

Measurement Guide and Programming Examples

N9060A Spectrum Analyzer Measurement Application

**For use with N9020A MXA Signal Analyzer and
N9010A EXA Signal Analyzer**

**This manual also provides documentation for the
IQ Analyzer Measurement Mode**



Agilent Technologies

**Manufacturing Part Number: N9060-90013
Supersedes N9060-90001**

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***Warning* denotes a hazard. It calls attention to a procedure which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a warning note until the indicated conditions are fully understood and met.**

CAUTION

Caution denotes a hazard. It calls attention to a procedure that, if not correctly performed or adhered to, could result in damage to or destruction of the instrument. Do not proceed beyond a caution sign until the indicated conditions are fully understood and met.

NOTE

Note calls out special information for the user's attention. It provides operational information or additional instructions of which the user should be aware.

Where to Find the Latest Information

Documentation is updated periodically. For the latest information about Agilent Technologies spectrum analyzer, including firmware upgrades and application information, please visit the following Internet URL:

<http://www.agilent.com/find/mxa>
<http://www.agilent.com/find/exa>

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Contents

1. Getting Started with the Spectrum Analyzer Measurement Application	
Making a Basic Measurement	8
Recommended Test Equipment	12
Accessories Available	13
2. Front and Rear Panel Features	
Front Panel Features	18
Display Annotations	22
Rear-Panel Features	24
Front and Rear Panel Symbols	26
3. Measuring Multiple Signals	
Comparing Signals on the Same Screen Using Marker Delta	28
Comparing Signals not on the Same Screen Using Marker Delta	30
Resolving Signals of Equal Amplitude	32
Resolving Small Signals Hidden by Large Signals	36
Decreasing the Frequency Span Around the Signal	39
Easily Measure Varying Levels of Modulated Power Compared to a Reference	41
4. Measuring a Low-Level Signal	
Reducing Input Attenuation	46
Decreasing the Resolution Bandwidth	49
Using the Average Detector and Increased Sweep Time	52
Trace Averaging	54
5. Improving Frequency Resolution and Accuracy	
Using a Frequency Counter to Improve Frequency Resolution and Accuracy	58
6. Tracking Drifting Signals	
Measuring a Source Frequency Drift	62
Tracking a Signal	65
7. Making Distortion Measurements	
Identifying Analyzer Generated Distortion	68
Third-Order Intermodulation Distortion	71
8. Measuring Noise	
Measuring Signal-to-Noise	76
Measuring Noise Using the Noise Marker	78
Measuring Noise-Like Signals Using Band/Interval Density Markers	81
Measuring Noise-Like Signals Using the Channel Power Measurement	84
Measuring Signal-to-Noise of a Modulated Carrier	86

Contents

Improving Phase Noise Measurements by Subtracting Signal Analyzer Noise	91
9. Making Time-Gated Measurements	
Generating a Pulsed-RF FM Signal	96
Connecting the Instruments to Make Time-Gated Measurements	101
Gated LO Measurement	103
Gated Video Measurement	106
Gated FFT Measurement	109
10. Measuring Digital Communications Signals	
Channel Power Measurements	112
Occupied Bandwidth Measurements	114
Making Adjacent Channel Power (ACP) Measurements	116
Making Statistical Power Measurements (CCDF)	120
Making Burst Power Measurements	124
Spurious Emissions Measurements	130
Spectrum Emission Mask Measurements	133
11. Demodulating AM Signals	
Measuring the Modulation Rate of an AM Signal	136
Measuring the Modulation Index of an AM Signal	139
12. IQ Analyzer Measurement	
Capturing wideband signals for further analysis	142
Complex Spectrum Measurement	143
IQ Waveform (Time Domain) Measurement	145
13. Concepts	
Resolving Closely Spaced Signals	150
Trigger Concepts	152
Time Gating Concepts	155
AM and FM Demodulation Concepts	174
IQ Analysis Concepts	175
Spurious Emissions Measurement Concepts	177
Spectrum Emission Mask Measurement Concepts	178
Occupied Bandwidth Measurement Concepts	179
14. Programming Examples	
Available Programming Examples	182
Programming Fundamentals	185

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 8
- “[Recommended Test Equipment](#)” on page 12
- “[Accessories Available](#)” on page 13

Technical Documentation Summary:

Your Signal Analysis measurement platform:	
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
Measurement Application specific documentation: (for example, Spectrum Analyzer Measurement Application or W-CDMA Measurement Application)	
Measurement Guide and Programming Examples	Examples of measurements made using the front panel keys or over a remote interface. The programming examples use a few different programming languages, and copies of the executable files are available.
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 Agilent Signal Analyzer measurement platform. This knowledge will help you with the following measurement example.

This section includes:

- “Using the Front Panel” on page 9
- “Presetting the Signal Analyzer” on page 10
- “Viewing a Signal” on page 10

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

Using the Front Panel

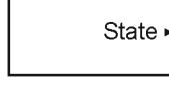
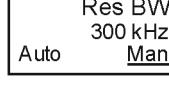
Entering Data

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 **Enter** 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:  Toggles the selection (underlined choice) each time you press the key.
- 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:

1. Set analyzer parameters as desired.
2. Press **User Preset, Save User Preset** to set the current parameters as the user preset state.
3. Then press **User Preset, User Preset** when you want to select the preset state.

Viewing a Signal

1. Press **Mode Preset** to return the current mode settings to its factory defaults.
2. Press **Input/Output, RF Calibrator, 50, MHz.** to route the internal 50 MHz signal to the analyzer input.
3. Press **AMPLTD Y Scale, 10, dBm** to set the reference level to 10 dBm.
4. Press **FREQ Channel, Center Freq, 40, MHz** to set the center frequency to 40 MHz.
The 50 MHz reference signal appears on the display.
5. Press **SPAN, 50, MHz** to set the frequency span to 50 MHz.

Reading Frequency & Amplitude

6. Press **Peak Search.**

This activates a marker and places it on the highest amplitude signal.

Note that 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.

7. If you have moved the marker, return it to the peak of the 50 MHz signal by pressing **Peak Search** again.

Changing Reference Level

8. Press **AMPLTD Y Scale** and note that reference level (Ref Level) is now the active function. Press **Marker →, Mkr → Ref Lvl.**

Note that changing the reference level changes the amplitude value of the top graticule

line.

Improving Frequency Accuracy

9. To increase the accuracy of the frequency reading in the marker annotation, turn on the frequency count function.
 - Press **Marker, More, Marker Count**.

The **Marker Count** softkeys appear.

Note softkey **Counter On Off**. If **Off** is underlined, press the softkey to toggle marker count on.

- The marker active function annotation changes from **Mkr1** to **Cntr1**.
- The displayed resolution in the marker annotation improves.

NOTE	When you use the frequency count function, if the ratio of the resolution bandwidth to the span is less than 0.002, you would 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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10. Press **Marker →, Mkr → CF** to move the 50 MHz peak to the center of the display.

Valid Marker Count Range

11. Move the marker down the skirt of the 50 MHz peak. Note that 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.

NOTE	Marker count functions properly only on CW signals or discrete peaks. For a valid reading, the marker must be ≥ 26 dB above the noise.
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12. Press **BW, Res BW**, then enter a new value. This action makes the resolution bandwidth (RBW) the active function and allows you to experiment with different resolution bandwidth values.
13. Press **Marker, Off** to turn the marker off.

Recommended Test Equipment

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

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

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

Accessories Available

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

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 Agilent Sales and Service Office.

For the latest information on Agilent signal analyzer options and upgrade kits, visit the following Internet URL:

http://www.agilent.com/find/sa_upgrades

50 Ohm Load

The Agilent 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 HP/Agilent 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 HP/Agilent 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 Agilent 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 Agilent 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 Agilent 8447D preamplifier provides a minimum of 25 dB gain from 100 kHz to 1.3 GHz.
- The Agilent 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 Agilent 83006A preamplifier provides a minimum of 26 dB gain from 10 MHz to 26.5 GHz.
- The Agilent 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 Agilent 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 Agilent 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 Agilent 11867A and 11693A RF Limiters protect the analyzer input circuits from damage due to high power levels. The 11867A 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 12.4 GHz, usable to 18 GHz) guards against input signals over 1 milliwatt up to 1 watt average power and 10 watts peak power.

The Agilent 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 Agilent 11667A/B/C power splitters are two-resister 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

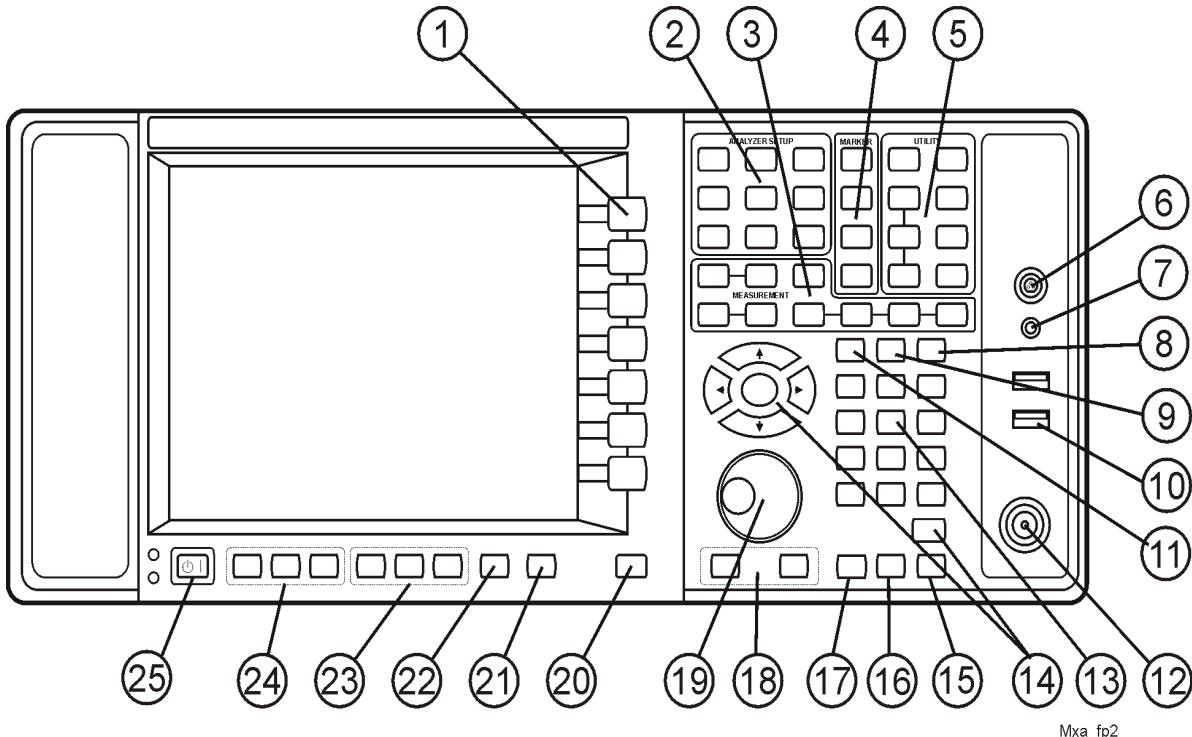
- 9300-1367 Wrist-strap, color black, stainless steel. Four adjustable links and a 7 mm post-type connection.
- 9300-0980 Wrist-strap cord 1.5 m (5 ft.)

2 Front and Rear Panel Features

- “Front Panel Features” on page 18
- “Display Annotations” on page 22
- “Rear-Panel Features” on page 24
- “Front and Rear Panel Symbols” on page 26

Front Panel Features

Front-Panel Connectors and Keys



Item		Description
#	Name	
1	Menu Keys	Key labels appear to the left of the menu keys to identify the current function of each key. The displayed functions are dependent on the currently selected Mode and Measurement, and are directly related to the most recent key press.
2	Analyzer Setup Keys	These keys set the parameters used for making measurements in the current Mode and Measurement.
3	Measurement Keys	These keys select the Mode, and the Measurement within the mode. They also control the initiation and frequency of measurement.
4	Marker Keys	Markers are often available for a measurement, to measure a very specific point/segment of data within the range of the current measurement data.

Item		Description
#	Name	
5	Utility Keys	<p>These keys control system-wide functionality like:</p> <ul style="list-style-type: none"> • instrument configuration information and I/O setup, • printer setup and printing, • file management, save and recall, • instrument presets.
6	Probe Power	Supplies power for external high frequency probes and accessories.
7	Headphones Output	Headphones can be used to hear any available audio output.
8	Back Space Key	Press this key to delete the previous character when entering alphanumeric information. It also works as the Back key in Help and Explorer windows.
9	Delete Key	Press this key to delete files, or to perform other deletion tasks.
10	USB Connectors	Standard USB 2.0 ports, Type A. Connect to external peripherals such as a mouse, keyboard, DVD drive, or hard drive.
11	Local/Cancel/(Esc) Key	<p>If you are in remote operation, Local:</p> <ul style="list-style-type: none"> • returns instrument control from remote back to local (the front panel). • turns the display on (if it was turned off for remote operation). • can be used to clear errors. (Press the key once to return to local control, and a second time to clear error message line.) <p>If you have not already pressed the units or Enter key, Cancel exits the currently selected function without changing its value.</p> <p>Esc works the same as it does on a pc keyboard. It:</p> <ul style="list-style-type: none"> • exits Windows dialogs • clears errors • aborts printing • cancels operations.
12	RF Input	Connector for inputting an external signal. Make sure that the total power of all signals at the analyzer input does <i>not</i> exceed +30 dBm (1 watt).
13	Numeric Keypad	Enters a specific numeric value for the current function. Entries appear on the upper left of the display, in the measurement information area.
14	Enter and Arrow Keys	<p>The Enter key terminates data entry when either no unit of measure is needed, or you want to use the default unit.</p> <p>The arrow keys:</p> <ul style="list-style-type: none"> • Increment and decrement the value of the current measurement selection. • Navigate help topics. • Navigate, or make selections, within Windows dialogs. • Navigate within forms used for setting up measurements. • Navigate within tables. <hr/> <p>NOTE The arrow keys cannot be used to move a mouse pointer around on the display.</p>

Front and Rear Panel Features

Front Panel Features

Item		Description
#	Name	
15	Menu/ (Alt) Key	Alt works the same as a pc keyboard. Use it to change control focus in Windows pull-down menus.
16	Ctrl Key	Ctrl works the same as a pc keyboard. Use it to navigate in Windows applications, or to select multiple items in lists.
17	Select / Space Key	Select is also the Space key and it has typical pc functionality. For example, in Windows dialogs, it selects files, checks and unchecks check boxes, and picks radio button choices. It opens a highlighted Help topic.
18	Tab Keys	Use these keys to move between fields in Windows dialogs.
19	Knob	Increments and decrements the value of the current active function.
20	Return Key	Exits the current menu and returns to the previous menu. Has typical pc functionality.
21	Full Screen Key	Pressing this key turns off the softkeys to maximize the graticule display area.
22	Help Key	Initiates a context-sensitive Help display for the current Mode. Once Help is accessed, pressing a front panel key brings up the help topic for that key function.
23	Speaker Control Keys	Enables you to increase or decrease the speaker volume, or mute it.
24	Window Control Keys	These keys select between single or multiple window displays. They zoom the current window to fill the data display, or change the currently selected window. They can be used to switch between the Help window navigation pane and the topic pane.
25	Power Standby/ On	Turns the analyzer on. A green light indicates power on. A yellow light indicates standby mode. <div style="border-top: 1px solid black; border-bottom: 1px solid black; padding: 5px; margin-top: 10px;"> NOTE The front-panel switch is a standby switch, <i>not</i> a LINE switch (disconnecting device). The analyzer continues to draw power even when the line switch is in standby. The main power cord can be used as the system disconnecting device. It disconnects the mains circuits from the mains supply. </div>

Overview of Key Types

The keys labeled **FREQ Channel**, **System**, and **Marker Function** are all examples of front-panel keys. Most of the dark or light gray keys access menus of functions that are displayed along the right side of the display. These displayed key labels are next to a column of keys called menu keys.

Menu keys list functions based on which front-panel key was pressed last. These functions are also dependant on the current selection of measurement application (**Mode**) and measurement (**Meas**).

If the numeric value of a menu key function can be changed, it is called an active function. The function label of the active function is highlighted after that key has been selected. For example, press **AMPTD Y Scale**. This calls up the menu of related amplitude functions. Note the function labeled **Reference Level** (the default selected key in the Amplitude menu) is highlighted. **Reference Level** also appears in the upper left of the display in the measurement information area. The displayed value indicates that the function is selected and its value can now be changed using any of the data entry controls.

Some menu keys have multiple choices on their label like On/Off or Auto/Man. The different choices are selected by pressing the key multiple times. Take an Auto/Man type of key as an example. To select the function, press the menu key and notice that Auto is underlined and the key becomes highlighted. To change the function to manual, press the key again so that Man is underlined. If there are more than two settings on the key, keep pressing it until the desired selection is underlined.

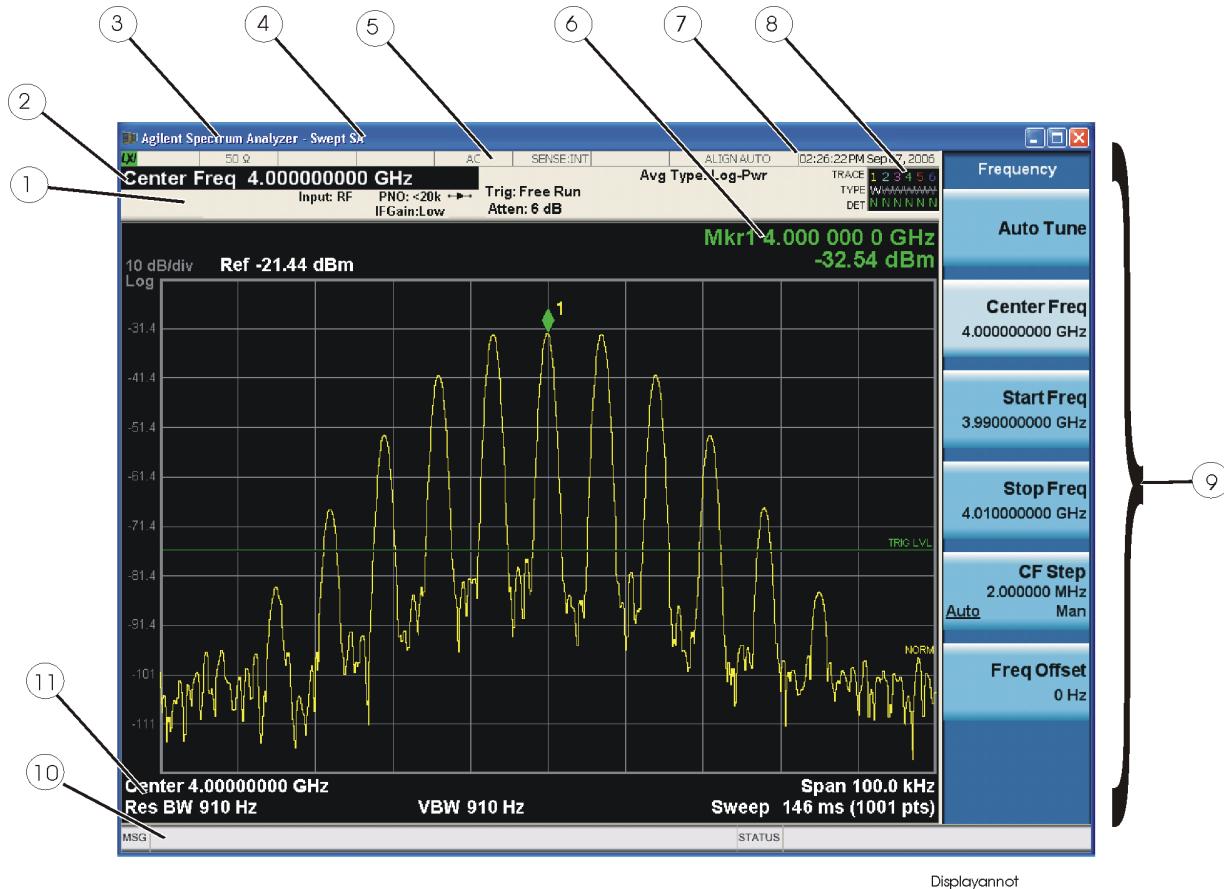
When a menu first appears, one key label will be highlighted to show which key is the default selection. If you press **Marker Function**, the **Marker Function Off** key is the menu default key, and it will be highlighted. Some of the menu keys are grouped together by a yellow bar running behind the keys near the left side. When you press a key within the yellow bar region, such as **Marker Noise**, the highlight will move to that key to show it has been selected. The keys that are linked by the yellow bar are related functions, and only one of them can be selected at any one time. For example, a marker can only have one marker function active on it. So if you select a different function it turns off the previous selection. If the current menu is two pages long, the yellow bar could include keys on the second page of keys.

