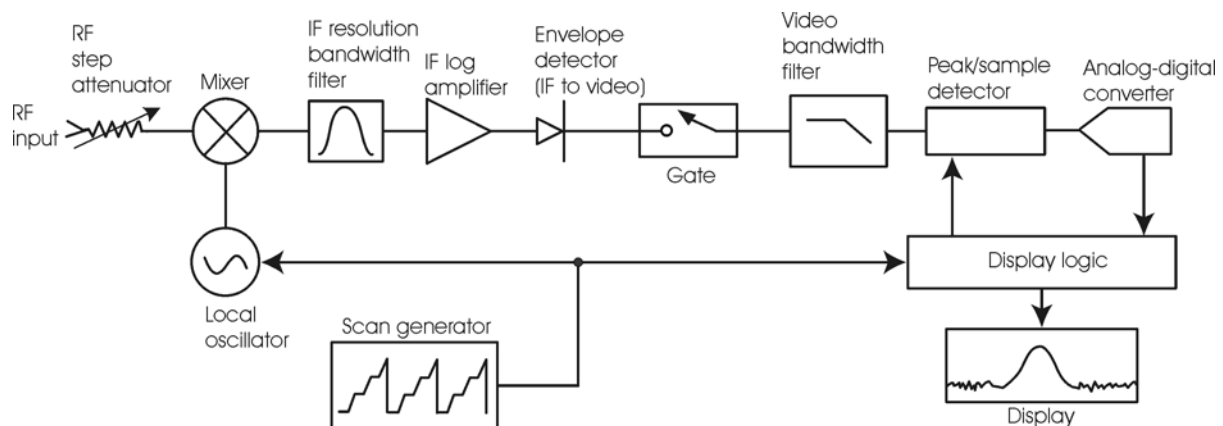
Gated video may be thought of as a simple gate switch, which connects the signal to the input of the signal analyzer. When the gate is “on” (under the Gate menu) the gate is passing a signal. When the gate is “off,” the gate is blocking the signal. Whenever the gate is passing a signal, the analyzer sees the signal. In [Figure 15-8](#) notice that the gate is placed after the envelope detector and before the video bandwidth filter in the IF path (hence “gated video”).

The RF section of the signal analyzer responds to the signal. The selective gating occurs before the video processing. This means that there are some limitations on the gate settings because of signal response times in the RF signal path.

With video gating the analyzer is continually sweeping, independent of the position and length of the gate. The analyzer must be swept at a minimum sweep time (see the sweep time calculations later in this chapter) to capture the signal when the gate is passing a signal. Because of this, video gating is typically slower than gated LO and gated FFT.

Figure 15-8

Gated Video Signal Analyzer Block Diagram

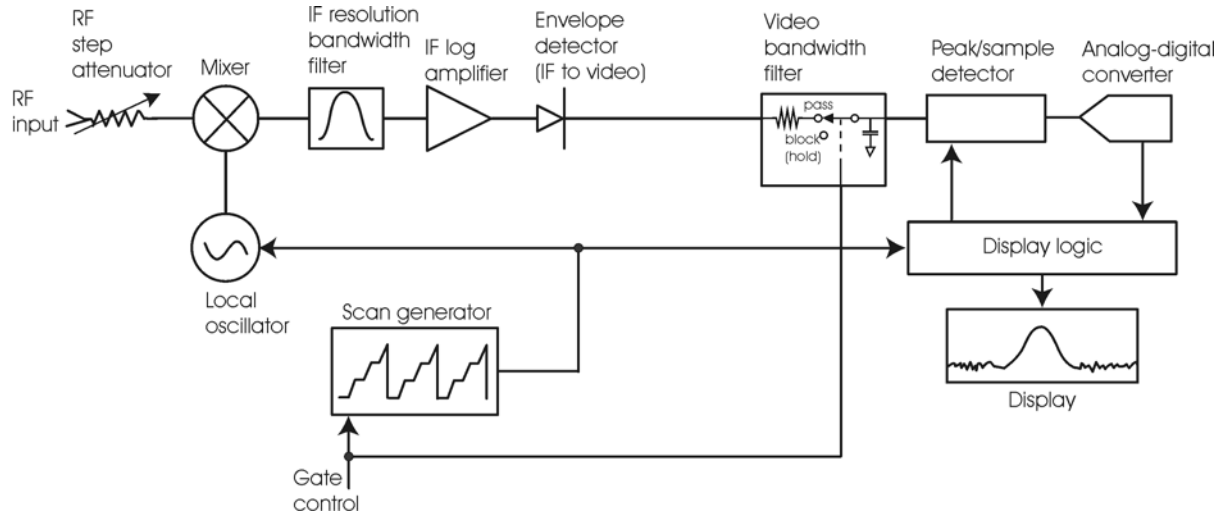


### Gated LO Concepts

Gated LO is a very sophisticated type of time gating that sweeps the LO only while the gate is “on” and the gate is passing a signal. See [Figure 15-9](#) for a simplified block diagram of gated LO operation. Notice that the gate control signal controls when the scan generator is sweeping and when the gate passes or blocks a signal. This allows the analyzer to sweep only during the periods when the gate passes a signal. Gated LO is faster than Gated Video because Gated Video must constrain sweep time so that each point is long enough to include a burst event. On the other hand, when in Gated LO, multiple points may be swept during each gate.



Figure 15-9 Gated LO Signal Analyzer Block Diagram



### Gated FFT Concepts

Gated FFT (Fast-Fourier Transform) is an FFT measurement which begins when the trigger conditions are satisfied.

The process of making a spectrum measurement with FFTs is inherently a “gated” process, in that the spectrum is computed from a time record of short duration, much like a gate signal in swept-gated analysis.

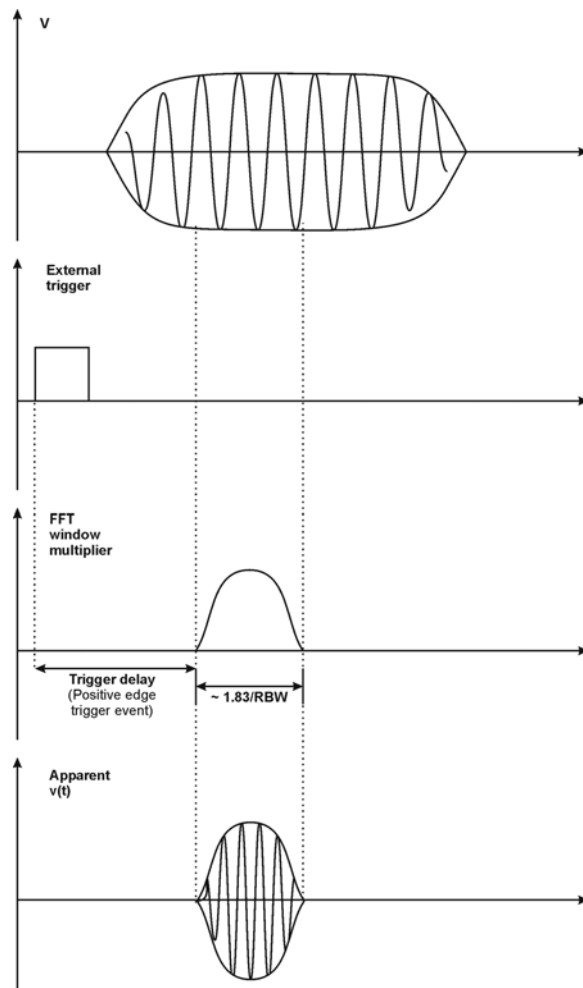
Using the analyzer in FFT mode, the duration of the time record to be gated is:

$$FFT \text{ Time Record (to be gated)} = \frac{1.83}{RBW}$$

The duration of the time record is within a tolerance of approximately 3% for resolution bandwidths up through 1 MHz. Unlike swept gated analysis, the duration of the analysis in gated FFT is fixed by the RBW, not by the gate signal. Because FFT analysis is faster than swept analysis (up to 7.99 MHz), the gated FFT measurements can have better frequency resolution (a narrower RBW) than swept analysis for a given duration of the signal to be analyzed.