In some key menus, a key label will be highlighted to show which key has been selected from multiple available choices. And the menu is immediately exited when you press one of the other keys. For example, when you press the **Select Trace** key (in the **Trace/Detector** menu), it will bring up its own menu of keys. The **Trace 1** key will be highlighted. When you press the **Trace 2** key, the highlight moves to that key and the screen returns to the **Trace/Detector** menu.

If a displayed key label shows a small solid-black arrow tip pointing to the right, it indicates that additional key menus are available. If the arrow tip is not filled in solid then pressing the key the first time selects that function. Now the arrow is solid and pressing it again will bring up an additional menu of settings.

Display Annotations

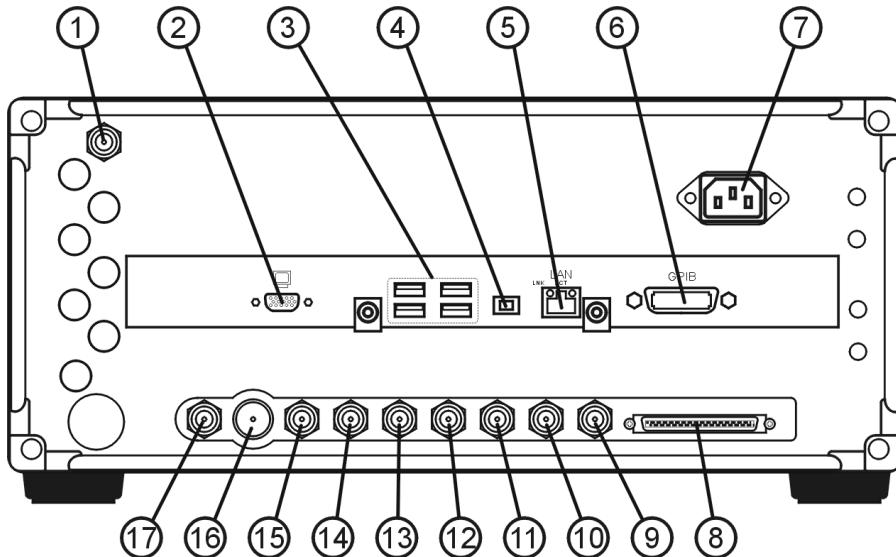
This section describes the display annotation as it is on the Spectrum Analyzer Measurement Application display. Other measurement application modes will have some annotation differences.



Item	Description	Function Keys
1	<p>Measurement bar - Shows general measurement settings and information.</p> <p>Indicates single/continuous measurement.</p> <p>Some measurements include limits that the data is tested against. A Pass/Fail indication may be shown in the lower left of the measurement bar.</p>	All the keys in the Analyzer Setup part of the front panel.
2	Active Function (measurement bar) - when the current active function has a settable numeric value, it is shown here.	Currently selected front panel key.

Item	Description	Function Keys
3	Banner - shows the name of the selected measurement application and the measurement that is currently running.	Mode, Meas
4	Measurement title (banner) - shows title information for the current Measurement, or a title that you created for the measurement.	Meas View/Display, Display, Title
5	Settings panel - displays system information that is not specific to any one application. <ul style="list-style-type: none"> • Input/Output status - green LXI indicates the LAN is connected. RLTS indicate Remote, Listen, Talk, SRQ • Input impedance and coupling • Selection of external frequency reference • Setting of automatic internal alignment routine 	Local and System, I/O Config Input/Output, Amplitude, System and others
6	Active marker frequency, amplitude or function value	Marker
7	Settings panel - time and date display.	System, Control Panel
8	Trace and detector information	Trace/Detector, Clear Write (W) Trace Average (A) Max Hold (M) Min Hold (m) Trace/Detector, More, Detector, Average (A) Normal (N) Peak (P) Sample (S) Negative Peak (p)
9	Key labels that change based on the most recent key press.	Softkeys
10	Displays information, warning and error messages. Message area - single events, Status area - conditions	
11	Measurement settings for the data currently being displayed in the graticule area. In the example above: center frequency, resolution bandwidth, video bandwidth, frequency span, sweep time and number of sweep points.	Keys in the Analyzer Setup part of the front panel.

Rear-Panel Features



Mxa_rp2

Item		Description
#	Name	
1	EXT REF IN	Input for a 1 to 50 MHz external frequency reference signal.
2	MONITOR	Allows connection of an external VGA monitor.
3	USB Connectors	Standard USB 2.0 ports, Type A. Connect to external peripherals such as a mouse, keyboard, printer, DVD drive, or hard drive.
4	USB Connector	USB 2.0 port, Type B. USB TMC (test and measurement class) connects to an external pc controller to control the instrument and for data transfers over a 480 Mbps link.
5	LAN	A TCP/IP Interface that is used for remote analyzer operation.
6	GPIB	A General Purpose Interface Bus (GPIB, IEEE 488.1) connection that can be used for remote analyzer operation.
7	Line power input	The AC power connection. See the product specifications for more details.
8	Digital Bus	Reserved for future use.
9	Analog Out	Reserved for future use.
10	TRIGGER 2 OUT	A trigger output used to synchronize other test equipment with the analyzer. Configurable from the Input/Output keys.
11	TRIGGER 1 OUT	A trigger output used to synchronize other test equipment with the analyzer. Configurable from the Input/Output keys.
12		
13		
14		
15		
16		
17		

Item		Description
#	Name	
12	Sync	Reserved for future use.
13	TRIGGER 2 IN	Allows external triggering of measurements.
14	TRIGGER 1 IN	Allows external triggering of measurements.
15	Noise Source Drive +28 V (Pulsed)	Reserved for future use.
16	SNS Series Noise Source	Reserved for future use.
17	10 MHz OUT	An output of the analyzer internal 10 MHz frequency reference signal. It is used to lock the frequency reference of other test equipment to the analyzer.

Front and Rear Panel Symbols

- | This symbol is used to indicate power ON (green LED).
-  This symbol is used to indicate power STANDBY mode (yellow LED).
-  This symbol indicates the input power required is AC.
-  The instruction documentation symbol. The product is marked with this symbol when it is necessary for the user to refer to instructions in the documentation.
-  The CE mark is a registered trademark of the European Community.
-  **N10149** The C-Tick mark is a registered trademark of the Australian Spectrum Management Agency.
-  This is a marking of a product in compliance with the Canadian Interference-Causing Equipment Standard (ICES-001).
-  This is also a symbol of an Industrial Scientific and Medical Group 1 Class A product (CISPR 11, Clause 4).
-  The CSA mark is a registered trademark of the Canadian Standards Association International.
-  This symbol indicates separate collection for electrical and electronic equipment mandated under EU law as of August 13, 2005. All electric and electronic equipment are required to be separated from normal waste for disposal (Reference WEEE Directive 2002/96/EC).

To return unwanted products, contact your local Agilent office, or see <http://www.agilent.com/environment/product/> for more information.

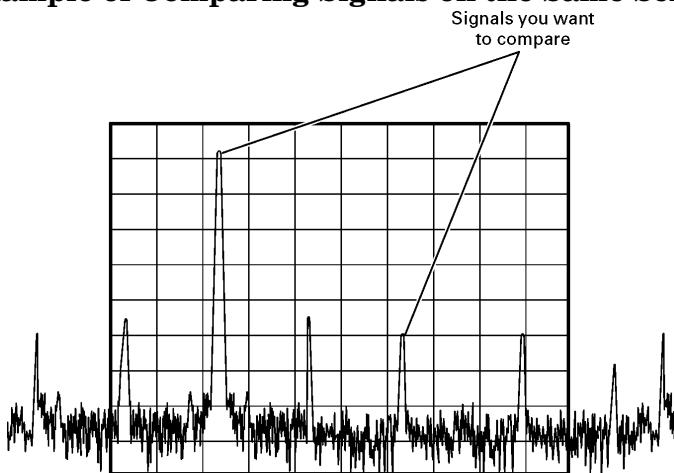
3 Measuring Multiple Signals

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 3-1. An Example of Comparing Signals on the Same Screen



Step 1. Connect the 10 MHz OUT from the rear panel to the front panel RF input.

Step 2. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 3. Preset the spectrum analyzer mode:

Press **Mode Preset**.

Step 4. Set the analyzer center frequency, span and reference level to view the 10 MHz signal and its harmonics up to 50 MHz:

Press **FREQ Channel, Center Freq, 30, MHz**.

Press **SPAN X Scale, Span, 50, MHz**.

Press **AMPTD Y Scale, Ref Level, 10, dBm**.

Step 5. Place a marker at the highest peak on the display (10 MHz):

Press **Peak Search**.

The **Next Pk Right** and **Next Pk Left** softkeys are available to move the marker from

peak to peak. The marker should be on the 10 MHz reference signal:

Step 6. Anchor the first marker and activate a second delta marker:

Press **Marker, Delta**.

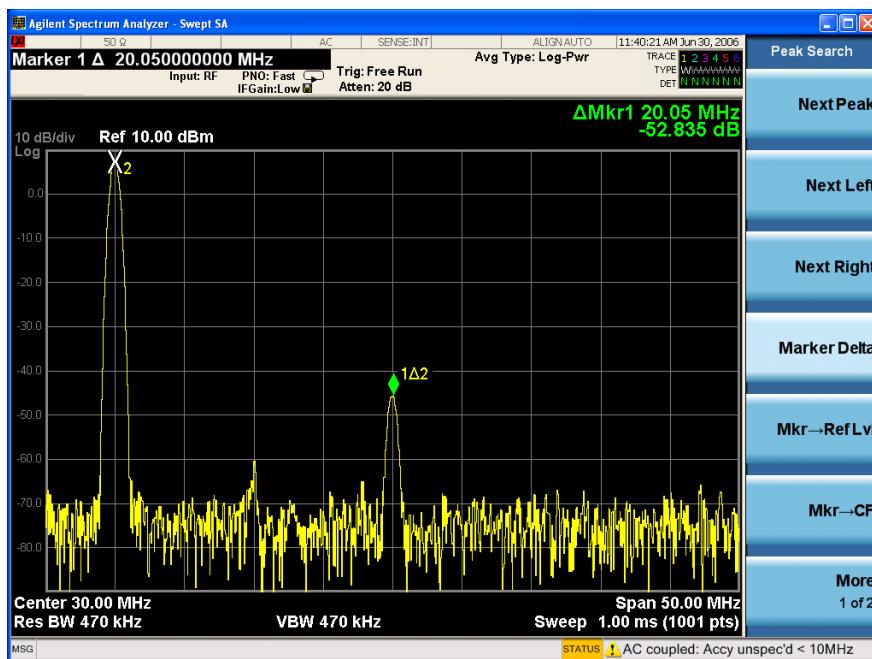
The symbol for the first marker is changed from a diamond to a cross (X) with a label that now reads 2, indicating that it is the fixed marker (reference point). The second marker symbol is a diamond labeled 1Δ2, indicating it is the delta marker. When you first press the Delta key, both markers are 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.

Step 7. Move the delta marker to another signal peak using the front-panel knob or by using the **Peak Search** key:

Press **Peak Search, Next Peak**

The amplitude and frequency *difference* between the markers is displayed in the marker results block of the screen. Refer to the upper right portion of the screen. Refer to Figure 3-2.

Figure 3-2. Using the Delta Marker Function



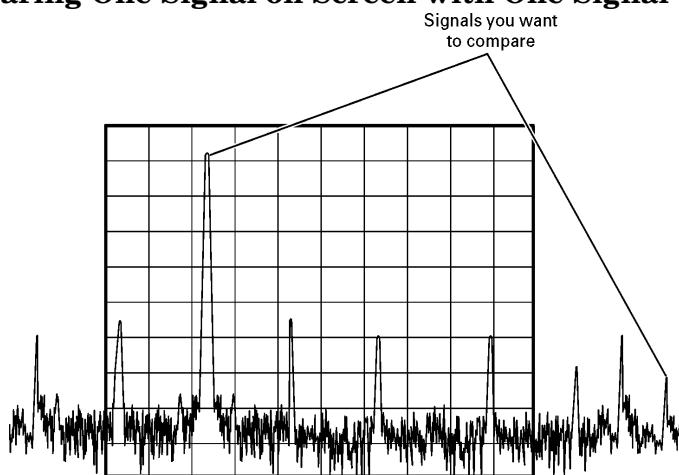
NOTE The frequency resolution of the marker readings can be increased by turning on the marker count function.

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 3-3. Comparing One Signal on Screen with One Signal Off Screen



Step 1. Connect the 10 MHz OUT from the rear panel to the front panel RF input.

Step 2. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 3. Preset the analyzer:

Press **Mode Preset**.

Step 4. Set the analyzer center frequency, span and reference level to view the 10 MHz signal and its harmonics up to 50 MHz:

Press **FREQ Channel, Center Freq, 10, MHz**.

Press **SPAN X Scale, Span, 5, MHz**.

Press **AMPTD Y Scale, Ref Level, 10, dBm**.

Step 5. Place a marker on the 10 MHz peak and then set the center frequency step size equal to the marker frequency (10 MHz):

Press **Peak Search**.

Press **Marker →, Mkr → CF Step**.

Step 6. Activate the marker delta function:

Press **Marker, Delta**.

Step 7. Increase the center frequency by 10 MHz:

Press **FREQ Channel, Center Freq, ↑**.

The first marker and delta markers move to the left edge of the screen, at the amplitude of the first signal peak.

Step 8. Move the delta marker to the new center frequency:

Press **Peak Search**.

Figure 3-4. shows the reference annotation for the first marker (X2) 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 ($1\Delta 2$) 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 3-4. Delta Marker with Reference Signal Off-Screen



Step 9. Turn the markers off:

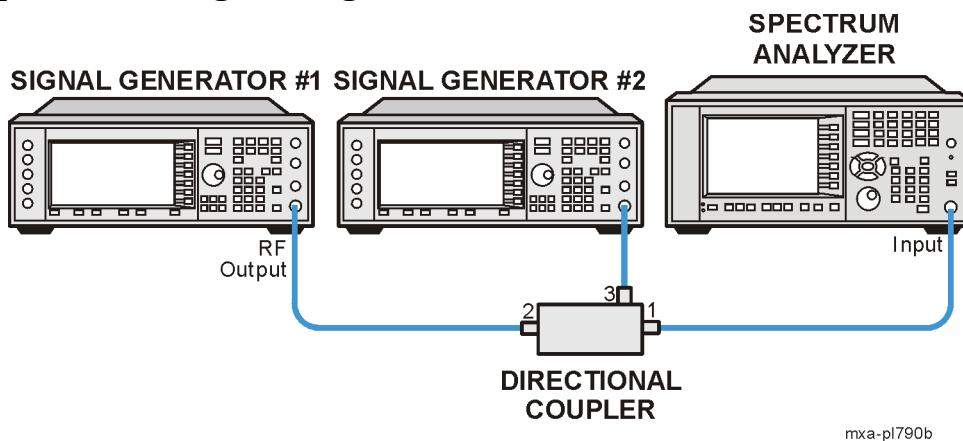
Press **Marker, Off**.

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 1. Connect two sources to the analyzer RF INPUT as shown in [Figure 3-5](#).

Figure 3-5. Setup for Obtaining Two Signals



Step 2. Setup the signal sources as follows:

Set one source to 300 MHz.

Set the frequency of the other source to 300.1 MHz.

Set signal generator #1 amplitude to -20 dBm.

Set signal generator #1 amplitude to -4 dBm.

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 signal -20 dBm signal.)

Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Setup the analyzer to view the signals:

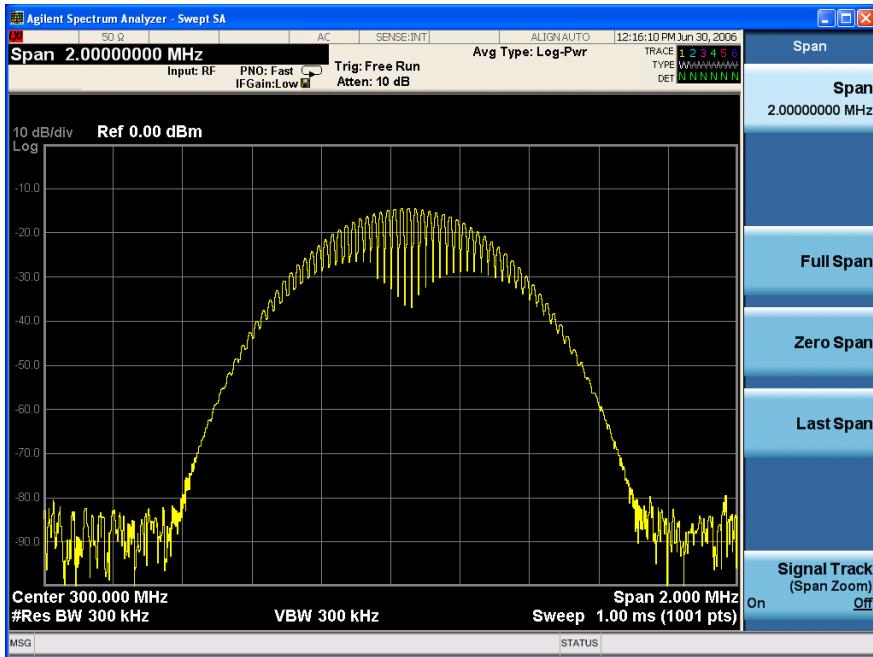
Press **FREQ Channel, Center Freq, 300, MHz**.

Press **BW, Res BW, 300, kHz**.

Press **SPAN X Scale, Span, 2, MHz**.

A single signal peak is visible. See [Figure 3-6](#).