Figure 15-10

Gated FFT Timing Diagram



### Time gating basics (Gated LO and Gated Video)

The gate passes or blocks a signal with the following conditions:

- **Trigger condition** - Usually an external transistor-transistor logic (TTL) periodic signal for edge triggering and a high/low TTL signal for level triggering.
- **Gate delay** - The time after the trigger condition is met when the gate begins to pass a signal.
- **Gate length** - The gate length setting determines the length of time a gate begins to pass a signal.

To understand time gating better, consider a spectrum measurement performed on two pulsed-RF signals sharing the same frequency spectrum. You will need to consider the timing interaction of three signals with this example:

- The composite of the two pulsed-RF signals.
- The gate trigger signal (a periodic TTL level signal).

- The gate signal. This TTL signal is low when the gate is “off” (blocking) and high when the gate is “on” (passing).

The timing interactions between the three signals are best understood if you observe them in the time domain (see [Figure 15-11](#)).

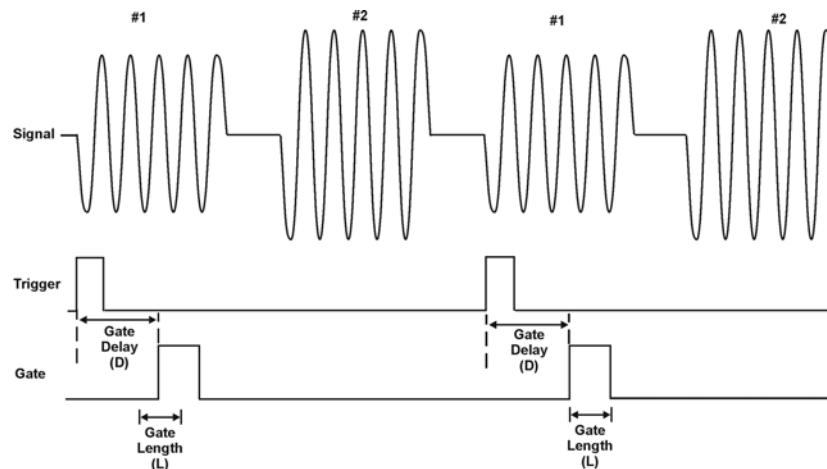
The main goal is to measure the spectrum of signal 1 and determine if it has any low-level modulation or spurious signals.

Because the pulse trains of signal 1 and signal 2 have almost the same carrier frequency, their spectra overlap. Signal 2 will dominate in the frequency domain due to its greater amplitude. Without gating, you won't see the spectrum of signal 1; it is masked by signal 2.

To measure signal 1, the gate must be on only during the pulses from signal 1. The gate will be off at all other times, thus excluding all other signals. To position the gate, set the gate delay and gate length, as shown in [Figure 15-11](#), so that the gate is on only during some central part of the pulse. Carefully avoid positioning the gate over the rising or falling pulse edges. When gating is activated, the gate output signal will indicate actual gate position in time, as shown in the line labeled “Gate.”

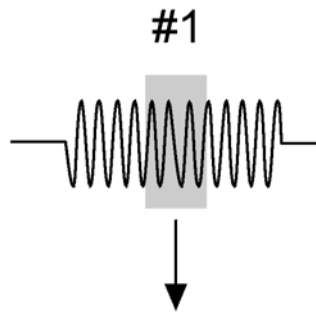
*Figure 15-11*

*Timing Relationship of Signals During Gating*



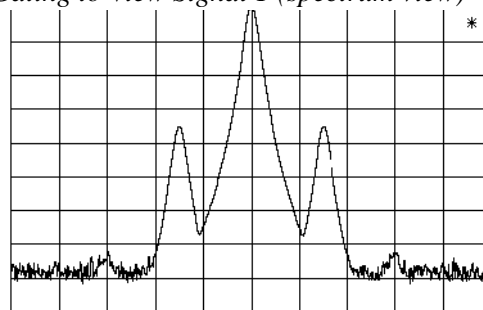
Once the signal analyzer is set up to perform the gate measurement, the spectrum of signal 1 is visible and the spectrum of signal 2 is excluded, as shown in [Figure 15-13](#). In addition, when viewing signal 1, you also will have eliminated the pulse spectrum generated from the pulse edges. Gating has allowed you to view spectral components that otherwise would be hidden.

Figure 15-12      Signal within pulse #1 (time-domain view)



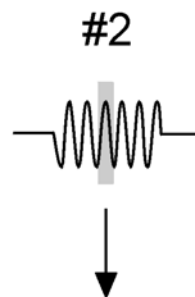
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Figure 15-13      Using Time Gating to View Signal 1 (spectrum view)



Moving the gate so that it is positioned over the middle of signal 2 produces a result as shown in [Figure 15-15](#). Here, you see only the spectrum within the pulses of signal 2; signal 1 is excluded.

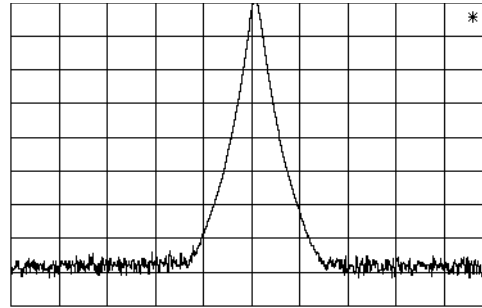
Figure 15-14      Signal within pulse #2 (time-domain view)



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Figure 15-15

Using Time Gating to View Signal 2 (spectrum view)



## Measuring a complex/unknown signal

### NOTE

The steps below help to determine the signal analyzer settings when using time gating. The steps apply to the time gating approaches using gated LO and gated video.

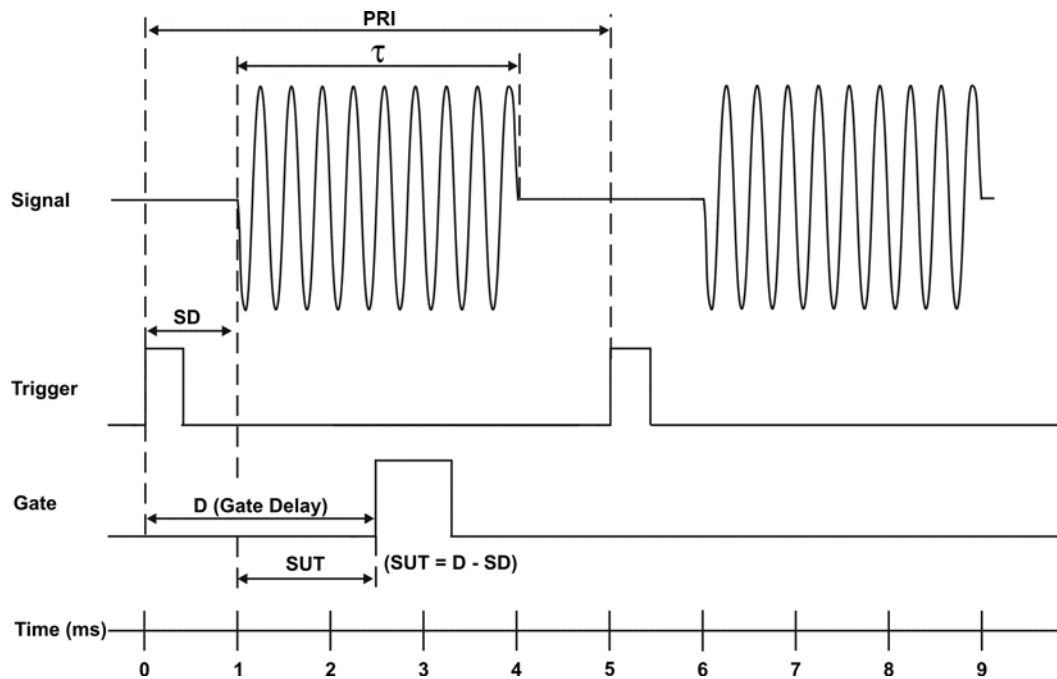
This example shows you how to use time gating to measure a very specific signal. Most signals requiring time gating are fairly complex and in some cases extra steps may be required to perform a measurement.

**Step 1.** Determine how your signal under test appears in the time domain and how it is synchronized to the trigger signal.

You need to do this to position the time gate by setting the delay relative to the trigger signal. To set the delay, you need to know the timing relationship between the trigger and the signal under test. Unless you already have a good idea of how the two signals look in the time domain, you can examine the signals with an oscilloscope to determine the following parameters:

- Trigger type (edge or level triggering)
- Pulse repetition interval (PRI), which is the length of time between trigger events (the trigger period).
- Pulse width, or  $\tau$
- Signal delay (SD), which is the length of time occurring between the trigger event and when the signal is present and stable. If your trigger occurs at the same time as the signal, signal delay will be zero.

Figure 15-16 Time-domain Parameters



In Figure 15-16, the parameters are:

- Pulse repetition interval (PRI) is 5 ms.
- Pulse width ( $\tau$ ) is 3 ms.
- Signal delay (SD) is 1 ms for positive edge trigger (0.6 ms for negative edge trigger).
- Gate delay (D) is 2.5 ms.
- Setup time (SUT) is 1.5 ms.

**Step 2.** Set the signal analyzer sweep time:

**Gated LO:** Sweep time does not affect the results of gated LO unless the sweep time is set too fast. In the event the sweep time is set too fast, Meas Uncal appears on the screen and the sweep time will need to be increased.

**Gated Video:** Sweep time does affect the results from gated video. The sweep time must be set accordingly for correct time gating results. The recommended sweep time is at least the number of **sweep points – 1** multiplied by the **PRI (pulse repetition interval)**. Measurements can be made with sweep times as fast as  $(\text{sweep points} - 1) * (\text{PRI} - \tau)$ .

**Step 3.** Locate the signal under test on the display of the signal analyzer. Set the center frequency and span to view the signal characteristics that you are interested in measuring. Although the analyzer is not yet configured for correct gated measurements, you will want to determine the approximate frequency and span in

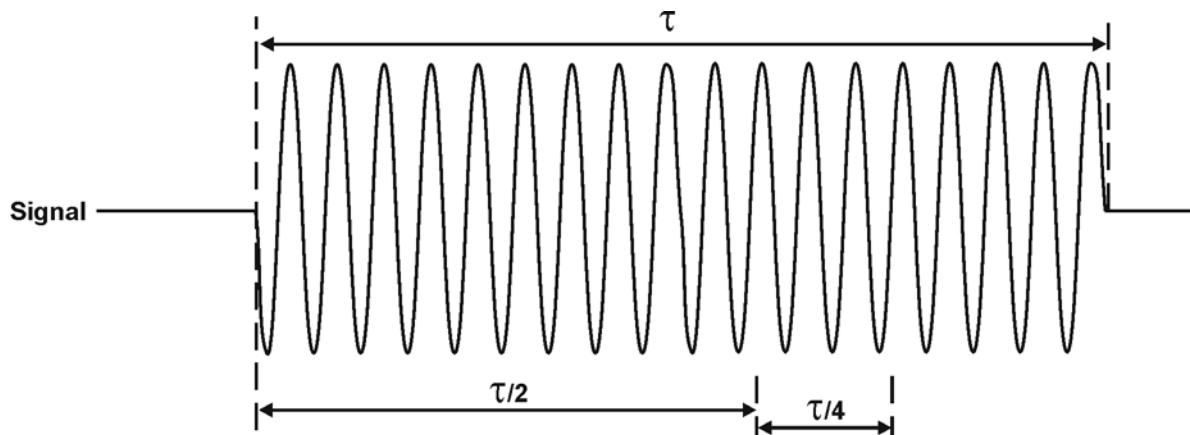
which to display the signal of interest. If the signal is erratic or intermittent, you may want to hold the maximum value of the signal with **Max Hold** (located under the **Trace/Detector** menu) to determine the frequency of peak energy.

To optimize measurement speed in the Gated LO case, set the span narrow enough so that the display will still show the signal characteristics you want to measure. For example, if you wanted to look for spurious signals within a 200 kHz frequency range, you might set the frequency span to just over 200 kHz.

**Step 4.** Determine the setup time and signal delay to set up the gate signal. Turn on the gate and adjust the gate parameters including gate delay and gate length as shown below.

Generally, the gate should be positioned over a part of the signal that is stable, not over a pulse edge or other transition that might disturb the spectrum. Starting the gate at the center of the pulse gives a setup time of about half the pulse width. Setup time describes the length of time during which that signal is present and stable before the gate comes on. The setup time (SUT) must be long enough for the RBW filters to settle following the burst-on transients. Signal delay (SD) is the length of time after the trigger, but before the signal of interest occurs and becomes stable. If the trigger occurs simultaneously with the signal of interest, SD is equal to zero, and SUT is equal to the gate delay. Otherwise, SUT is equal to the gate delay minus SD. See [Figure 15-17](#)

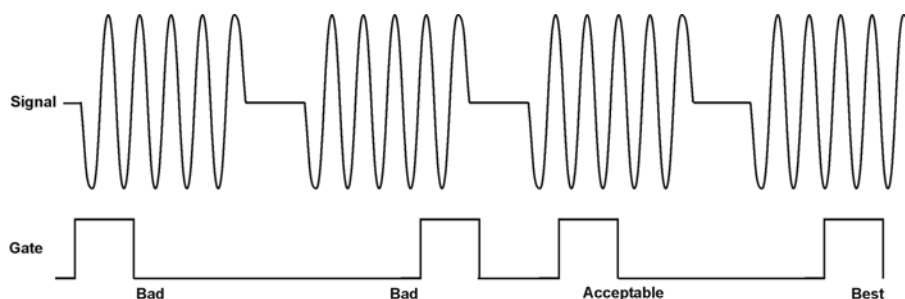
Figure 15-17 Positioning the Gate



There is flexibility in positioning the gate, but some positions offer a wider choice of resolution bandwidths. A good rule of thumb is to position the gate from 20 % to 90 % of the burst width. Doing so provides a reasonable compromise between setup time and gate length.