Figure 3-6. Unresolved Signals of Equal Amplitude



Step 6. Change the resolution bandwidth (RBW) to 100 kHz so that the RBW setting is less than or equal to the frequency separation of the two signals and decrease the video bandwidth to 10 kHz:

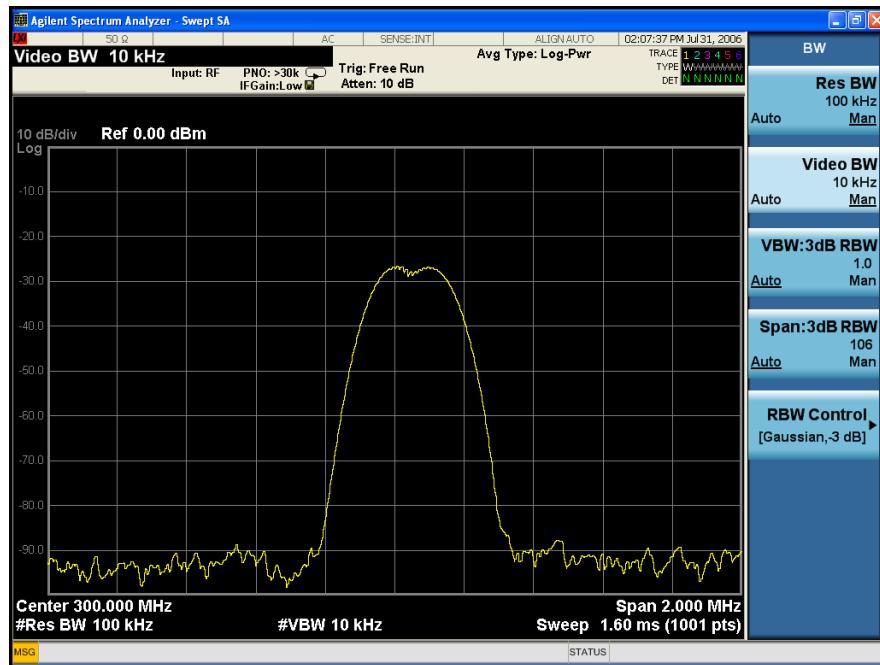
Press **BW, Res BW, 100, kHz.**

Press **Video BW, 10, kHz**

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. Refer to [Figure 3-7](#).

Measuring Multiple Signals
Resolving Signals of Equal Amplitude

Figure 3-7. Unresolved Signals of Equal Amplitude

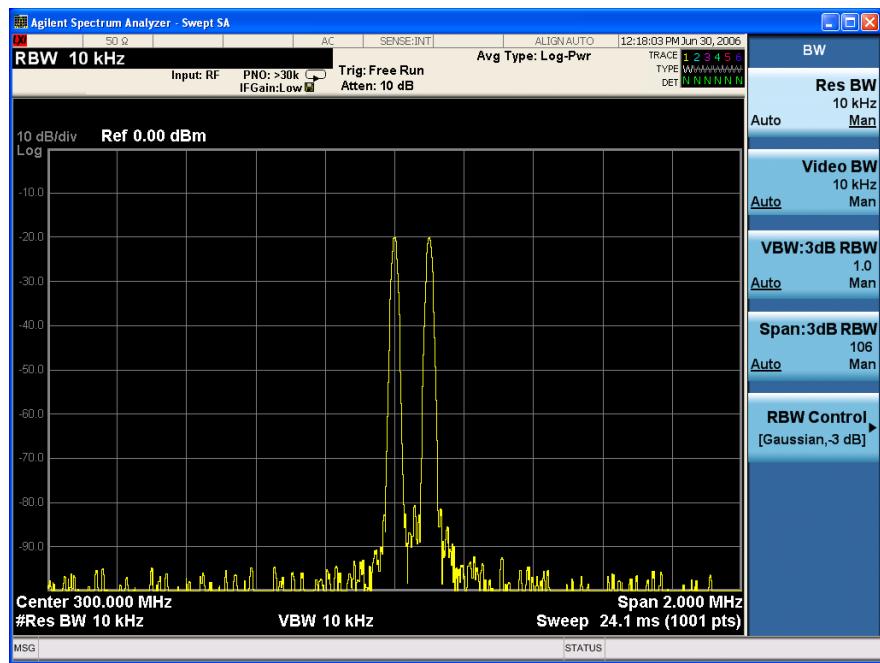


Step 7. Decrease the resolution bandwidth (RBW) to 10 kHz:

Press **BW, Res BW, 10, kHz**.

Two signals are now visible as shown in [Figure 3-8](#). You can use the front-panel knob or step keys to further reduce the resolution bandwidth and better resolve the signals.

Figure 3-8. 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 *Agilent Technologies User's and Programmer's Reference N9060A Spectrum Analyzer Mode*.)

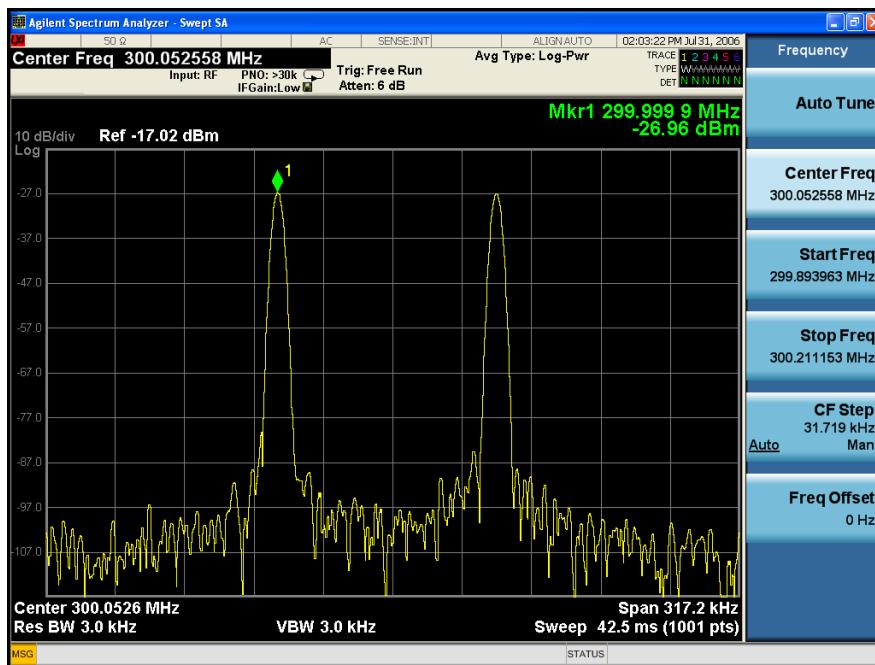
NOTE An alternative method for resolving two equal amplitude signals is to use the Auto Tune Function as follows:

Press **Mode Preset**.

Press **Freq Channel, Auto Tune**

The two signals are fully resolved with a marker placed on the highest peak. Refer to [Figure 3-9](#).

Figure 3-9. Resolving Signals of Equal Amplitude

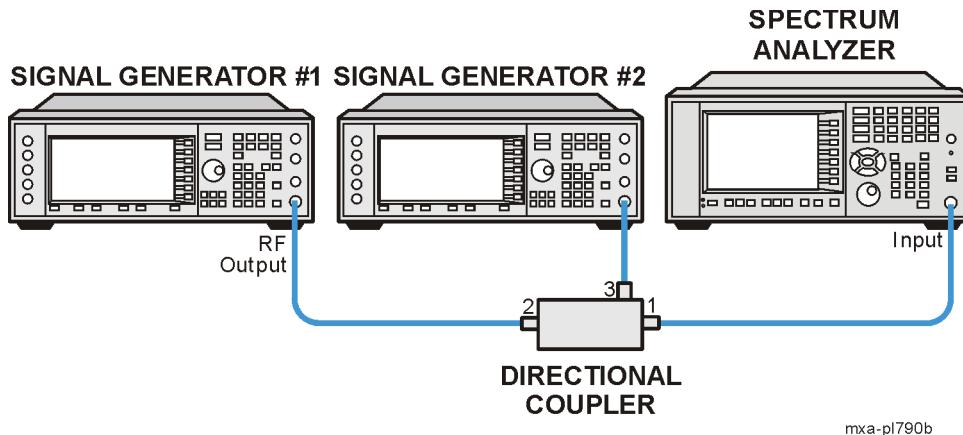


Resolving Small Signals Hidden by Large Signals

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 1. Connect two sources to the analyzer RF INPUT as shown in [Figure 3-10](#).

Figure 3-10. Setup for Obtaining Two Signals



Step 2. Setup the signal sources as follows:

- Set signal generator #1 to 300 MHz at -10 dBm.
- Set signal generator #2 to 300.05 MHz, so that the signal is 50 kHz higher in frequency than the first signal.
- Set signal generator #2 amplitude to -54 dBm (The -54 dBm setting plus -16 dB coupling factor of the 86205A results in a signal 60 dB below the first signal).

Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the analyzer as follows:

- Press **FREQ Channel, Center Freq, 300, MHz**.
- Press **BW, 30, kHz**.
- Press **SPAN X Scale, Span, 500, kHz**.

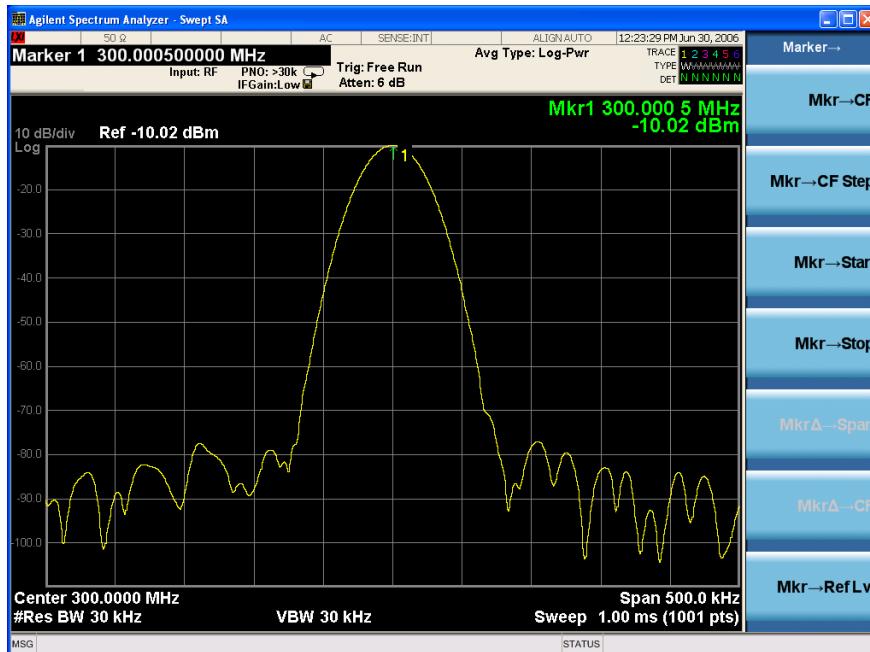
Step 6. Set the 300 MHz signal peak to the reference level:

Press **Peak Search, Mkr → Ref Lvl**.

NOTE 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-bandwidth, or 61.5 kHz, is NOT narrower than the frequency separation of 50 kHz, so the input signals can not be resolved. Refer to [Figure 3-11](#).

Figure 3-11. Signal Resolution with a 30 kHz RBW



Step 7. Reduce the resolution bandwidth filter to view the smaller hidden signal. Place a delta marker on the smaller signal:

Press **BW, 10, kHz**.

Press **Peak Search, Marker Delta, 50, kHz**.

NOTE The Signal Analyzer 10 kHz filter shape factor of 4.1:1 has a bandwidth of 4.1 kHz at the 60 dB point. The half-bandwidth, or 20.5 kHz, is narrower than 50 kHz, so the input signals can be resolved. Refer to [Figure 3-12](#).

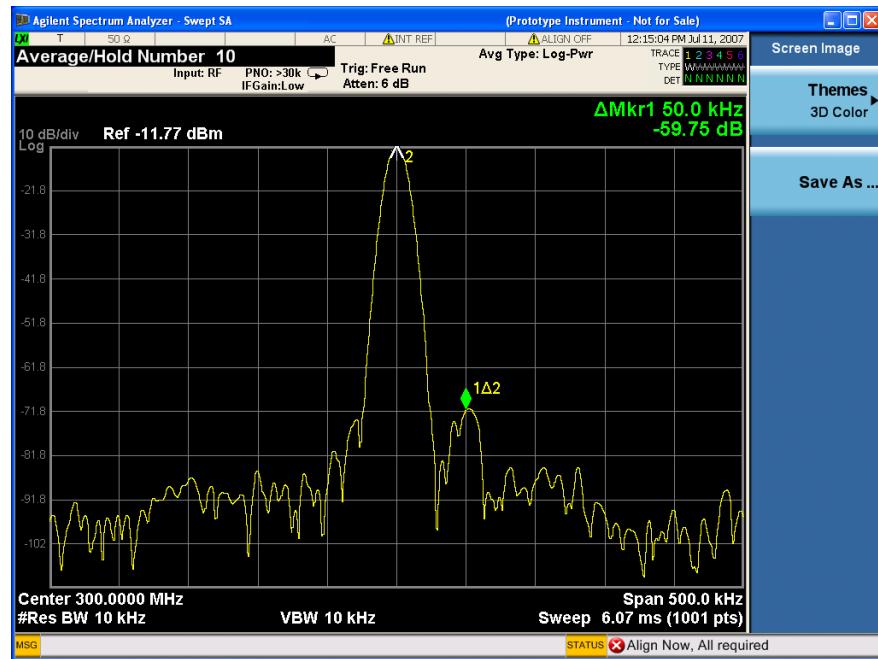
NOTE To make the separate signals more clear in the display, you may need to use averaging. To set the averaging to 10 averages:

Press **Meas Setup**.

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

Measuring Multiple Signals
Resolving Small Signals Hidden by Large Signals

Figure 3-12. Signal Resolution with a 10 kHz RBW



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 1. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 2. Preset the analyzer:

Press **Mode Preset**.

Step 3. Enable the internal 50 MHz amplitude reference signal of the analyzer as follows:

Press **Input/Output, RF Calibrator, 50 MHz**.

Step 4. Set the start frequency to 20 MHz and the stop frequency to 1 GHz:

Press **FREQ Channel, Start Freq, 20, MHz**.

Press **FREQ Channel, Stop Freq, 1, GHz**.

Step 5. Turn on the signal tracking function to place a marker at the peak and move the signal to the center of the screen (if it is not already positioned there) and initiate Span Zoom:

Press **Span X Scale, Signal Track (Span Zoom) (On)**.

See the left-side of figure [Figure 3-13](#).

Step 6. Set the 50 MHz calibration signal to the reference level:

Press **Mkr →, Mkr →Ref Lvl**.

NOTE 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.

Step 7. Reduce span and resolution bandwidth to further zoom in on the marked signal:

Press **SPAN X Scale, Span, 200, kHz**.

See the right-side of figure [Figure 3-13](#).

Measuring Multiple Signals

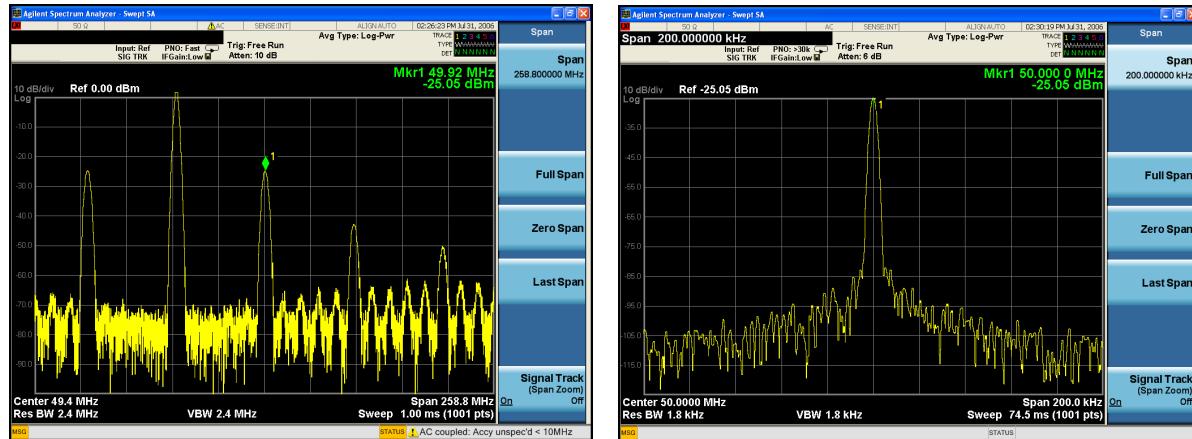
Decreasing the Frequency Span Around the Signal

NOTE If the span change is large enough, the span decreases in steps as automatic zoom is completed. See [Figure 3-13](#). on the right side. You can also use the front-panel knob or step keys to decrease the span and resolution bandwidth values.

Step 8. Turn off signal tracking:

Press **SPAN X Scale, Signal Track (Off)**.

Figure 3-13. Signal Tracking



LEFT: Signal tracking on before span decrease
RIGHT: After zooming in on the signal

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.

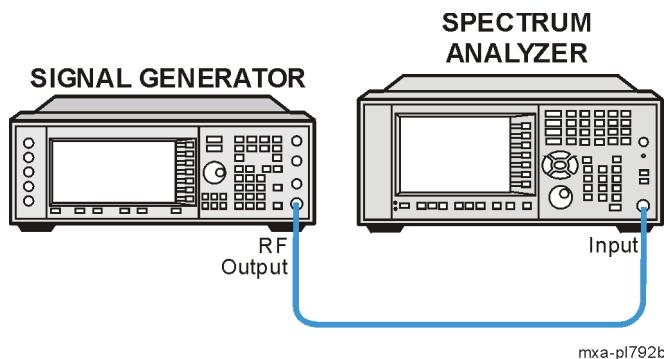
An important key to making accurate Band Power Marker measurements is to insure that the Average Type under the Meas Setup key is set to “Auto”.

Step 1. Setup the signal source as follows:

Setup a 4-carrier W-CDMA signal
Set the source frequency to 1.96 GHz.
Set the source amplitude to -10 dBm

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 3-14](#).

Figure 3-14. Setup for Signal-to-Noise Measurement



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements:

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Tune to the W-CDMA signal and set the analyzer reference level:

Press **FREQ Channel, Auto Tune**

Press **AMPTD Y Scale, Ref Level, 0, dBm**

Step 6. Enable trace averaging and the Band/Interval Power Marker function for measuring the total power of the reference 4-carrier W-CDMA signal.

Press **Trace/Detector, Select Trace, Trace 1, Trace Average**

Press **Marker Function, Band/Interval Power**

Step 7. Center the frequency of the Band/Interval Power marker on the 4-carrier reference signal envelope:

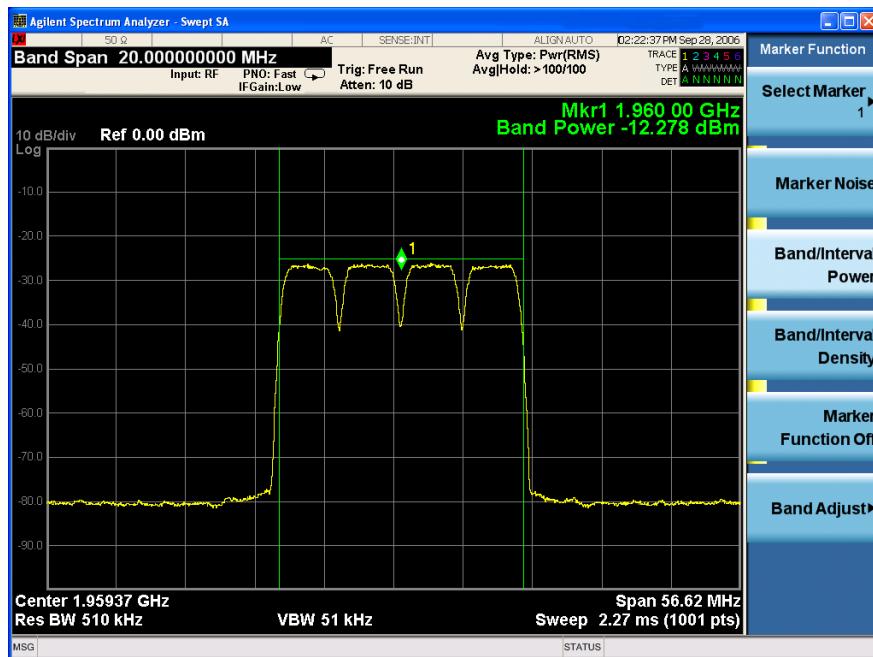
Press **Select Marker, Marker 1, 1.96, GHz**

Step 8. Adjust the width (or span) of the Band/Interval Power marker to encompass the entire 4-carrier W-CDMA reference signal (refer to [Figure 3-15.](#)):

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.