Figure 15-18

*Best Position for Gate*



As a general rule, you will obtain the best measurement results if you position the gate relatively late within the signal of interest, but without extending the gate over the trailing pulse edge or signal transition. Doing so maximizes setup time and provides the resolution bandwidth filters of the signal analyzer the most time to settle before a gated measurement is made. “Relatively late,” in this case, means allowing a setup time of at least  $3.84/\text{resolution bandwidth}$  (see [step 5](#) for RBW calculations).

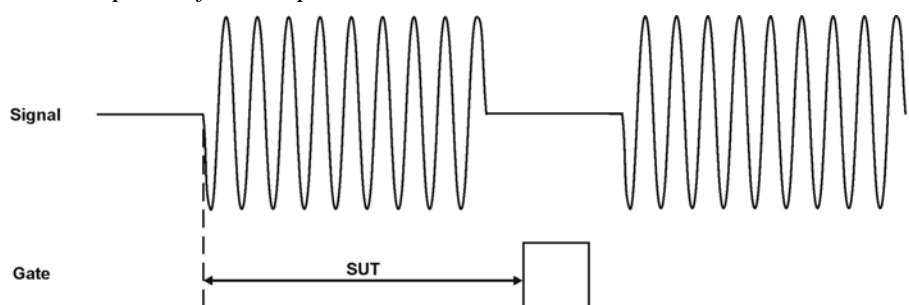
As an example, if you want to use a 1 kHz resolution bandwidth for measurements, you will need to allow a setup time of at least 3.84 ms.

Note that the signal need not be an RF pulse. It could be simply a particular period of modulation in a signal that is continuously operating at full power, or it could even be during the off time between pulses. Depending on your specific application, adjust the gate position to allow for progressively longer setup times (ensuring that the gate is not left on over another signal change such as a pulse edge or transient), and select the gate delay and length that offer the best representation of the signal characteristics of interest on the display.

If you were measuring the spectrum occurring between pulses, you should use the same (or longer) setup time after the pulse goes away, but before the gate goes on. This lets the resolution bandwidth filters fully discharge the large pulse before the measurement is made on the low-level interpulse signal.

Figure 15-19

*Setup Time for Interpulse Measurement*



**Step 5.** The resolution bandwidth will need to be adjusted for gated LO and gated video. The video bandwidth will only need to be adjusted for gated video.

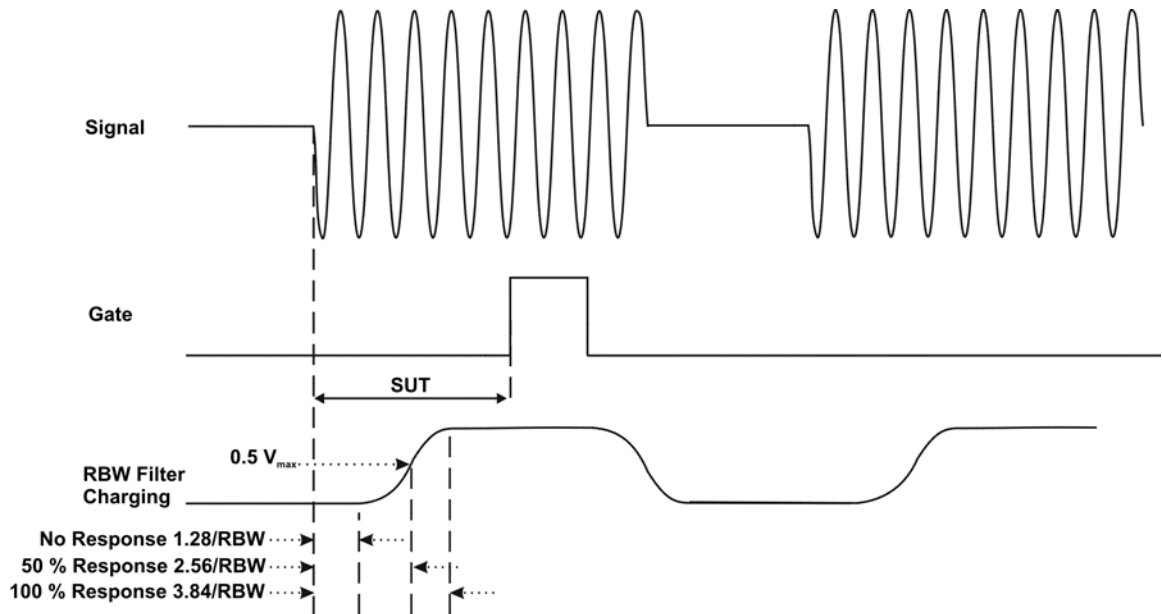
**Resolution Bandwidth:**



The resolution bandwidth you can choose is determined by the gate position, so you can trade off longer setup times for narrower resolution bandwidths. This trade-off is due to the time required for the resolution-bandwidth filters to fully charge before the gate comes on. Setup time, as mentioned, is the length of time that the signal is present and stable before the gate comes on.

Figure 15-20

Resolution Bandwidth Filter Charge-Up Effects



Because the resolution-bandwidth filters are band-limited devices, they require a finite amount of time to react to changing conditions. Specifically, the filters take time to charge fully after the analyzer is exposed to a pulsed signal.

Because setup time should be greater than filter charge times, be sure that:

$$SUT > \frac{3.84}{RBW}$$

where SUT is the same as the gate delay in this example. In this example with SUT equal to 1.5 ms, RBW is greater than 2.56 kHz; that is, RBW is greater than 1333 Hz. The resolution bandwidth should be set to the next larger value, 2.7 kHz.

#### Video Bandwidth:

For gated LO measurements the VBW filter acts as a track-and-hold between sweep times. With this behavior, the VBW does not need to resettle on each restart of the sweep.

#### Step 6. Adjust span as necessary, and perform your measurement.

The analyzer is set up to perform accurate measurements. Freeze the trace data by activating single sweep, or by placing your active trace in view mode. Use the markers to measure the signal parameters you chose in step 1. If necessary, adjust span, but do not decrease resolution bandwidth, video bandwidth, or sweep time.

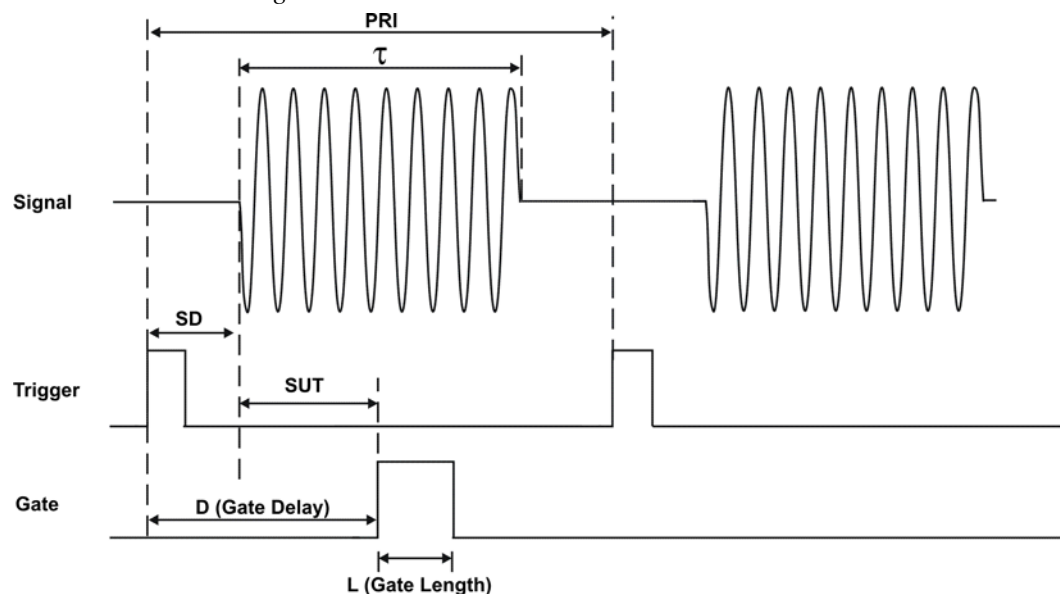
## “Quick Rules” for making time-gated measurements

This section summarizes the rules described in the previous sections.

Table 15-1 *Determining Signal Analyzer Settings for Viewing a Pulsed RF Signal*

Signal Analyzer Function	Signal Analyzer Setting	Comments
Sweep Time (gated video only)	Set the sweep time to be equal to or greater than (number of sweep points - 1) $\times$ pulse repetition interval (PRI):	Because the gate must be on at least once per trace point, the sweep time should be set such that the sweep time for each trace point is greater than or equal to the pulse repetition interval.
Gate Delay	The gate delay is equal to the signal delay plus one-fourth the pulse width: $\text{Gate Delay} = \text{Signal Delay} + \tau/5$	The gate delay must be set so that the gating captures the pulse. If the gate delay is too short or too long, the gating can miss the pulse or include resolution band width transient responses.
Gate Length	The gate length minimum is equal to one-fourth the pulse width (maximum about one-half): $\text{Gate Length} = 0.7 \times \tau/4$	If the gate length is too long, the signal display can include transients caused by the signal analyzer filters.  The recommendation for gate placement can be between 20 % to 90 % of the pulse width.
Resolution Band width	Set the resolution band width: $\text{RBW} > 19.5/\tau$	The resolution band width must be wide enough so that the charging time for the resolution band width filters is less than the pulse width of the signal.

Figure 15-21 *Gate Positioning Parameters*



Most control settings are determined by two key parameters of the signal under test: the pulse repetition interval (PRI) and the pulse width ( $\tau$ ). If you know these parameters, you can begin by picking some standard settings. [Table 15-2](#) summarizes the parameters for a signal whose trigger event occurs at the same time as the beginning of the pulse (in other words, SD is 0). If your signal has a non-zero delay, just add it to the recommended gate delay.

*Table 15-2 Suggested Initial Settings for Known Pulse Width ( $\tau$ ) and Zero Signal Delay*

Pulse width ( $\tau$ )	Gate Delay (SD + $\tau/5$ )	Resolution Band width ( $>19.5/\tau$ )	Gate Length ( $0.7 \times \tau/4$ )
4 $\mu$ s	0.8 $\mu$ s	4.875 MHz	0.7 $\mu$ s
10 $\mu$ s	2 $\mu$ s	1.95 MHz	1.753 $\mu$ s
50 $\mu$ s	10 $\mu$ s	390 kHz	8.75 $\mu$ s
63.5 $\mu$ s	12.7 $\mu$ s	307 kHz	11.11 $\mu$ s
100 $\mu$ s	20 $\mu$ s	195 kHz	17.5 $\mu$ s
500 $\mu$ s	100 $\mu$ s	39 kHz	87.5 $\mu$ s
1 ms	200 $\mu$ s	19.5 kHz	0.175 ms
5 ms	1 ms	3.9 kHz	0.875 ms
10 ms	2 ms	1.95 kHz	1.75 ms
16.6 ms	3.32 ms	1.175 kHz	2.905 ms
33 ms	6.6 ms	591 Hz	5.775 ms
50 ms	10 ms	390 Hz	8.75 ms
100 ms	20 ms	195 Hz	17.5 ms
$\geq 130$ ms	26 ms	151 Hz	22.75 ms

*Table 15-3 If You Have a Problem with the Time-Gated Measurement*

Symptom	Possible Causes	Suggested Solution
Erratic analyzer trace with dropouts that are not removed by increasing analyzer sweep time; oscilloscope view of gate output signal jumps erratically in time domain.	Gate Delay may be greater than trigger repetition interval.	Reduce Gate Delay until it is less than trigger interval.  Check <b>Gate View</b> to make sure the gate delay is timed properly.

Table 15-3 *If You Have a Problem with the Time-Gated Measurement*

Symptom	Possible Causes	Suggested Solution
Gate does not trigger.	1) Gate trigger voltage may be wrong. 2) Gate may not be activated. 3) <b>Gate Source</b> selection may be wrong.	With external gate trigger: ensure that the trigger threshold is set near the midpoint of the waveform (view the waveform on an oscilloscope using high input impedance, not 50 $\Omega$ ). With RF Burst Gate Source: ensure that the start and stop frequencies are within 10 MHz of the center frequency of the carrier. Check to see if other connections to trigger signal may be reducing voltage. If using an oscilloscope, check that all inputs are high impedance, not 50 $\Omega$ .
Display spectrum does not change when the gate is turned on.	Insufficient setup time.	Increase setup time for the current resolution bandwidth, or increase resolution bandwidth.
Displayed spectrum too low in amplitude.	Resolution bandwidth or video bandwidth filters not charging fully.	Widen resolution bandwidth or video bandwidth, or both.