Press **Marker Function, Band Adjust, Band/Interval Span, 20, MHz**

Figure 3-15. Measured Power of Reference 4-Carrier W-CDMA Signal using Band/Interval Power Marker



Step 9. Enable the Delta Band Power Marker functionality which will change the reference Band Power Marker into a fixed power value (labeled X2) and initiate a second Band Power Marker (labeled 1?2) to measure any changes in power levels relative to the reference Band Power Marker X2.

Press **Marker, Select Marker, Marker 1, Delta**

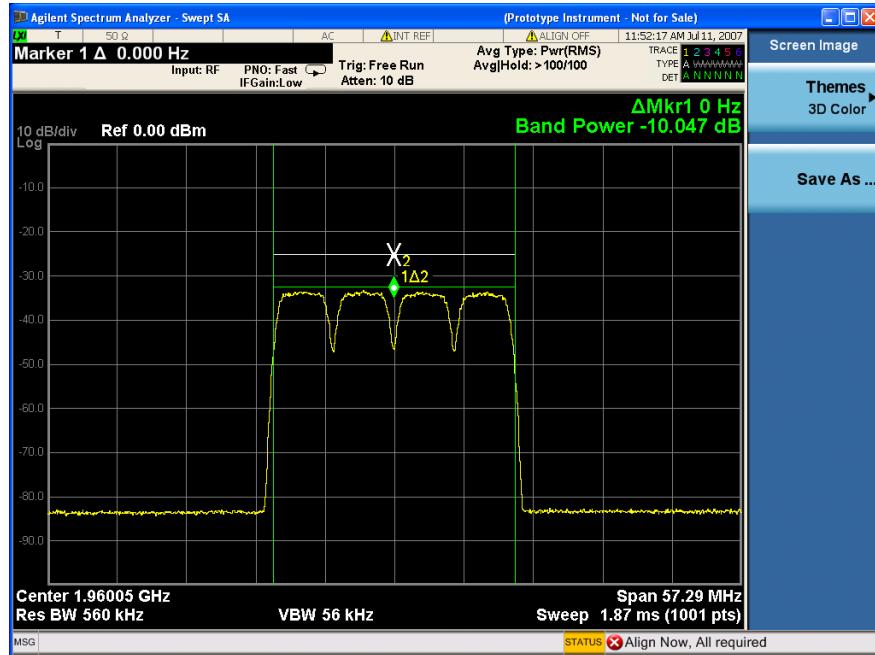
Step 10. Simulate a varying power level resulting from either adjustments, changes to the reference DUT, or a different DUT by lowering the signal source power.

Set the source amplitude to -20 dBm

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 (refer to [Figure 3-16](#)).

Figure 3-16. 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

4 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.

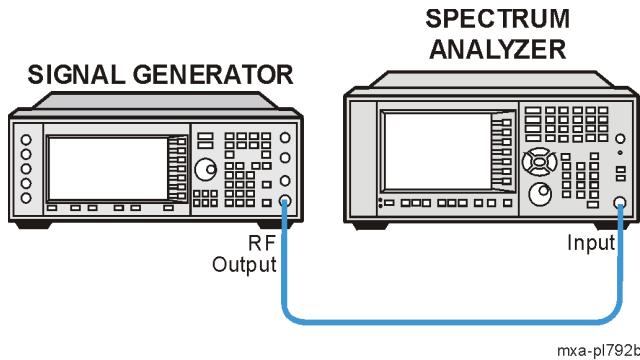
CAUTION Ensure that the total power of all input signals at the analyzer RF input does not exceed +30 dBm (1 watt).

Step 1. Setup the signal source as follows:

Set the frequency of the signal source to 300 MHz.
Set the source amplitude to –80 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 4-1](#).

Figure 4-1. Setup for Measuring a Low-Level Signal



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the center frequency, span and reference level:

Press **FREQ Channel, Center Freq, 300, MHz**.
Press **SPAN X Scale, Span, 5, MHz**.
Press **AMPTD Y Scale, Ref Level, 40, –dBm**.

Step 6. Move the desired peak (in this example, 300 MHz) to the center of the display:

Press **Peak Search, Marker →, Mkr → CF.**

Step 7. Reduce the span to 1 MHz (as shown in [Figure 4-2.](#)) and if necessary re-center the peak:

Press **Span, 1, MHz.**

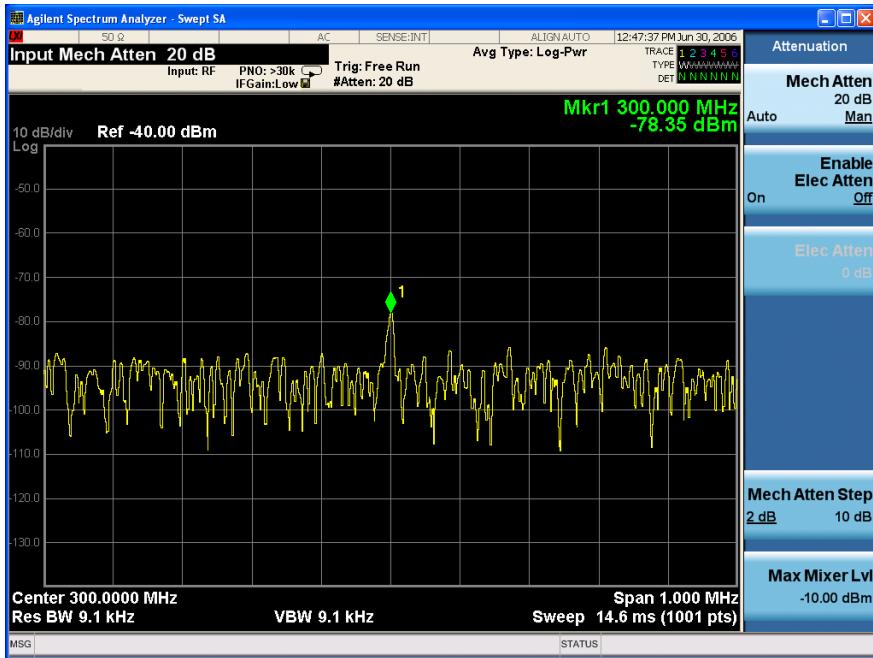
Step 8. Set the attenuation to 20 dB:

Press **AMPTD Y Scale, Attenuation, Mech Atten (Man), 20, dB.**

Note that increasing the attenuation moves the noise floor closer to the signal level.

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.

Figure 4-2. Measuring a Low-Level Signal Using Mechanical Attenuation



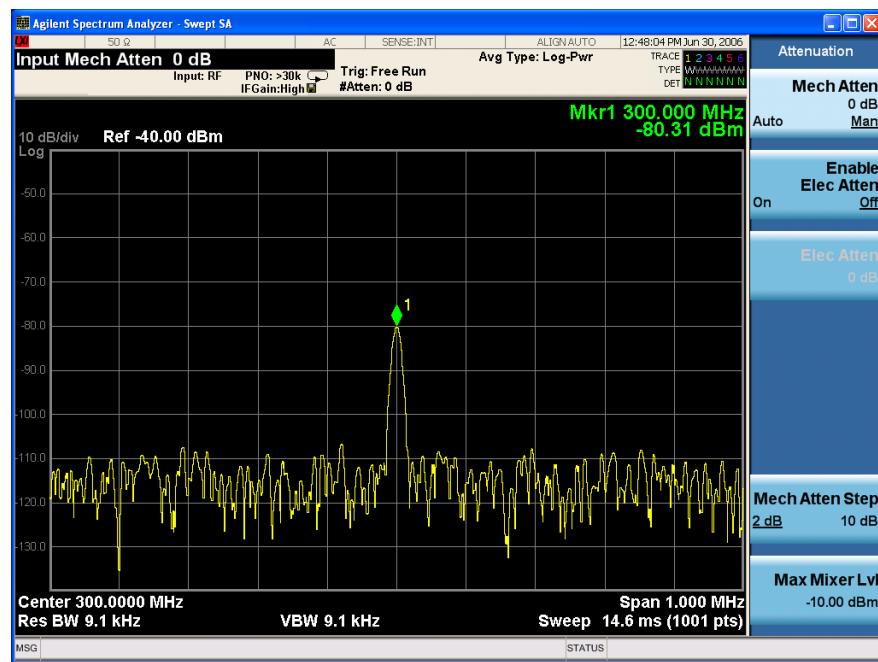
Step 9. To see the signal more clearly, set the attenuation to 0 dB:

Press **AMPTD Y Scale, Attenuation, Mech Atten (Man), 0, dB.**

See [Figure 4-3.](#) shows 0 dB input attenuation.

Measuring a Low-Level Signal Reducing Input Attenuation

Figure 4-3. 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 (Auto)** or press **Auto Couple**.

Decreasing the Resolution Bandwidth

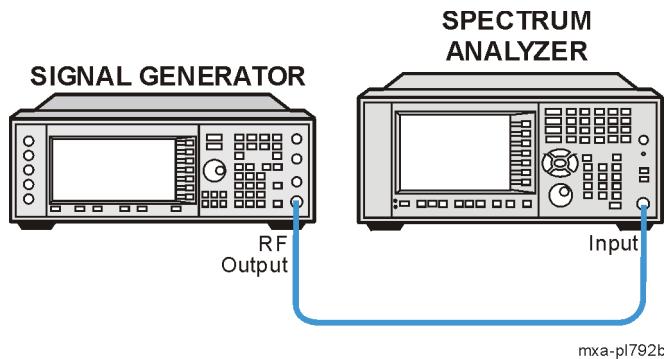
Resolution bandwidth settings affect the level of internal noise without affecting the level of continuous wave (CW) signals. Decreasing the RBW by a decade reduces the noise floor by 10 dB.

Step 1. Setup the signal sources as follows:

- Set the frequency of the signal source to 300 MHz.
- Set the source amplitude to -80 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 4-4](#).

Figure 4-4. Setup for Measuring a Low-Level Signal



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the center frequency, span and reference level:

Press **FREQ Channel, Center Freq, 300, MHz**.

Press **SPAN X Scale, Span, 50, MHz**.

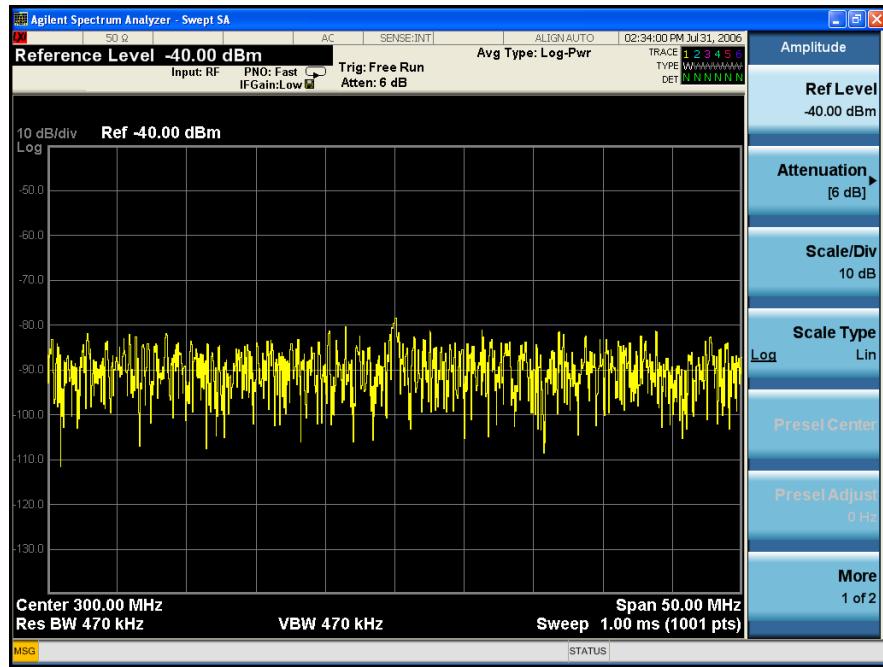
Press **AMPTD Y Scale, Ref Level, 40, -dBm**.

Refer to [Figure 4-5](#).

Measuring a Low-Level Signal

Decreasing the Resolution Bandwidth

Figure 4-5. Default Resolution Bandwidth

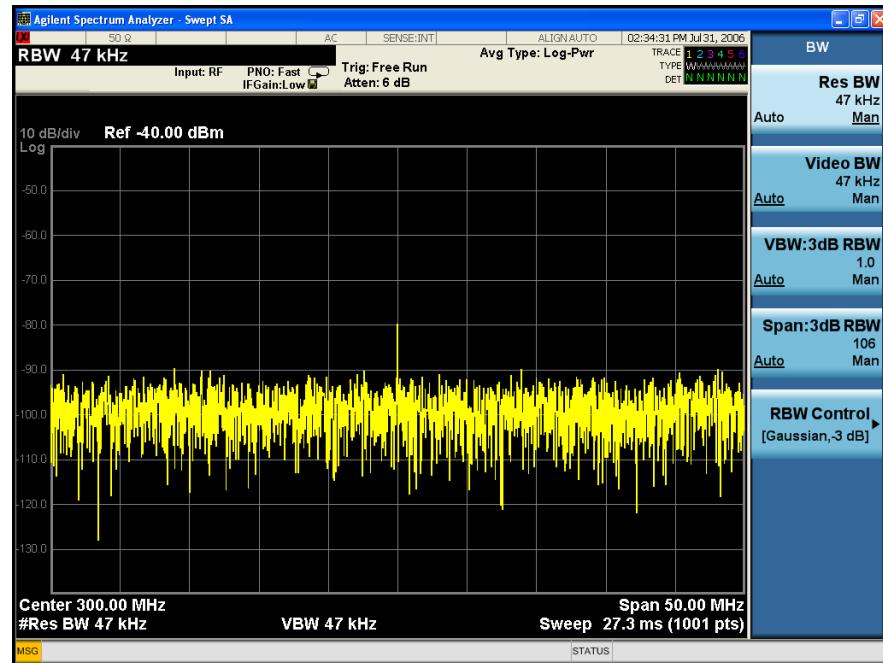


Step 6. Decrease the resolution bandwidth:

Press **BW, 47, kHz**.

The low-level signal appears more clearly because the noise level is reduced (refer to [Figure 4-6.](#)).

Figure 4-6. Decreasing Resolution Bandwidth



A “#” mark appears next to the Res BW annotation in the lower left corner of the screen, indicating that the resolution bandwidth 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

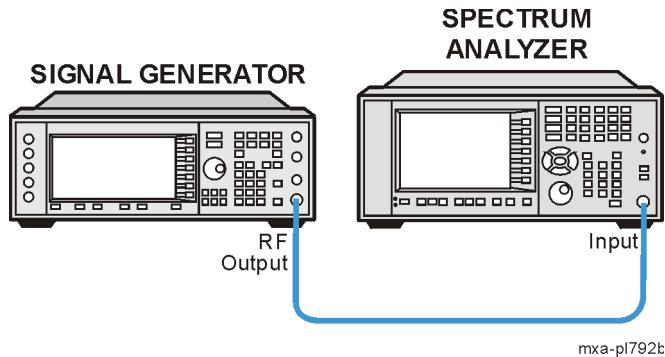
When the analyzer noise masks low-level signals, changing to the average detector and increasing the sweep time smooths the noise and improves the signal visibility. Slower sweeps are required to average more noise variations.

Step 1. Setup the signal source as follows:

Set the frequency of the signal source to 300 MHz.
Set the source amplitude to -80 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 4-7](#).

Figure 4-7. Setup for Measuring a Low-Level Signal



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the center frequency, span and reference level:

Press **FREQ Channel, Center Freq, 300, MHz**.

Press **SPAN X Scale, Span, 5, MHz**.

Press **AMPTD Y Scale, Ref Level, 40, -dBm**.

Step 6. Select the average detector:

Press **Trace/Detector, More, Detector, Average (Log/RMS/V)**.

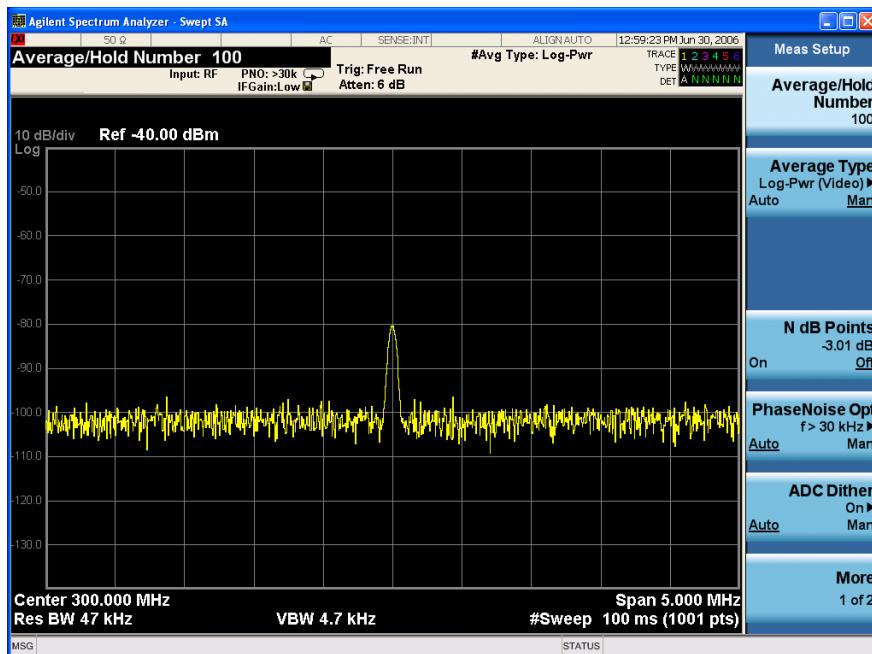
The number 1 (Trace 1 indicator) in the Trace/Detector panel (in the upper right-hand corner of the display) changes from green to white, indicating that the detector has been chosen manually. In addition, the letter in the Det row has been set to "A" indicating that the Average detector has been selected. (see [Figure 4-8](#)).

Step 7. Increase the sweep time to 100 ms:Press **Sweep/Control, Sweep Time (Man)**, 100, ms.

Note how the noise smooths out, as there is more time to average the values for each of the displayed data points.

Step 8. With the sweep time at 100 ms, change the average type to log averaging:Press **Meas Setup, Average Type, Log-Pwr Avg (Video)**.

Note how the noise level drops.

Figure 4-8. 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.

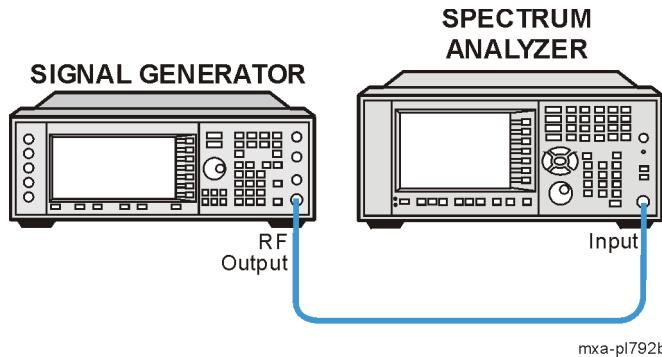
NOTE This is a trace processing function and is not the same as using the average detector (as described on [page 52](#)).