## Using the Edge Mode or Level Mode for triggering

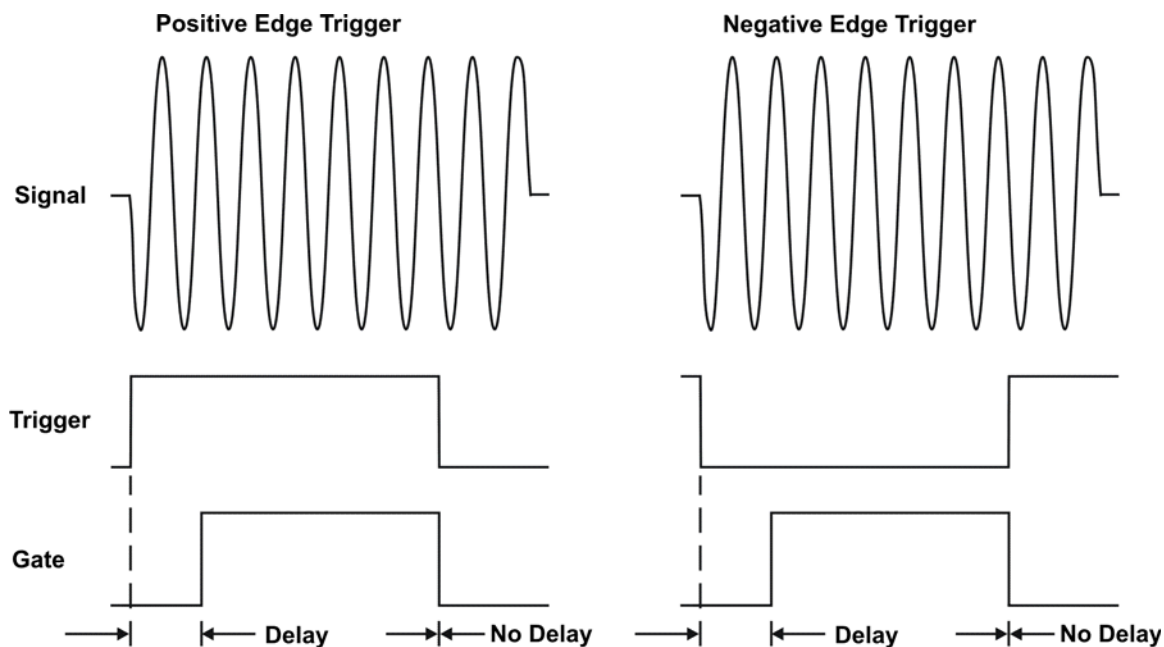
Depending on the trigger signal that you are working with, you can trigger the gate in one of two separate modes: edge or level. This gate-trigger function is separate from the normal external trigger capability of the signal analyzer, which initiates a sweep of a measurement trace based on an external signal.

### Edge Mode

Edge mode lets you position the gate relative to either the rising or falling edge of a trigger signal. The left diagram of Figure 15-22 shows triggering on the positive edge of the trigger signal while the right diagram shows negative edge triggering.

Example of key presses to initiate positive edge triggering:  
Press **Sweep, Gate, More, Polarity (Pos)**.

Figure 15-22 Using Positive or Negative Edge Triggering



### Level Mode

In level gate-control mode, an external trigger signal opens and closes the gate. Either the TTL high level or TTL low level opens the gate, depending on the setting of **Trig Slope**. Gate delay affects the start of the gate but not the end. Gate length is applicable when using level mode triggering. Level mode is useful when your trigger signal occurs at exactly the same time as does the portion of the signal you want to measure.

## Noise measurements using Time Gating

Time gating can be used to measure many types of signals. Noise and noise-like signals are often a special case in spectrum analysis. With the history of gated measurements, these signals are especially noteworthy.

The average detector is the best detector to use for measuring noise-like signals because it uses all the available noise power all the time in its measurement. The sample detector is also a good choice because it, too, is free from the peak biases of the peak detector, normal and negative peak detectors.

When using the average or sample detector, noise density measurements using the noise marker or band/interval density marker can be made without any consideration of the use of gating--gated measurements work just as well as non-gated measurements. Thus, the average detector is recommended for noise density measurements.

Older analyzers only had the gated video version of gating available, and these only worked with the peak detector, so the rest of this section will discuss the trade-offs associated with trying to replicate these measurements with an X-Series analyzer.

Unlike older analyzers, X-Series analyzers can make competent measurements of noise density using the noise marker with all detectors, not just those that are ideal for noise measurements. Thus, X-Series analyzers can make noise density measurements with peak detection, compensating for the extent to which peak detection increases the average response of the analyzer to noise. When comparing a gated video measurement using the noise marker between an X-Series and an older analyzer where both use the peak detector, the X-Series answer will be approximately correct, while the older analyzer will need a correction factor. That correction factor is discussed in Keysight Technologies Application Note 1303, Spectrum Analyzer Measurements and Noise, in the section on Peak-detected Noise and TDMA ACP Measurements.

When making measurements of Band/Interval Power or Band/Interval Density, the analyzer does not make compensations for peak detection. For best measurements with these marker functions, average or sample detection should be used.

## AM and FM Demodulation Concepts

### Demodulating an AM signal using the analyzer as a fixed tuned receiver (Time-Domain)

The zero span mode can be used to recover amplitude modulation on a carrier signal.

The following functions establish a clear display of the waveform:

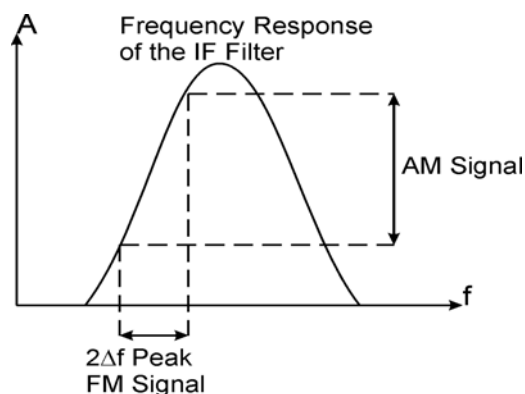
- Triggering stabilizes the waveform trace by triggering on the modulation envelope. If the modulation of the signal is stable, video trigger synchronizes the sweep with the demodulated waveform.
- Linear display mode should be used in amplitude modulation (AM) measurements to avoid distortion caused by the logarithmic amplifier when demodulating signals.
- Sweep time to view the rate of the AM signal.
- RBW and VBW are selected according to the signal bandwidth.

### Demodulating an FM signal using the analyzer as a fixed tuned receiver (Time-Domain)

To recover the frequency modulated signal, a spectrum analyzer can be used as a manually tuned receiver (zero span). However, in contrast to AM, the signal is not tuned into the passband center, but to one slope of the filter curve as [Figure 15-23](#)

Figure 15-23

*Determining FM Parameters using FM to AM Conversion*



Here the frequency variations of the FM signal are converted into amplitude variations (FM to AM conversion) utilizing the slope of the selected bandwidth filter. The reason we want to measure the AM component is that the envelope detector responds only to AM variations. There are no changes in amplitude if the frequency changes of the FM signal are limited to the flat part of the RBW (IF filter). The resultant AM signal is then detected with the envelope detector and displayed in the time domain.

## **IQ Analysis Concepts**

### **Purpose**

IQ Analysis (Basic) mode is used to capture complex time domain data from wide bandwidth RF signals. This mode preserves the instantaneous vector relationships of time, frequency, phase and amplitude contained within the selected digitizer span or analysis BW, at the analyzer's center frequency, for output as IQ data. This IQ data can then be utilized internally or output over LAN, USB or GPIB for use with external analysis tools. Each measurement description specifies the types of data available remotely for that measurement.