Step 1. Setup the signal source as follows:

Set the frequency of the signal source to 300 MHz.
Set the source amplitude to -80 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 4-7](#).

Figure 4-9. Setup for Measuring a Low-Level Signal



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the center frequency, span and reference level:

Press **FREQ Channel, Center Freq, 300, MHz**.
Press **SPAN X Scale, Span, 5, MHz**.
Press **AMPTD Y Scale, Ref Level, 40, -dBm**.

Step 6. Turn trace averaging on:

Press **Trace/Detector, Trace Average**.

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. Refer to [Figure 4-10](#).

Step 7. With trace average as the active function, set the number of averages to 25:

Press **Meas Setup, Average/Hold Number, 25, Enter.**

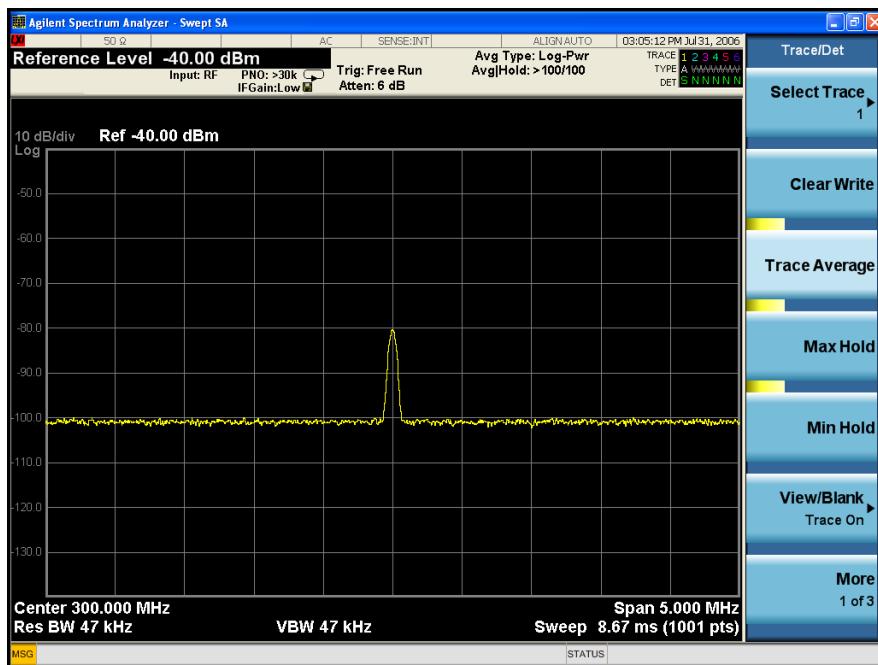
Annotation above the graticule in the measurement bar to the right of center shows the type of averaging, Log-Pwr. Also, the number of traces averaged is shown on the Average/Hold Number key.

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.

Figure 4-10. Trace Averaging



Measuring a Low-Level Signal
Trace Averaging

5 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 1. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 2. Preset the analyzer:

Press **Mode Preset**.

Step 3. Enable the internal 50 MHz amplitude reference signal as follows:

Press **Input/Output, RF Calibrator, 50 MHz**.

Step 4. Set the center frequency to 50 MHz and the span to 80 MHz:

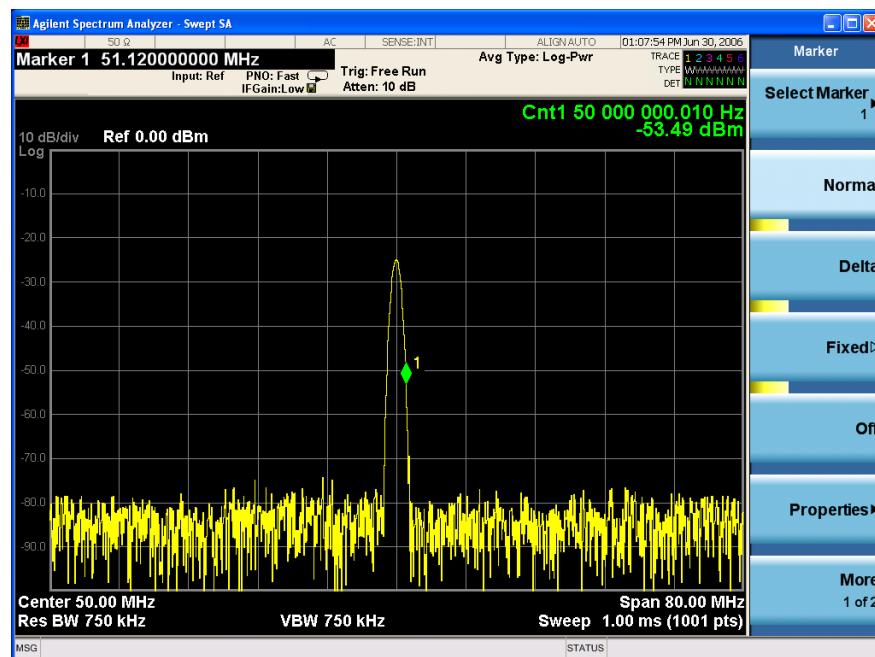
Press **FREQ Channel, Center Freq, 50, MHz**.

Press **SPAN X Scale, Span, 80, MHz**.

Step 5. Turn the frequency counter on:

Press **Marker, More, Marker Count, Counter (On)**.

Figure 5-1. Using Marker Counter



Step 6. The marker counter remains on until turned off. Turn off the marker counter:

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

Press **Marker, More, Marker Count, Count (Off)**
Or
Press **Marker, Off**.

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

6 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.

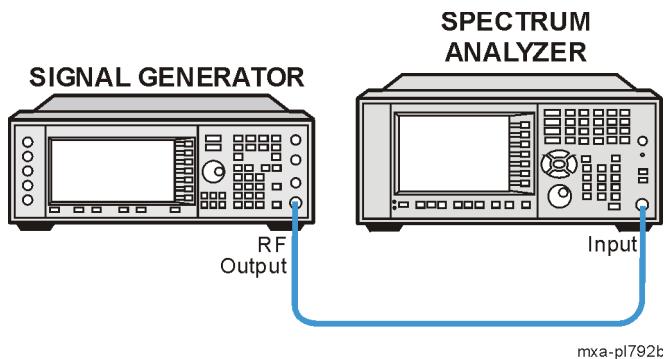
This procedure uses signal tracking to keep the drifting signal in the center of the display. The drifting is captured by the analyzer using maximum hold.

Step 1. Setup the signal sources as follows:

- Set the frequency of the signal source to 300 MHz.
- Set the source amplitude to -20 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 6-1](#).

Figure 6-1. Setup for Measuring Source Drift



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the analyzer center frequency, span and reference level.

Press **FREQ Channel, Center Freq, 300, MHz**.

Press **SPAN X Scale, Span, 10, MHz**.

Press **AMPTD Y Scale, Ref Level, 10, -dBm**.

Step 6. Place a marker on the peak of the signal and turn signal tracking on:

Press **Peak Search**.

Press **SPAN X Scale, Signal Track (On)**.

Step 7. Reduce the span to 500 kHz:

Press **SPAN, 500, kHz**.

Notice that the signal is held in the center of the display.

Step 8. Turn off the signal track function:

Press **SPAN X Scale, Signal Track (Off)**.

Step 9. Measure the excursion of the signal with maximum hold:

Press **Trace/Detector, Max Hold**.

As the signal varies, maximum hold maintains the maximum responses of the input signal.

NOTE

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.

Step 10. Activate trace 2 and change the mode to continuous sweeping:

Press **Trace/Detector, Select Trace, Trace (2)**.

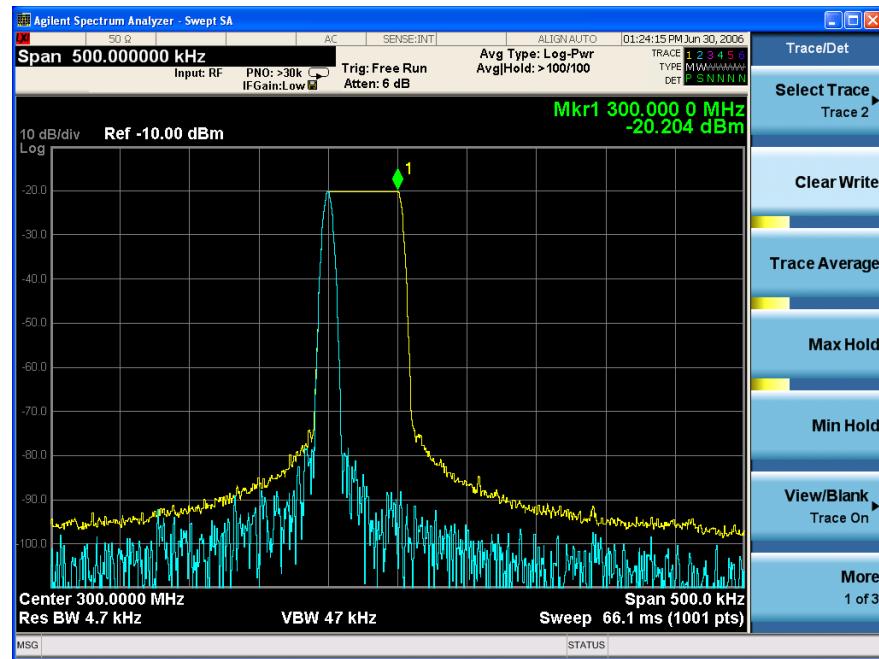
Press **Clear Write**.

Trace 1 remains in maximum hold mode to show any drift in the signal.

Step 11. Slowly change the frequency of the signal generator \pm 50 kHz in 1 kHz increments. Your analyzer display should look similar to [Figure 6-2](#).

Tracking Drifting Signals
Measuring a Source Frequency Drift

Figure 6-2. 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.

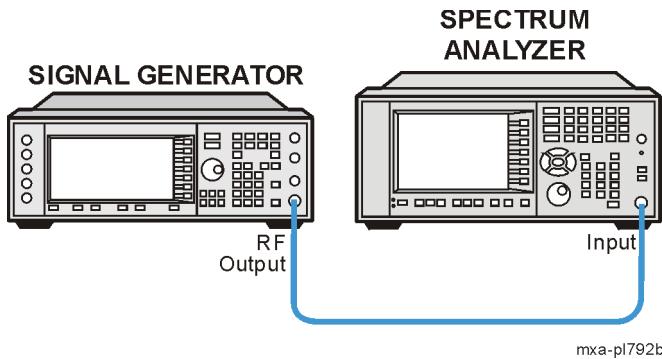
Note that the primary function of the signal track function is to track unstable signals, not to track a signal as the center frequency of the analyzer is changed. If you choose to use the signal track function when changing center frequency, check to ensure that the signal found by the tracking function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

Step 1. Setup the signal sources as follows:

Set the frequency of the signal source to 300 MHz.
Set the source amplitude to -20 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 6-3](#).

Figure 6-3. Setup for Tracking a Signal



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the analyzer center frequency at a 1 MHz offset:

Press **FREQ Channel, Center Freq, 301, MHz**.

Press **SPAN X Scale, Span, 10, MHz**.

Step 6. Turn the signal tracking function on:

Press **SPAN X Scale, Signal Track (On)**.

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.

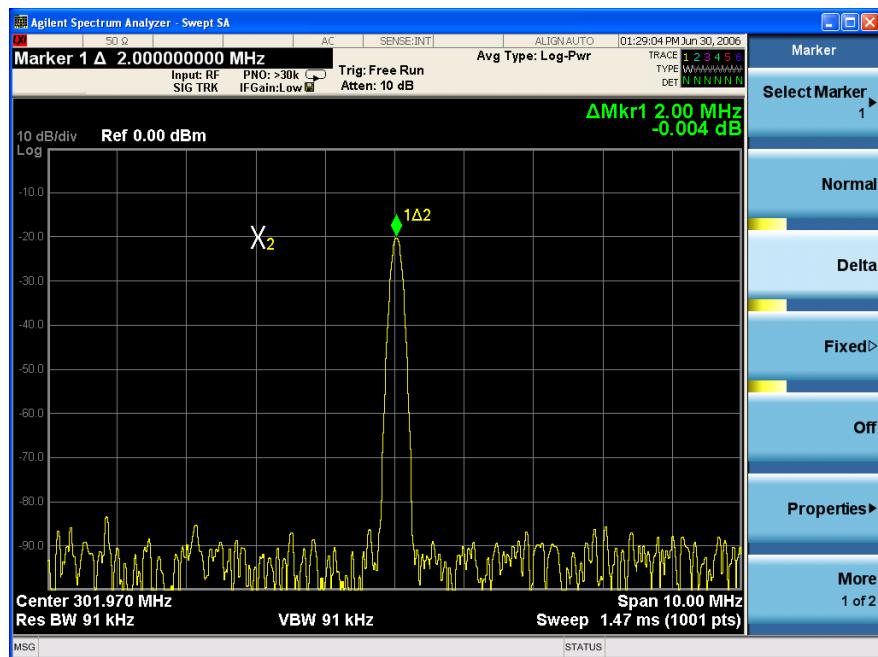
Step 7. Turn the delta marker on to read signal drift:

Press **Marker, Delta**.

Step 8. 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 6-4. Tracking a Drifting Signal



7 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.

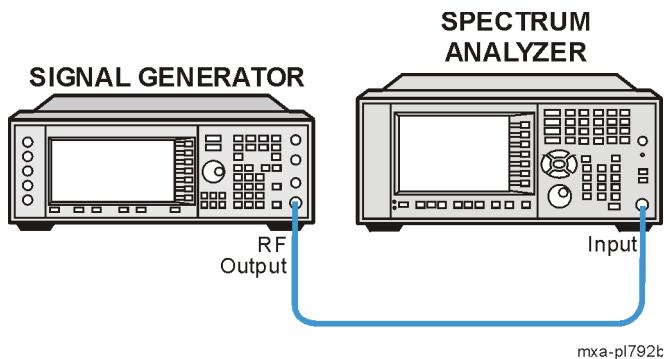
Using a signal from a signal generator, determine whether the harmonic distortion products are generated by the analyzer.

Step 1. Setup the signal source as follows:

- Set the frequency of the signal source to 200 MHz.
- Set the source amplitude to 0 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 7-1](#).

Figure 7-1. Setup for Identifying Analyzer Generated Distortion



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the analyzer center frequency, span, and video bandwidth:

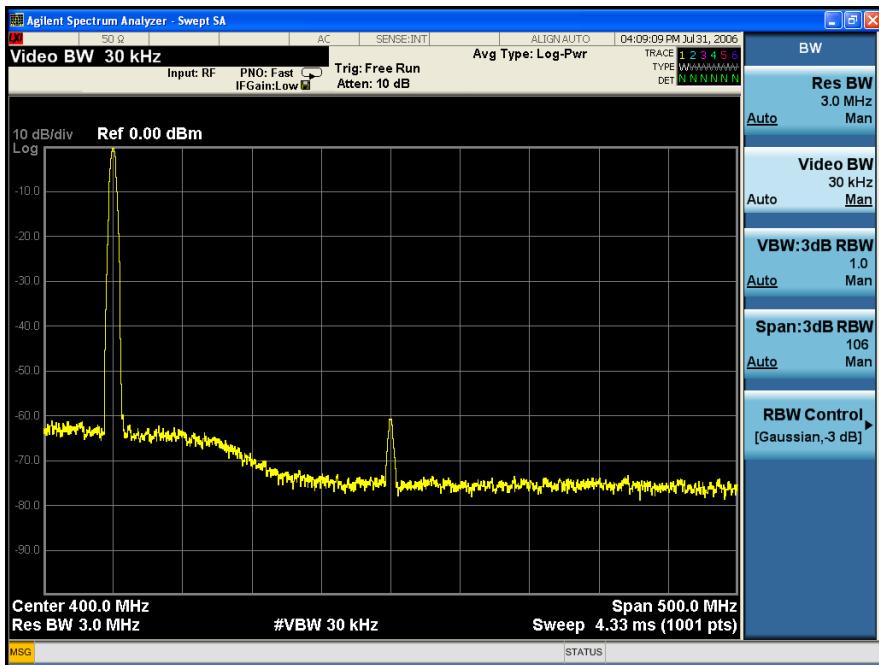
Press **FREQ Channel, Center Freq, 400, MHz**.

Press **SPAN X Scale, Span, 500, MHz**.

Press **BW, Video BW, 30, kHz**.

The signal produces harmonic distortion products (spaced 200 MHz from the original 200 MHz signal) in the analyzer input mixer as shown in [Figure 7-2](#).

Figure 7-2. Harmonic Distortion



Step 6. Change the center frequency to the value of the first harmonic:

Press **Peak Search, Next Peak, Mkr→CF**.

Step 7. Change the span to 50 MHz and re-center the signal:

Press **SPAN X Scale, Span, 50, MHz**.

Press **Peak Search, Mkr→CF**.

Step 8. Set the attenuation to 0 dB:

Press **AMPTD Y Scale, Attenuation, 0, dB**.

Step 9. To determine whether the harmonic distortion products are generated by the analyzer, first save the trace data in trace 2 as follows:

Press **Trace/Detector, Select Trace, Trace 2, Clear Write**.

Step 10. Allow trace 2 to update (minimum two sweeps), then store the data from trace 2 and place a delta marker on the harmonic of trace 2:

Press **Trace/Detector, View/Blank, View** (Update Off, Display On).

Press **Peak Search, Marker Delta**.

The analyzer display shows the stored data in trace 2 and the measured data in trace 1. The $\Delta Mkr1$ amplitude reading is the difference in amplitude between the reference and active markers.

Step 11. Increase the RF attenuation to 10 dB:

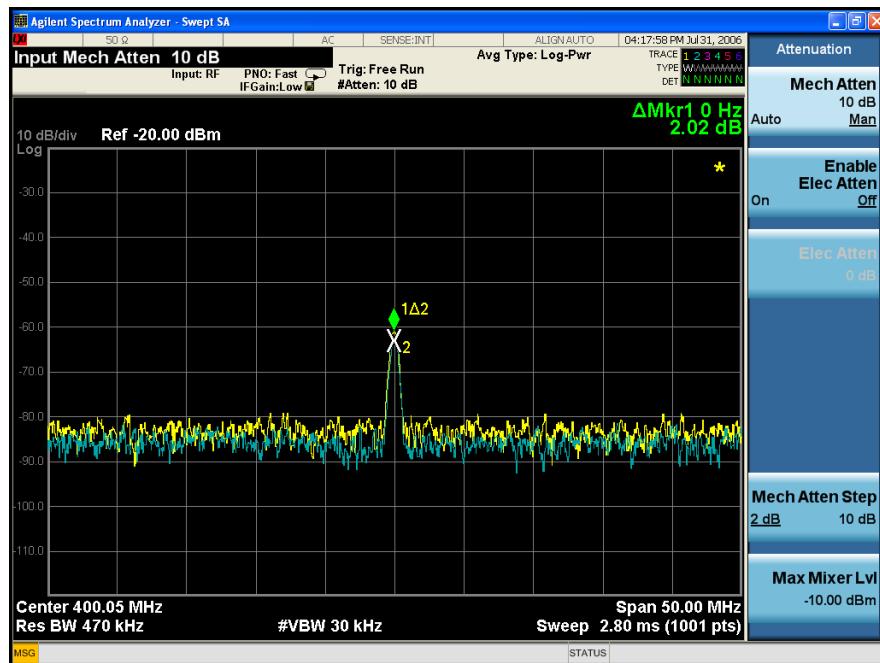
Press **AMPTD Y Scale, Attenuation, 10, dB**.

Notice the $\Delta Mkr1$ amplitude reading. This is the difference in the distortion

Making Distortion Measurements
Identifying Analyzer Generated Distortion

product amplitude readings between 0 dB and 10 dB input attenuation settings. If the ΔM_{kr1} amplitude absolute value is approximately ≥ 1 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 ΔM_{kr1} 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 Figure 7-3.

Figure 7-3. RF Attenuation of 10 dB



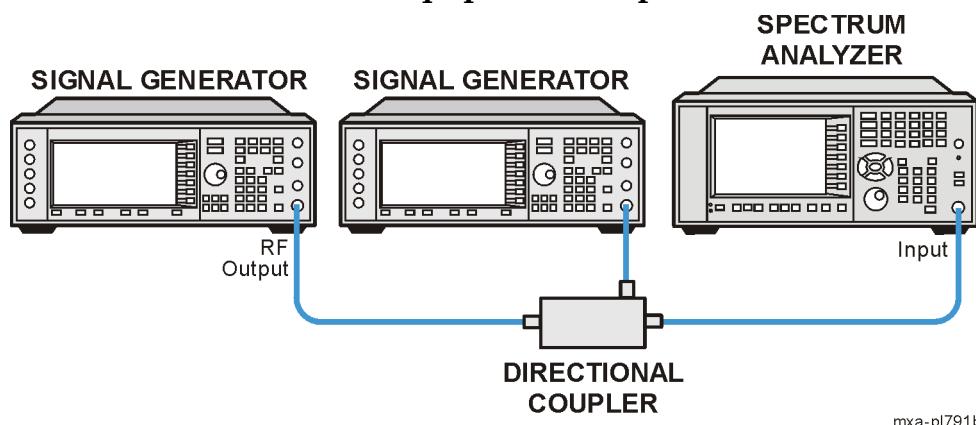
Third-Order Intermodulation Distortion

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.

Step 1. Connect the equipment as shown in [Figure 7-4](#). This combination of signal generators, low pass filters, and 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/analyizer combination. After the performance of the source/analyizer 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.

Figure 7-4. Third-Order Intermodulation Equipment Setup



NOTE The coupler should have a high degree of isolation between the two input ports so the sources do not intermodulate.

Step 2. Set the sources as follows:

Set one signal generator to 300 MHz.

Set the other source to 301 MHz. This produces a frequency separation of 1 MHz. Set the sources equal in amplitude as measured by the analyzer (in this example, they are set to -5 dBm).

Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the analyzer center frequency and span:

Press **FREQ Channel, Center Freq, 300.5, MHz**.

Press **SPAN X Scale, Span, 5, MHz**.

Step 6. Set the analyzer detector to Peak:

Press **Trace/Detector, Detector, Peak**.

Step 7. Set the mixer level to improve dynamic range:

Press **AMPTD Y Scale, Attenuation, Max Mixer Lvl, -10, dBm**.

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.

Step 8. Move the signal to the reference level:

Press **Peak Search, Mkr →, Mkr → Ref Lvl**.

Step 9. Reduce the RBW until the distortion products are visible:

Press **BW, Res BW, ↓**.

Step 10. Activate the second marker and place it on the peak of the distortion product closest to the marker test signal using the **Next Right** key (if the first marker is on the right-hand test signal) or **Next Left** key (if the first marker is on the left-hand test signal):

Press **Peak Search, Marker Delta, Next Left or Next Right** (as appropriate).

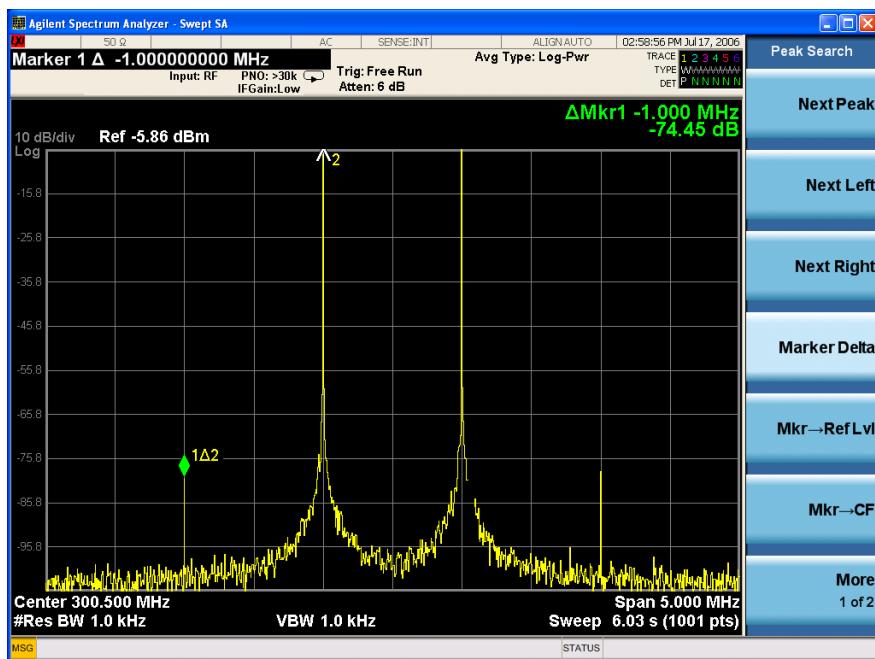
Step 11. Measure the other distortion product:

Press **Marker, Normal, Peak Search, Next Peak**.

Step 12. Activate the second marker and place it on the peak of the distortion product closest to the marked test signal using the **Next Right** key (if the first marker is on the right-hand test signal) or the **Next Left** key (if the first marker is on the left-hand test signal) (see [Figure 7-5](#)):

Press **Marker, Normal, Marker Delta, Next Left or Next Right** (as appropriate).

Figure 7-5. Measuring the Distortion Product



Making Distortion Measurements
Third-Order Intermodulation Distortion

8 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 1. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 2. Preset the analyzer:

Press **Mode Preset**.

Step 3. Enable the internal 50 MHz amplitude reference signal as follows:

Press **Input/Output, RF Calibrator, 50, MHz**.

Step 4. Set the center frequency, span, reference level and attenuation:

Press **FREQ Channel, Center Freq, 50, MHz**.

Press **SPAN X Scale, Span, 1, MHz**.

Press **AMPTD Y Scale, Ref Level, -10, dBm**.

Press **AMPTD Y Scale, Attenuation, 40, dB**.

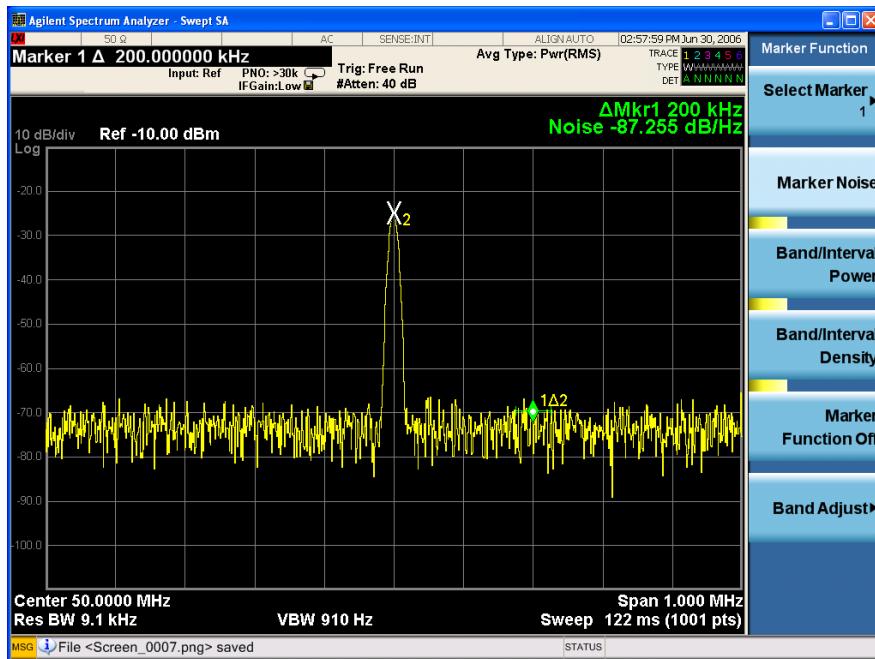
Step 5. Place a marker on the peak of the signal and then place a delta marker in the noise at a 200 kHz offset:

Press **Peak Search, Marker Delta, 200, kHz**.

Step 6. Turn on the marker noise function to view the signal-to-noise measurement results:

Press **Marker Function, Marker Noise**.

Figure 8-1. Measuring the 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 78.

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 1. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 2. Preset the analyzer:

Press **Mode Preset**.

Step 3. Enable the internal 50 MHz amplitude reference signal as follows:

Press **Input/Output, RF Calibrator, 50, MHz**.

Press **FREQ Channel, Center Freq, 49.98, MHz**.

Press **Span X Scale, Span, 100, kHz**.

Press **AMPTD Y Scale, Ref Level, -10, dBm**.

Press **AMPTD Y Scale, Attenuation, Mech Atten, 40, dB**.

Step 4. Activate the noise marker:

Press **Marker Function, Marker Noise**.

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 bandwidth.

For noise power in a different bandwidth, add $10 \times \log(\text{BW})$. For example, for noise power in a 1 kHz bandwidth, dBm (1 kHz), add $10 \times \log(1000)$ or 30 dB to the noise marker value.

Step 5. Reduce the variations of the sweep-to-sweep marker value by increasing the sweep time:

Press **Sweep/Control, Sweep Time, 3, s**.

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 6. Move the marker to 50 MHz:

Press **Marker, 50, MHz**.

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.

Step 7. To adjust the width of the noise marker relative to the span:

Press **Marker Function**, **Band Adjust**, **Band/Interval Span**, and adjust the value to the desired marker width.

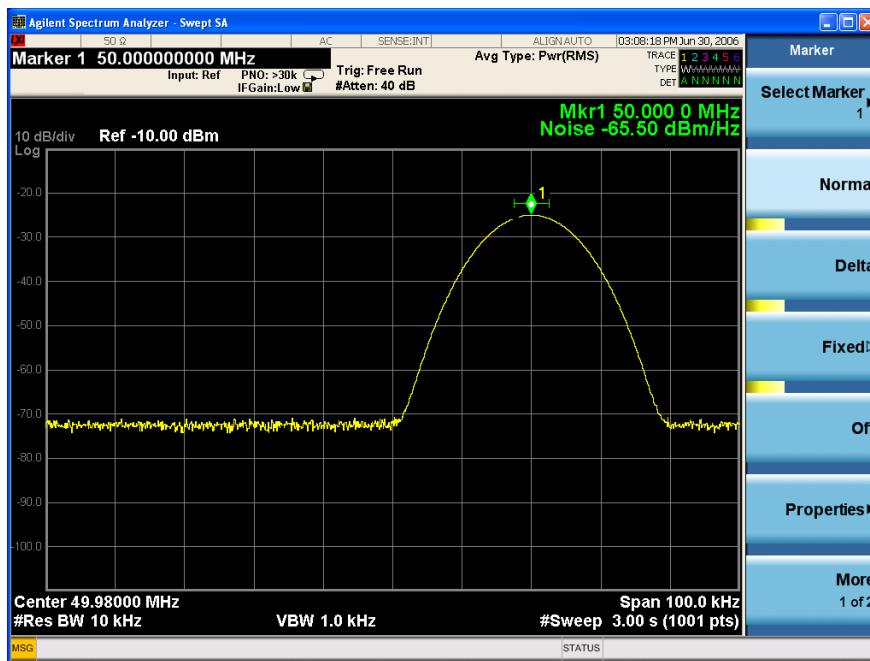
Notice that the marker does not go to the peak of the signal unless the Band/Interval Span is set to 0 Hz because otherwise there are not enough points at the peak of the signal. With a Band Interval Span greater than 0 Hz, the noise marker is also averaging points below the peak due to the narrow RBW.

Step 8. Widen the resolution bandwidth to allow the marker to make a more accurate peak power measurement using the noise marker:

Press **BW**, **Res BW**, 10, **kHz**.

Refer to [Figure 8-2](#).

Figure 8-2. Noise Marker



Step 9. 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 filter. (See [Figure 8-3](#).)

Remember that the noise marker calculates a value based on an average of the

Measuring Noise

Measuring Noise Using the Noise Marker

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).

Figure 8-3. 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 1. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 2. Preset the analyzer:

Press **Mode Preset**.

Step 3. Set the center frequency, span, reference level and attenuation:

Press **FREQ Channel, Center Freq, 50, MHz**.

Press **SPAN X Scale, Span, 100, kHz**.

Press **AMPTD Y Scale, Ref Level, -20, dBm**.

Press **AMPTD Y Scale, Attenuation, 40, dB**.

Step 4. Measure the total noise power between the markers:

Press **Marker Function, Band/Interval Density**.

Step 5. Set the band span:

Press **Band Adjust, Band/Interval Span, 40, kHz**.

Step 6. Set the resolution and video bandwidths:

Press **BW, Res BW, 1, kHz**.

Press **BW, Video BW, 10, kHz**.

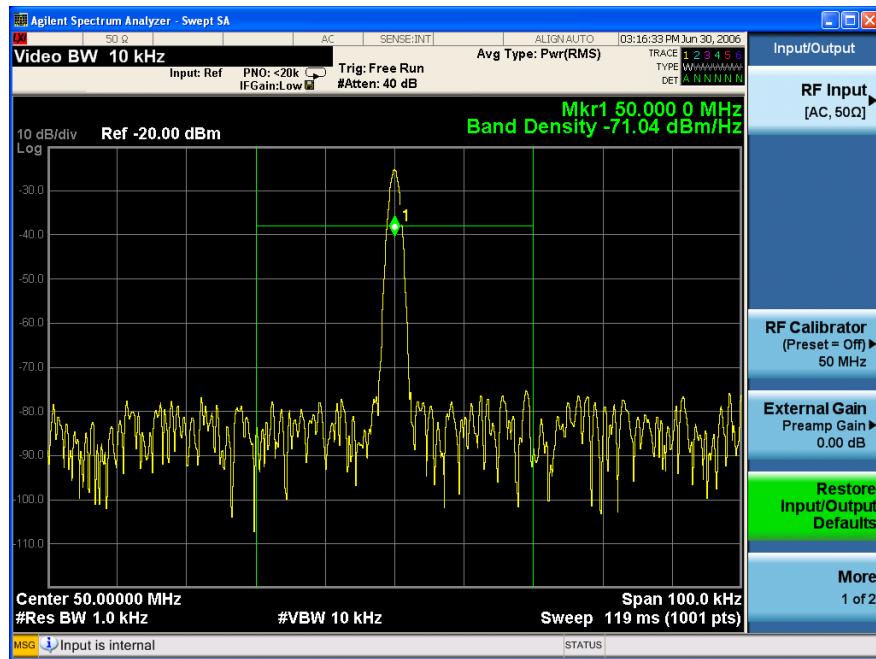
Common practice is to set the resolution bandwidth from 1% to 3% of the measurement (marker) span, 40 kHz in this example.

Step 7. Add a discrete tone to see the effects on the reading. Enable the internal 50 MHz amplitude reference signal of the analyzer as follows:

Press **Input/Output, RF Calibrator, 50 MHz**.

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

Figure 8-4. Band/Interval Density Measurement

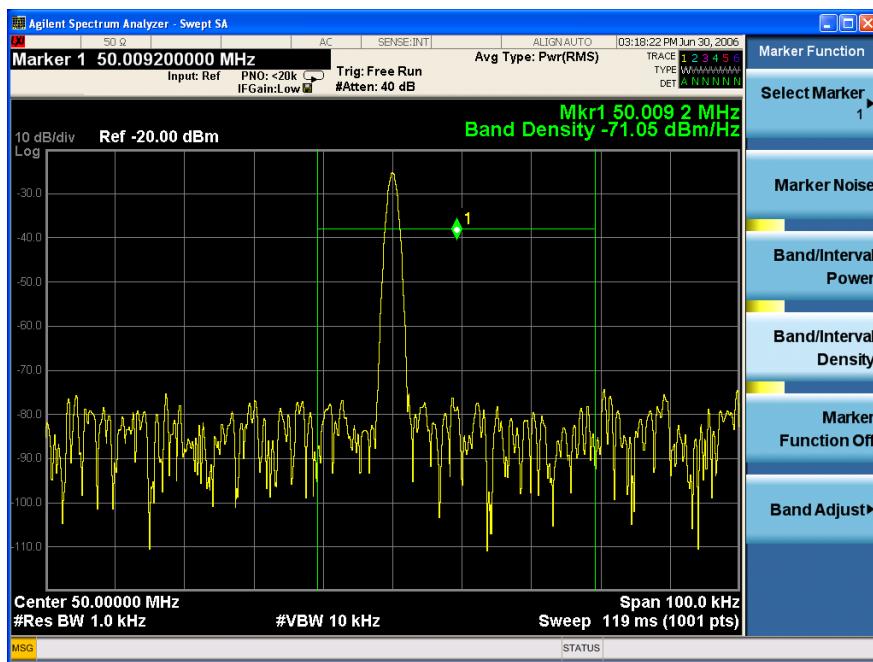


Step 8. Set the Band/Interval Density Markers to enable moving the markers (set at 40 kHz span) around without changing the Band/Interval span. Use the front-panel knob to move the band power markers and note the change in the power reading:

Press **Marker Function**, **Band/Interval Density**, then rotate front-panel knob. (Refer to [Figure 8-5](#).)

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

Figure 8-5. Band/Interval Density Measurement



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 1. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 2. Preset the analyzer:

Press **Mode Preset**.

Step 3. Set the center frequency:

Press **FREQ Channel, Center Freq, 50, MHz**.

Step 4. Start the channel power measurement:

Press **Meas, Channel Power**.

Step 5. Enable the Bar Graph:

Press **View/Display, Bar Graph, On**.

Step 6. Add a discrete tone to see the effects on the reading. Enable the internal 50 MHz amplitude reference signal of the analyzer as follows:

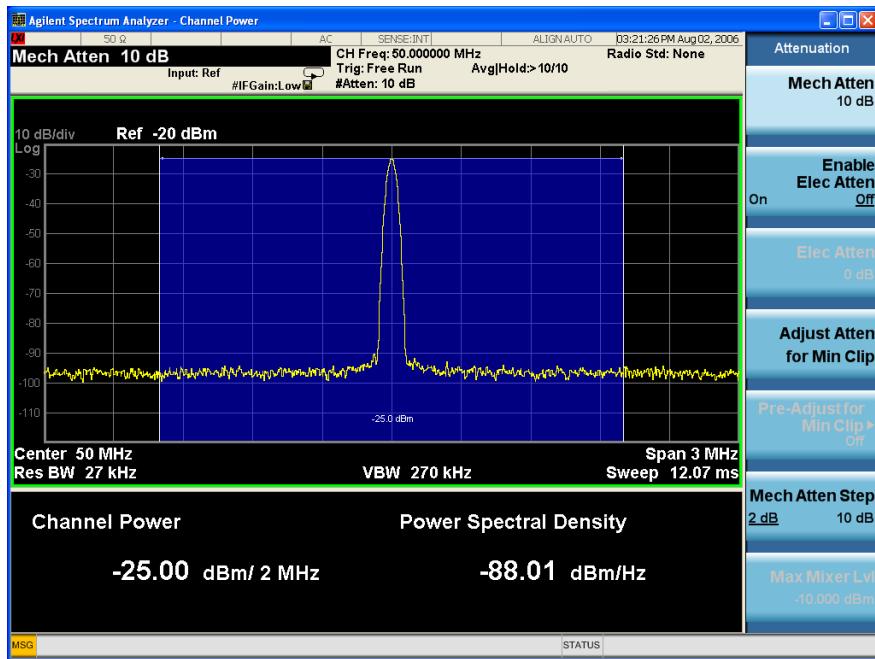
Press **Input/Output, RF Calibrator, 50 MHz**.