Within the IQ Analyzer mode, basic frequency domain, time domain and IQ measurements are available as initial signal and data verification tools in preparation for deriving the IQ data output. This is accomplished using the Complex Spectrum and IQ Waveform measurements. Although Complex Spectrum and IQ Waveform are defined as measurements in the IQ Analyzer (Basic) mode, they act primarily as tools to verify the signals and data as stated above.

### **Complex Spectrum measurement**

#### **Purpose**

This measurement is FFT (Fast Fourier Transform) based. The FFT-specific parameters are located in the **Advanced** menu. The Complex Spectrum measurement provides a display in the upper window of power versus frequency with current (yellow trace) and average (blue trace) data. In addition, an IQ waveform of voltage versus time is provided in the lower window. One advantage of having an I/Q view available while in the spectrum measurement is that it allows you to view complex components of the same signal without changing settings or measurements.

#### **Measurement method**

The measurement uses digital signal processing to sample the input signal and convert it to the frequency domain. With the instrument tuned to a fixed center frequency, samples are digitized at a high rate, converted to I and Q components with DSP hardware, and then converted to the frequency domain with FFT software.

#### **Troubleshooting hints**

Changes made by the user to advanced spectrum settings, particularly to ADC range settings, can inadvertently result in spectrum measurements that are invalid and cause error messages to appear. Care needs to be taken when using advanced features.



## **IQ Waveform Measurement**

### **Purpose**

The IQ Waveform measurement provides a time domain view of the RF signal envelope with power versus time or an IQ waveform with the I and Q signal waveforms in parameters of voltage versus time. The RF Envelope view provides the power versus time display, and the I/Q Waveform view provides the voltage versus time display. One advantage of having an I/Q Waveform view available while making a waveform measurement is that it allows you to view complex components of the same signal without changing settings or measurements.

The waveform measurement can be used to perform general purpose power measurements in the time domain with excellent accuracy.

### **Measurement method**

The instrument makes repeated power measurements at a set frequency, similar to the way a swept-tuned signal analyzer makes zero span measurements. The input analog signal is converted to a digital signal, which then is processed into a representation of a waveform measurement. The measurement relies on a high rate of sampling to create an accurate representation of a time domain signal.

## Spurious Emissions Measurement Concepts

### Purpose

Spurious signals can be caused by different combinations of signals in the transmitter. The spurious emissions from the transmitter should be minimized to guarantee minimum interference with other frequency channels in the system. Harmonics are distortion products caused by nonlinear behavior in the transmitter. They are integer multiples of the transmitted signal carrier frequency.

This measurement verifies the frequency ranges of interest are free of interference by measuring the spurious signals specified by the user defined range table.

### Measurement method

The table-driven measurement has the flexibility to set up custom parameters such as frequency, span, resolution bandwidth, and video bandwidth. Up to the top 40 spurs can be viewed

For each range that you specify and activate, the analyzer scans the band using the specified Range Table settings. Then using the Peak Excursion and Peak Threshold values determines which spurs to report.

As each band is swept, any signal which is above the Peak Threshold value and has a peak excursion of greater than the Peak Excursion value will be added to a list of spurs displayed in the lower results window. A total of 200 spurs can be recorded for one measurement, with a limit of 10 spurs per frequency range. To improve repeatability, you can increase the number of averages.

From the spurs in the list, those with peak amplitude greater than the Absolute Limit for that range will be logged as a measurement failure and denoted by an 'F' in the 'Amplitude' column of the table. If no spurs are reported, but the measured trace exceeds the limit line for any range, the fail flag is set to fail.

This measurement has the ability to display two traces using different detectors on the display simultaneously. All spur detection and limit line testing are only applied to the trace associated with Detector 1, which will be colored yellow. The trace associated with Detector 2 will be colored cyan.

If the sweep time for the range exceeds 2 seconds, a flashing message "Sweeping...Please Wait" will appear in the annunciator area. This advises you that the time to complete the sweep is between 2 and 2000 seconds, and is used as without it the display would appear stagnant and you may think the measurement is not functional.

## Spectrum Emission Mask Measurement Concepts

### Purpose

The Spectrum Emission Mask measurement includes the in-band and out-of-band spurious emissions. As it applies to W-CDMA (3GPP), this is the power contained in a specified frequency bandwidth at certain offsets relative to the total carrier power. It may also be expressed as a ratio of power spectral densities between the carrier and the specified offset frequency band.

This spectrum emission mask measurement is a composite measurement of out-of-channel emissions, combining both in-band and out-of-band specifications. It provides useful figures-of-merit for the spectral regrowth and emissions produced by components and circuit blocks, without the rigor of performing a full spectrum emissions mask measurement.

### Measurement method

The spectrum emission mask measurement measures spurious signal levels in up to five pairs of offset/region frequencies and relates them to the carrier power. The reference channel integration bandwidth method is used to measure the carrier channel power and offset/region powers. When **Offset** is selected, spectrum emission mask measurements are made, relative to the carrier channel frequency bandwidth. When **Region** is selected, spurious emission absolute measurements are made, set by specifying start and stop RF frequencies. The upper frequency range limit is 3.678 GHz.

This integration bandwidth method is used to perform a data acquisition. In this process, the reference channel integration bandwidth (Meas BW) is analyzed using the automatically defined resolution bandwidth (Res BW), which is much narrower than the channel bandwidth. The measurement computes an average power of the channel or offset/region over a specified number of data acquisitions, automatically compensating for resolution bandwidth and noise bandwidth.

This measurement requires the user to specify the measurement bandwidths of carrier channel and each of the offset/region frequency pairs up to 5. Each pair may be defined with unique measurement bandwidths. The results are displayed both as relative power in dBc, and as absolute power in dBm.

## Occupied Bandwidth Measurement Concepts

### Purpose

Occupied bandwidth measures the bandwidth containing 99.0 of the total transmission power.

The spectrum shape of a signal can give useful qualitative insight into transmitter operation. Any distortion to the spectrum shape can indicate problems in transmitter performance.

### Measurement method

The instrument uses digital signal processing (DSP) to sample the input signal and convert it to the frequency domain. With the instrument tuned to a fixed center frequency, samples are digitized at a high rate with DSP hardware, and then converted to the frequency domain with FFT software.

The total absolute power within the measurement frequency span is integrated for its 100% of power. The lower and upper frequencies containing 0.5% each of the total power are then calculated to get 99.0% bandwidth.

## Baseband I/Q Inputs (Option BBA) Measurement Concepts

The N9020A Option BBA Baseband I/Q Inputs provides the ability to analyze baseband I/Q signal characteristics of mobile and base station transmitters. This option may be used only in conjunction with the following modes:

- IQ Analyzer (Basic)
- 802.16 OFDMA (WiMAX/WiBro)
- cdma2000
- GSM/EDGE
- TD-SCDMA

### What are Baseband I/Q inputs?

Option BBA consists of a Baseband Input module, four input connectors, and a calibration output connector. The connectors are at the left side of the front panel. The two ports labeled “I” and “Q” are the “unbalanced” inputs.

An unbalanced or “single-ended” baseband measurement of an I or Q signal is made using a probe connected to the I or Q connector. A simultaneous I/Q unbalanced single-ended measurement may be made using two probes connected to the I and Q input connectors.