Step 7. Optimize the analyzer attenuation level setting:

Press **AMPTD, Attenuation, Adjust Atten for Min Clip**.

Your display should be similar to [Figure 8-6](#).

Figure 8-6. Measuring Channel Power



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".

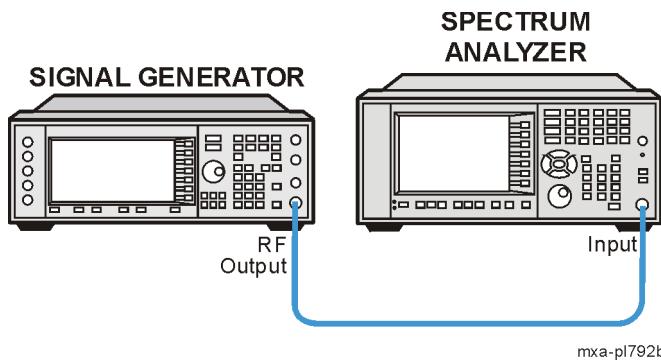
In this example a 4 carrier W-CDMA digitally modulated carrier is used as the fundamental signal and the internal noise of the analyzer is measured as the system noise.

Step 1. Setup the signal source as follows:

- Setup a 4 carrier W-CDMA signal.
- Set the source frequency to 1.96 GHz.
- Set the source amplitude to -10 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 8-7](#).

Figure 8-7. Setup for Signal-to-Noise Measurement



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements:

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Tune to the W-CDMA signal:

Press **FREQ Channel, Auto Tune**

Step 6. Enable the Band Power Marker function for measuring the total power of the 4 carrier W-CDMA signal.

Press **Marker Function, Band/Interval Power**

Step 7. Center the frequency of the Band Power marker on the signal:

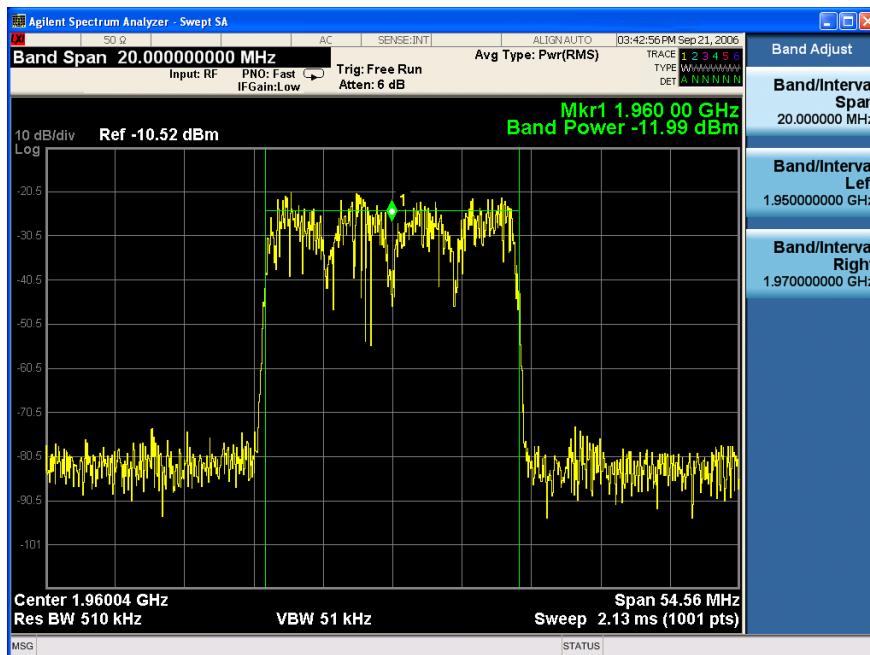
Press **Select Marker 1, 1.96, GHz**

Step 8. Adjust the width (or span) of the Band Power marker to encompass the entire 4 carrier W-CDMA signal (refer to [Figure 8-8](#).):

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.

Press **Marker Function, Band Adjust, Band/Interval Span, 20, MHz**

Figure 8-8. 4 Carrier W-CDMA Signal Power using Band Power Marker



Step 9. Enable the Noise Marker using marker 2 for measuring the system noise power:

Press **Marker Function, Select Marker, Marker 2, Marker Noise**

Step 10. Move the Noise Marker 2 to the system noise frequency of interest:

Press **Select Marker 2, 1.979, GHz**

Step 11. Adjust the width of the noise marker region to encompass the desired noise power (refer to [Figure 8-9](#).):

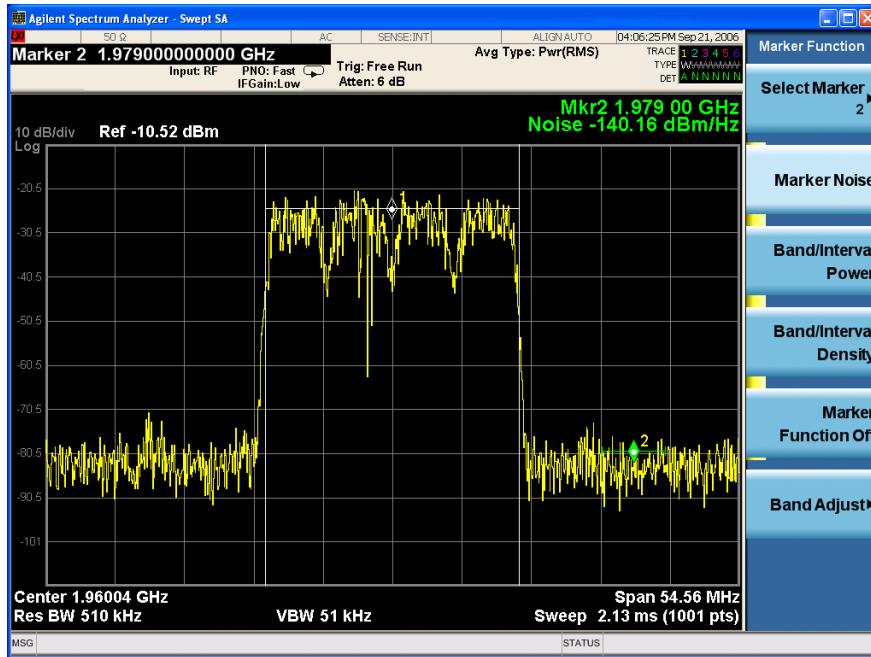
Measuring Noise

Measuring Signal-to-Noise of a Modulated Carrier

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.

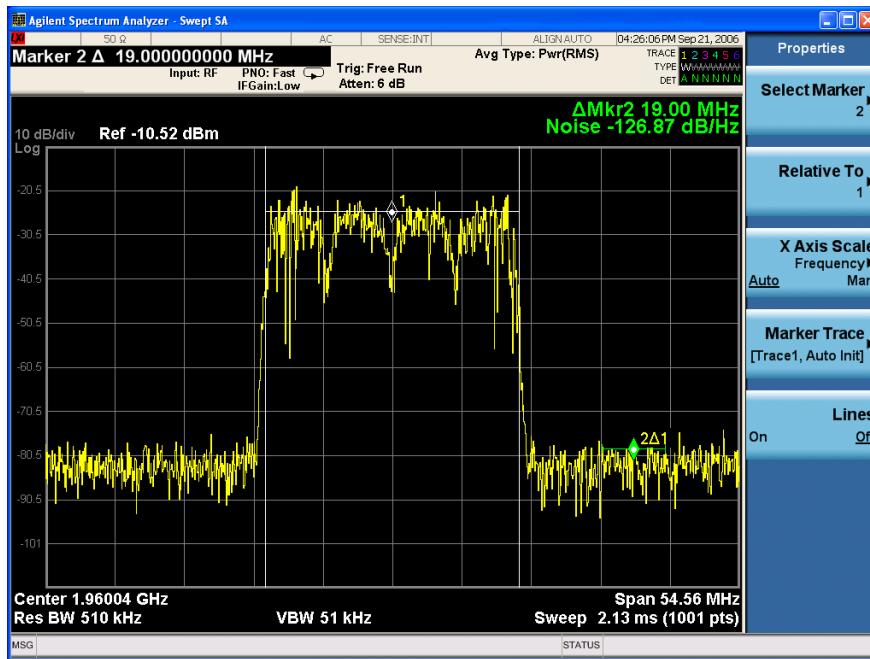
Press **Marker Function**, **Select Marker**, **Marker 2**, **Band Adjust**, **Band/Interval**, **5, MHz**

Figure 8-9. Noise Marker Measuring System Noise



Step 12. Measure carrier-to-noise by making the Noise Marker relative to the carrier's Band Power Marker (refer to [Figure 8-10](#)):

Press **Marker**, **Properties**, **Select Marker**, **Marker 2**, **Relative to**, **Marker 1**

Figure 8-10. Signal-to-Noise Measurement

Step 13. Simultaneously measure carrier-to-noise on a second region of the system by enabling another Noise Marker (up to 11 available).

Press **Marker Function**, **Select Marker**, **Marker 3**, **Marker Noise**

Press **Select Marker 3**, 1.941, GHz

Press **Return**, **Band Adjust**, **Band/Interval**, 5, MHz

Press **Marker**, **Properties**, **Select Marker**, **Marker 3**, **Relative to**, **Marker 1**

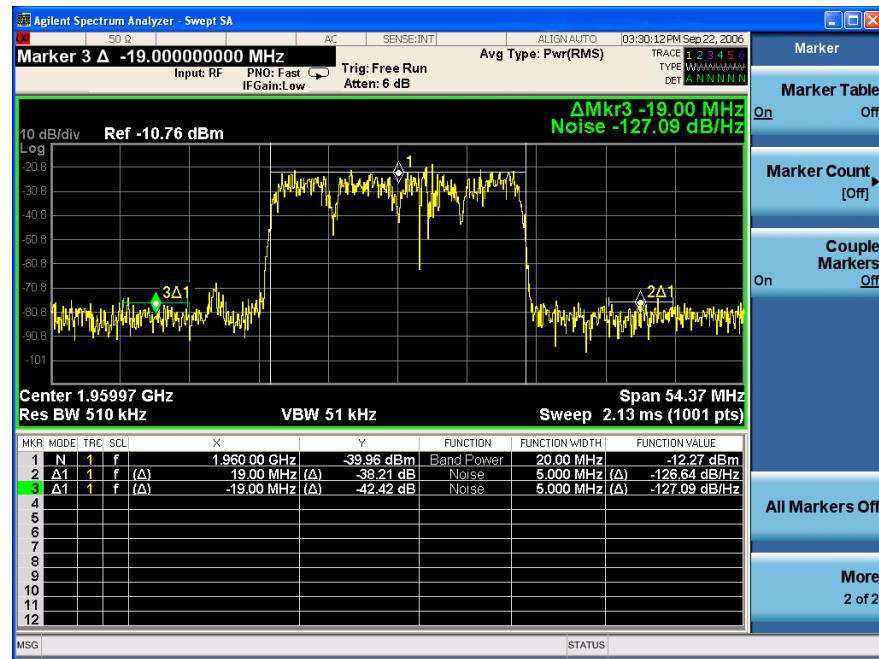
Step 14. Enable the Marker Table to view results of both carrier-to-noise measurements and all other markers (refer to [Figure 8-10.](#)):

Press **Marker**, **More**, **Marker Table**, **On**

Measuring Noise

Measuring Signal-to-Noise of a Modulated Carrier

Figure 8-11. Multiple Signal-to-Noise Measurements with Marker Table



Improving Phase Noise Measurements by Subtracting Signal Analyzer Noise

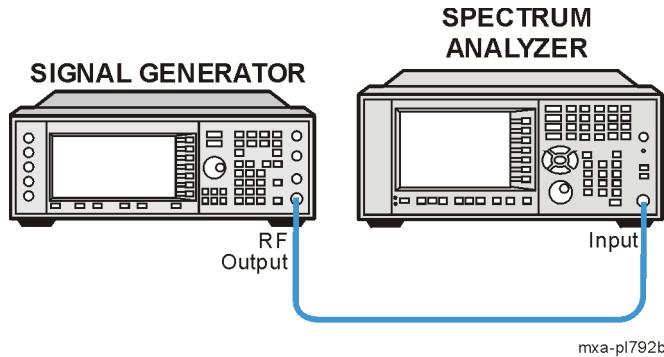
Making noise power measurements (such as phase noise) near the noise floor of the signal analyzer can be challenging where every dB improvement is important. Utilizing the analyzer trace math function Power Diff and 3 separate traces allows measurement of the DUT phase noise in one trace, the analyzer 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 1. Setup the signal source as follows:

- Setup an unmodulated signal
- Set the source frequency to 1.96 GHz.
- Set the source amplitude to -30 dBm

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 8-12.](#)

Figure 8-12. Setup for Phase Noise Measurement



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements:

Press **Mode, Spectrum Analyzer.**

Step 4. Preset the analyzer:

Press **Mode Preset.**

Step 5. Tune to the unmodulated carrier, adjust the span and RBW:

- Press **FREQ Channel, Auto Tune**
- Press **Span, Span, 200, kHz**
- Press **BW, Res BW, 910, Hz**

Step 6. Measure and store the DUT phase noise plus the analyzer noise using trace 1 with trace averaging (allow time for sufficient averaging). Refer to [Figure 8-13.](#):

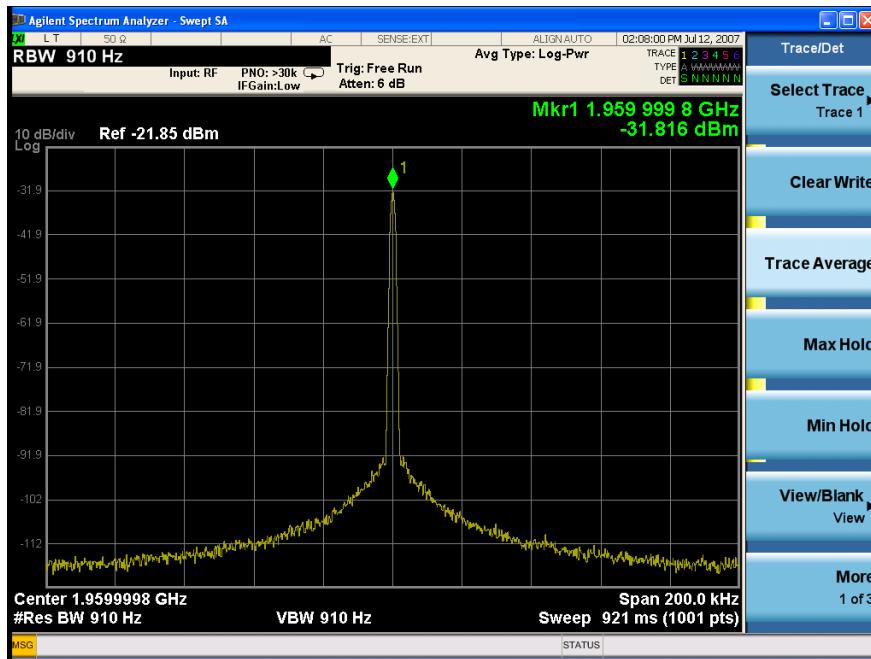
Press **Trace/Detector, Select Trace, Trace 1, Trace Average**

Measuring Noise

Improving Phase Noise Measurements by Subtracting Signal Analyzer Noise

After sufficient averaging
Press **View/Blank, View**

Figure 8-13. Measurement of DUT and Analyzer Noise



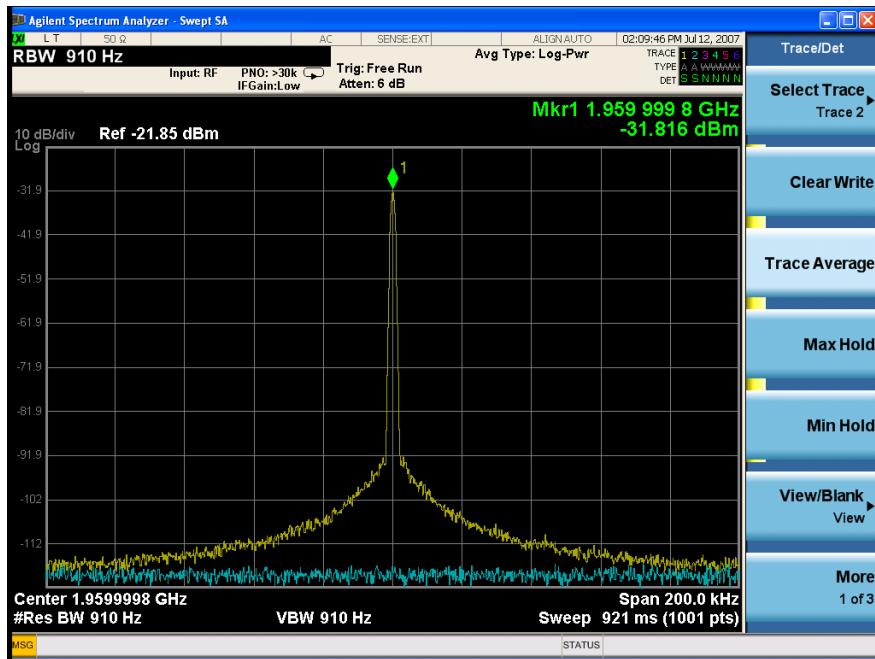
Step 7. Measure only the analyzer noise using trace 2 (blue trace) with trace averaging (allow time for sufficient averaging). Refer to [Figure 8-14.](#):

Turn off or remove the DUT signal to the RF input of the analyzer

Press **Trace/Detector, Select Trace, Trace 2, Clear Write, Trace Average**

After sufficient averaging

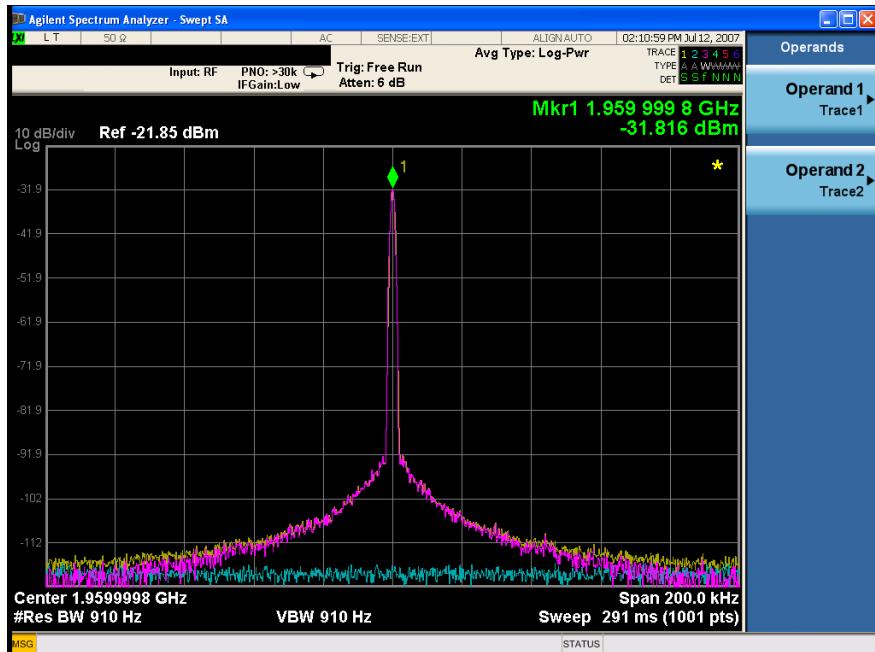
Press **View/Blank, View**

Figure 8-14. Measurement of Analyzer Noise

Step 8. Subtract the noise from the DUT phase noise measurement using the Power Diff math function and note the phase noise improvement at 100 kHz offset between trace 1 (yellow trace) and trace 3 (magenta trace). Refer to [Figure 8-15.](#):