If “balanced” signals are available, they may be used to make a more accurate measurement. Balanced signals are signals present in two separate conductors, are symmetrical about ground, and are opposite in polarity, or out of phase by 180 degrees.

Measurements using balanced signals can have a higher signal to noise ratio resulting in improved accuracy. Noise coupled into each conductor equally in a “common mode” to both signals may be separated from the signal. The measure of this separation is “common-mode rejection”.

To make a balanced measurement, the two connectors labeled “I” and “Q” are used in conjunction with the I and Q inputs. The terms “I-bar” and “Q-bar” may be applied to the signals, as well as the inputs themselves. Probes (customer provided) must be used to input balanced baseband I/Q signals. This may be referred to as a balanced measurement.

Balanced baseband measurements are made using the I and connectors for I only signal measurements, while the Q and connectors are used for a Q only signal measurement. Balanced measurements of I/Q require differential probe connections to all four input connectors. For details of probe selection and use, refer to [“Selecting input probes for baseband measurements” on page 223](#).

### What are Baseband I/Q signals?

In transmitters, the term baseband I/Q refers to signals that are the fundamental products of individual I/Q modulators, before the I and Q component signals are combined, and before upconversion to IF or RF frequencies.

In receivers, baseband I/Q analysis may be used to test the I and Q products of I/Q demodulators, after an RF signal has been downconverted and demodulated.

### Why make measurements at baseband?

Baseband I/Q measurements are a valuable means of making qualitative analyses of the following operating characteristics:

- I/Q signal layer access for performing format-specific demodulation measurements (for example, CDMA, GSM, W-CDMA).
- Modulation accuracy – that is,. I/Q plane metrics:
  - rho
  - error vector magnitude; rms, peak, or 95%
  - carrier feed-through
  - frequency error
  - magnitude and phase errors
- Code-domain analysis (including code-specific metrics)
- CCDF of  $I^2 + Q^2$
- Single sideband (SSB) metrics for assessing output quality
- Basic analysis of I and Q signals in isolation including: DC content, rms and peak to peak levels, CCDF of each channel

Comparisons of measurements made at baseband and RF frequencies produced by the same device are especially revealing. Once signal integrity is verified at baseband, impairments can be traced to specific stages of upconversion, amplification, or filtering by RF analysis. In addition, impairments to signal quality that are apparent at RF frequencies may be traceable to baseband using baseband analysis.

## Selecting input probes for baseband measurements

The selection of baseband measurement probe(s) and measurement method is primarily dependent on the location of the measurement point in the circuit. The probe must sample voltages without imposing an inappropriate load on the circuit.

The system supports a variety of 1 M $\Omega$  impedance input passive probes as well as the Keysight 1153A active differential probe using the InfiniMax probe interface.

The Keysight 1153A active probe can be used for both single-ended and differential measurements. In either case a single connection is made for each channel (on either the I or Q input). The input is automatically configured to 50  $\Omega$  single-ended type measurement and the probe power is supplied through the InfiniMax interface. The probe can be configured for a variety of input coupling and low frequency rejection modes. In addition, a wide range of offset voltages and probe attenuation accessories are supported at the probe interface. The active probe has the advantage that it does not significantly load the circuit under test, even with unity gain probing.

With passive 1 M $\Omega$  probes, the probe will introduce a capacitive load on the circuit, unless a higher attenuation is used at the probe interface. Higher attenuation helps isolate the probe, however, it reduces the signal level and degrades the signal-to-noise-ratio of the measurement. Passive probes are available with a variety of attenuation values for a moderate cost. Many Keysight passive probes can be automatically identified by the system, setting the input impedance required as well as the nominal attenuation. For single-ended measurements a single probe is used for each channel. Other passive probes can be used, after manually setting the attenuation and probe impedance configurations.

For full differential measurements, the system supports probes on each of the four inputs. The attenuation for each of the probes should be the same for good common mode rejection and channel match.

### Supported probes

The following table lists the probes currently supported by Option BBA:

Probe Type	Model Number	Description
Active	1130A	1.5 GHz differential probe amp (No probe head)
	1131A <sup>a</sup>	InfiniMax 3.5 GHz probe
	1132A <sup>a</sup>	InfiniMax 5 GHz probe
	1133A <sup>a</sup>	InfiniMax 7 GHz probe
Passive	1161A	Miniature passive probe, 10:1, 10 M $\Omega$ , 1.5 m

- a. Probe heads are necessary to attach to your device properly. Probe connectivity kits such as the E2668A, E2669A or E2675A are needed. For more details, refer to the Keysight probe configuration guide, 5968-7141EN and 5989-6162EN.

### Probes without stored calibration

The following 115xA active probes may be used with the MXA's baseband IQ inputs and may use the same probe calibration utility software. However, the probe calibration data is not stored in the MXA and will be lost if power is cycled. Use of the E2655B de-skew and calibration kit, including the calibration fixture, is required because of the different physical configuration of the probes. (The physical connections are different mechanically, not electrically.)

Probe Type	Model Number	Description
Active	1153A	200MHz differential probe
	1156A	Active probe, 1.5 GHz
	1157A	Active probe, 2.5 GHz
	1158A	Active probe, 4 GHz

Refer to the current Keysight probe data sheet for specific information regarding frequency of operation and power supply requirements.

## Baseband I/Q measurement views

Measurement result views made in the IQ Analyzer (Basic) mode are available for baseband signals if they relate to the nature of the signal itself. Many measurements which relate to the characteristics that baseband I and Q signals have when mixed and upconverted to signals in the RF spectrum can be made as well. However, measurements which relate to the characteristics of an upconverted signal that lie beyond the bandwidth available to the Baseband I/Q Input circuits can not be measured (the limit are dependent on the installed options: Standard – 10 Hz to 20 MHz, Option B25 – 10 Hz to 50 MHz, and Option S40 – 10 Hz to 80 MHz).

At RF frequencies, power measurements are conventionally displayed on a logarithmic vertical scale in dBm units, whereas measurements of baseband signals using Baseband I/Q inputs may be conveniently displayed as voltage using a linear vertical scale as well as a log scale.

### Spectrum views and 0 Hz center frequency

To view the Spectrum display of I only or Q only signals, use the Complex Spectrum measurement capability in IQ Analyzer (Basic) Mode.

I only and Q only Spectrum views are conventional, displayed with 0 Hz at the left side of the horizontal axis. When upconverted or multiplied, an I only or Q only signal could ultimately lie above or below the carrier center frequency, but in either case it will only occupy half the bandwidth.



**Waveform Signal Envelope views of I only or Q only**

To view the Signal Envelope display of I only or Q only signals, use the Waveform measurement capability in IQ Analyzer (Basic) Mode.

The I and Q Waveform of an I/Q signal is very different from the complex signal displayed in the RF Envelope view. That is because the RF Envelope is a product of both the I and Q modulation waveforms.

However, an I and Q Waveform measurement of an I only or Q only signal is exactly the same signal displayed in the RF Envelope view. That is because an I only or Q only waveform determines the I only or Q only signal envelope. Thus, the RF Envelope view can be used to measure an I only or Q only waveform directly.