Press **Trace/Detector, Select Trace, Trace 3, Clear Write**

Press **More, More, Math, Power Diff, Trace Operands, Operand 1, Trace 1, Operand 2, Trace 2**

Figure 8-15. Improved Phase Noise Measurement

Measuring Noise

Improving Phase Noise Measurements by Subtracting Signal Analyzer Noise

Step 9. Measure the noise measurement improvement with delta Noise markers between traces. Note the up to 6 dB improvement in the Marker Results Block. Refer to Figure 8-16.:

Press **Marker, Select Marker, Marker 1, Normal**

Press **Properties, Select Marker, Marker 1, Marker Trace, Trace 1**

Adjust Marker 1 to approximately 90 kHz offset from the carrier on trace 1 using the knob

Press **Return, Select Marker, Marker 2, Normal**

Press **Properties, Select Marker, Marker 2, Marker Trace, Trace 3**

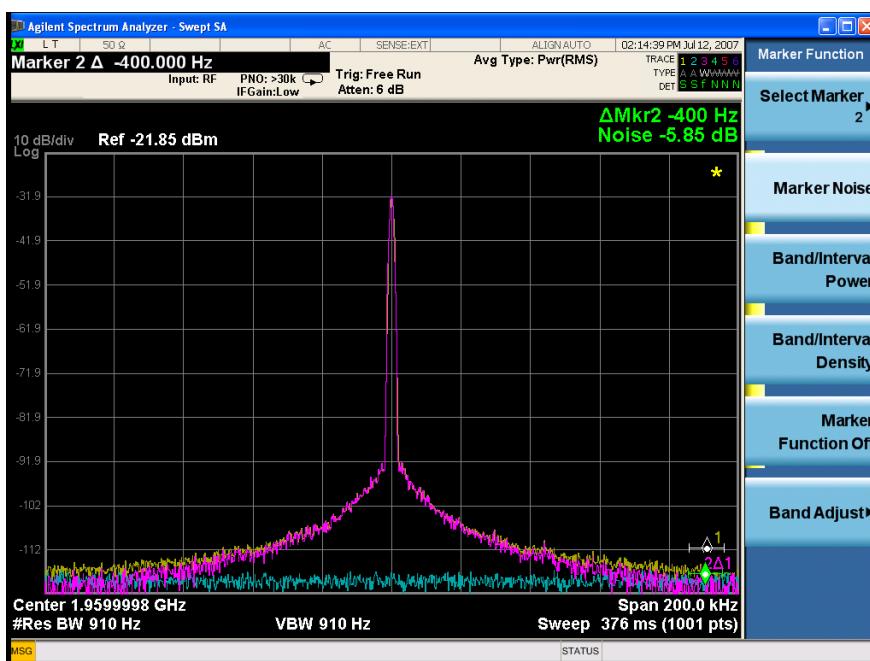
Press **Relative To, Marker 1**

Adjust Marker 2 to approximately 90 kHz offset from the carrier on trace 3 using the knob

Press **Marker Function, Select Marker, Marker 1, Marker Noise**

Press **Select Marker, Marker 2, Marker Noise**

Figure 8-16. Improved Phase Noise Measurement with Delta Noise Markers



9 Making Time-Gated Measurements

Generating a Pulsed-RF FM Signal

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.

When performing these measurements you can use a digitizing oscilloscope or your Agilent X-Series Signal Analyzer (using Gate View) to setup the gated signal. Refer back to these first three steps to setup the pulse signal, the pulsed-RF FM signal and the oscilloscope settings when performing the gated LO procedure ([page 103](#)), the gated video procedure ([page 106](#)) and gated FFT procedure ([page 109](#)).

For an instrument block diagram and instrument connections see “[Connecting the Instruments to Make Time-Gated Measurements](#)” on [page 101](#).

Step 1. Setup 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 9-1](#). for setup information of a pulse generator and [Table 9-2](#). for setup information of the internal generator of the ESG. Select either the pulse generator or a second ESG to create the pulse signal. You need two ESGs if you want to use the ESG internal function generator to create a pulse signal.

Table 9-1. 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 9-2. 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 9-3. 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

Making Time-Gated Measurements
Generating a Pulsed-RF FM Signal

Step 3. If you are using your Agilent X-Series Signal Analyzer (using Gate View), set up the analyzer to view the gated RF signal (see [Figure 9-1](#) for an example of the display):

1. Set the analyzer to the Spectrum Analyzer mode:

Press **Mode, Spectrum Analyzer, Mode Preset**.

2. Set the analyzer center frequency, span and reference level:

Press **FREQ Channel, Center Freq, 40, MHz**.

Press **SPAN X Scale, Span, 500, kHz**.

Press **AMPTD Y Scale, Ref Level, 0, dBm**.

3. Set the analyzer bandwidth:

Press **BW, Res BW (Man), 100, kHz**.

Press **SPAN X Scale, Span, 500, kHz**.

Press **AMPTD Y Scale, Ref Level, 0, dBm**.

4. Enable Gate View and Gate:

Press **Sweep/Control, Gate, Gate (On)**.

Press **Gate, Gate View (On)**.

5. Set the gate delay to 1.764 ms, the gate length to 1.350 ms, and gate sweep time to 10 ms. Check that the gate trigger is set to edge:

Press **Sweep/Control, Gate, Gate Delay, 1.764, ms**.

Press **Gate Length, 1.350, ms**.

Press **Gate View Sweep Time, 10, ms**.

Press **More, Control (Edge)**.

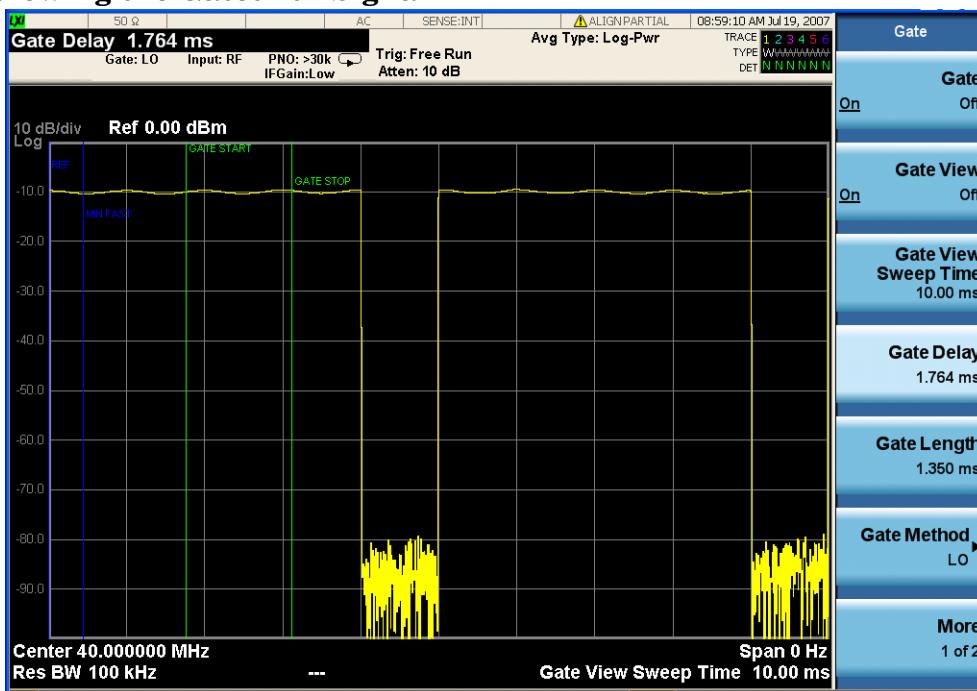
6. Set the gate method to the LO:

Press **Sweep/Control, Gate, Gate Method, LO**.

7. Set the gate source to the rear external trigger input:

Press **Sweep/Control, Gate, More, Gate Source, External 1**.

Figure 9-1. Viewing the Gated RF Signal



Step 4. If you are using a digitizing oscilloscope, set up the oscilloscope to view the trigger, gate and RF signals (see [Figure 9-2.](#) for an example of the oscilloscope display):

Table 9-4. Agilent 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 Ω input, connect to the pulse signal (ESG LF OUTPUT or pulse generator OUTPUT). Adjust channel 1 settings as necessary.
Channel 2	ON, 500 mV/div, OFFSET = 2 V, DC coupled, 1 M Ω 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 Ω 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 9-2. Viewing the Gate Timing with an Oscilloscope

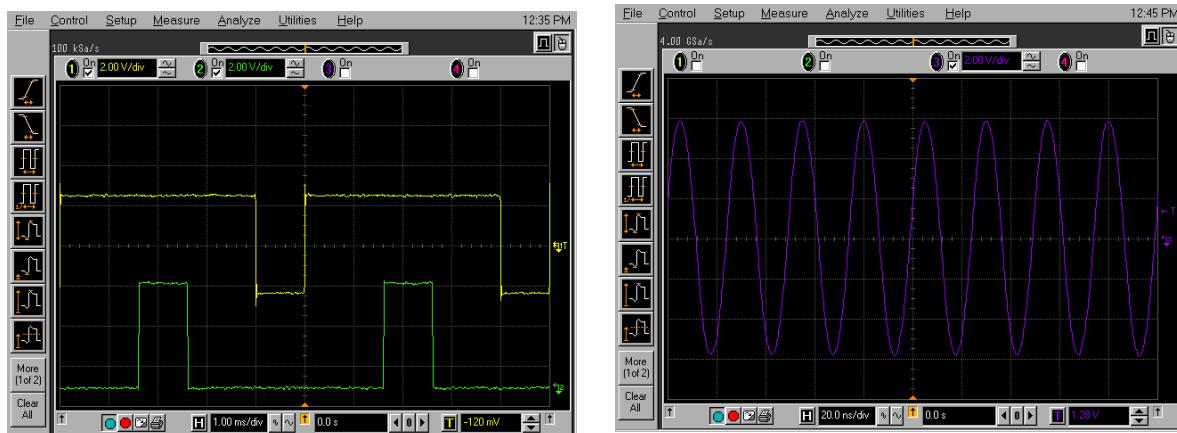


Figure 9-2. oscilloscope channels:

1. Channel 1 (left display, top trace) - the trigger signal.
2. Channel 2 (left display, bottom trace) - the gate signal (gate signal is not active until the gate is on in the spectrum analyzer).
3. Channel 3 (right display) - the RF output of the signal generator.

Connecting the Instruments to Make Time-Gated Measurements

Figure 9-3. shows a block 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.

Figure 9-3. Instrument Connection Diagram with Oscilloscope

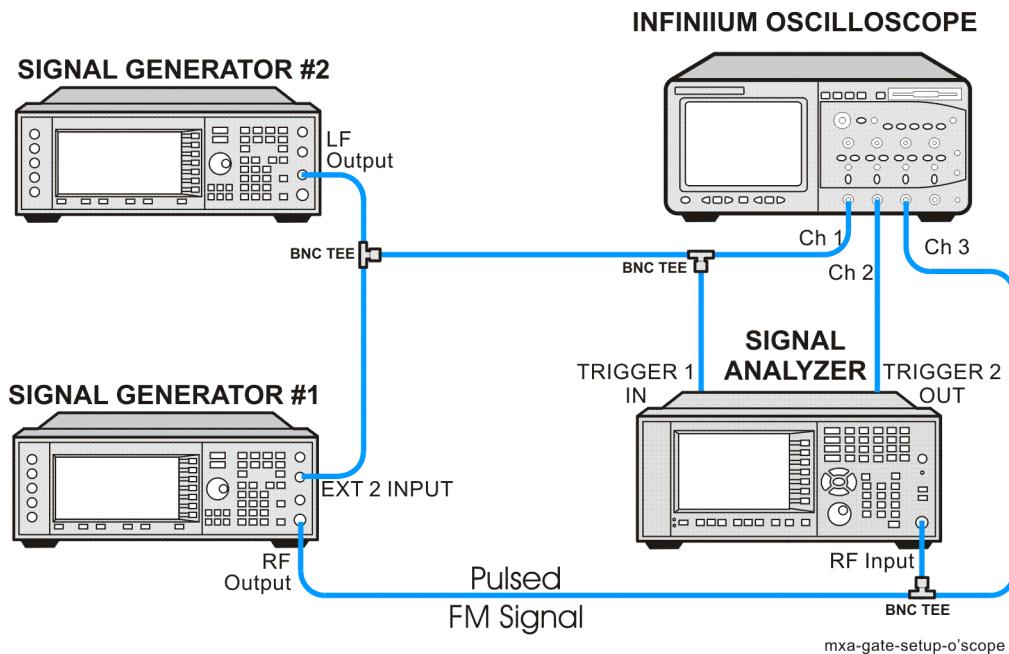
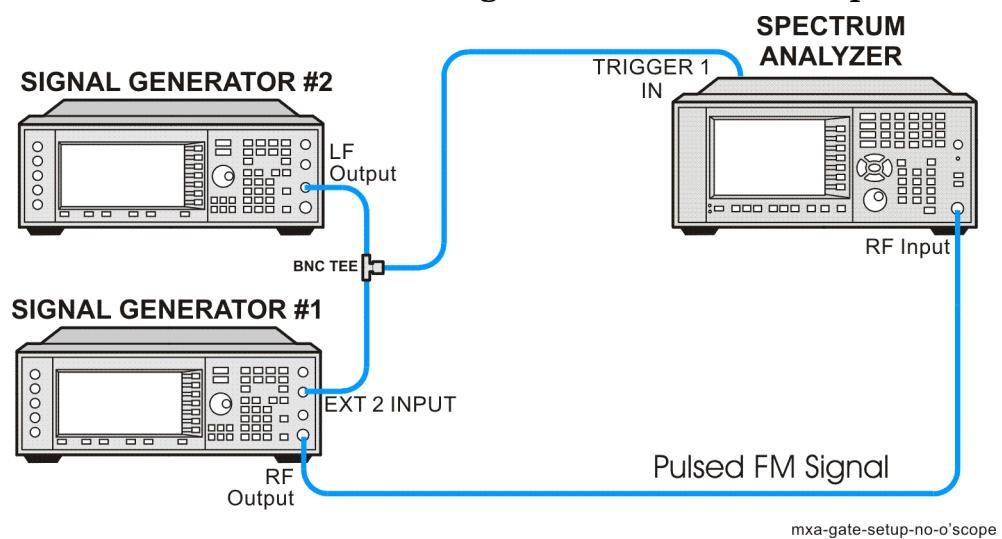


Figure 9-4. Instrument Connection Diagram without Oscilloscope



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 157.

Step 1. Set the analyzer to the Spectrum Analyzer mode:

Press **Mode, Spectrum Analyzer, Mode Preset**.

Step 2. Set the analyzer center frequency, span and reference level:

Press **FREQ Channel, Center Freq, 40, MHz**.

Press **SPAN X Scale, Span, 500, kHz**.

Press **AMPTD Y Scale, Ref Level, 0, dBm**.

In [Figure 9-6](#). (left), 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 well be blocked out, leaving the original FM signal.

Step 3. Set the gate source to the rear external trigger input:

Press **Sweep/Control, Gate, More, Gate Source, External 1**.

Step 4. Set the gate delay to 2 ms, the gate length to 1 ms, and gate sweep time to 5 ms. Check that the gate trigger is set to edge:

Press **Sweep/Control, Gate, Gate Delay, 2, ms**.

Press **Gate Length, 1, ms**.

Press **Gate View Sweep Time, 5, ms**.

Press **More, Control (Edge)**.

Step 5. Use the analyzer gate view display to confirm the gate “on” time is during the RF burst interval (alternatively you could also use the oscilloscope to view the gate settings):

Press **Sweep/Control, Gate, Gate View (On)**.

Making Time-Gated Measurements

Gated LO Measurement

Figure 9-5. Viewing the Gate Settings with Gated LO



In Figure 9-5, the blue vertical line (the far left line outside of the RF envelope) represents the location equivalent to a zero gate delay.

In Figure 9-5, 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.

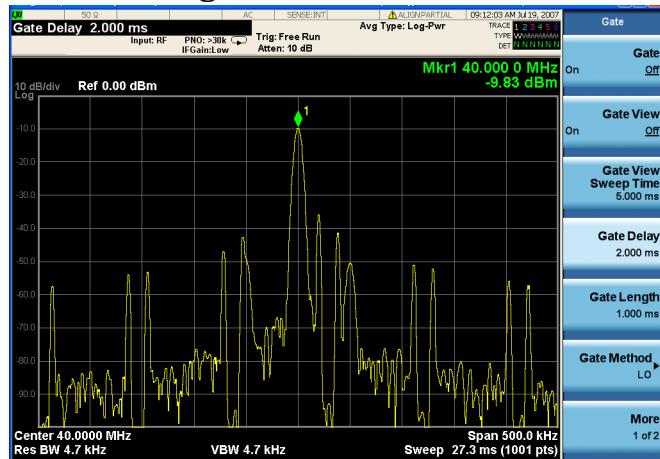
While gate view mode is on, move the gate delay, length and polarity around. Notice the changes in the vertical gate bars while making your changes. Set the gate delay, length and polarity back to the step 3 settings.

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

Step 6. Turn the gate view off (see Figure 9-6.):

Press **Sweep/Control, Gate, Gate View (Off)**.

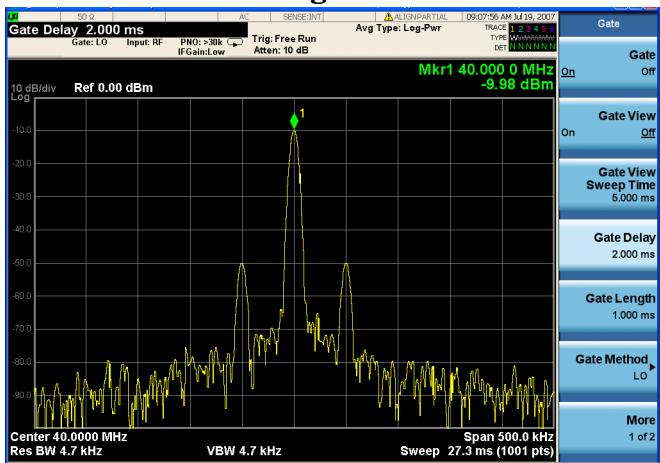
Figure 9-6. Pulsed-RF FM Signal



Step 7. Enable the gate settings (see [Figure 9-7.](#)):

Press **Gate** (On).

Figure 9-7. Pulsed and Gated FM Signal



Step 8. Turn off the pulse modulation on ESG #1 by pressing **Pulse**, **Pulse** so that Off is selected.

Notice that the gated spectrum is much cleaner than the ungated spectrum (as seen in [Figure 9-6.](#)). 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.

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 157.

Step 1. Set the analyzer to the Spectrum Analyzer mode:

Press **Mode, Spectrum Analyzer, Mode Preset**.

Step 2. Set the analyzer center frequency, span and reference level:

Press **FREQ Channel, Center Freq, 40, MHz**.

Press **SPAN X Scale, Span, 500, kHz**.

Press **AMPTD Y Scale, Ref Level, 0, dBm**.

Step 3. Set analyzer points to 401 and sweep time to 2000 ms:

Press **Sweep/Control, Points, 401, Enter**.

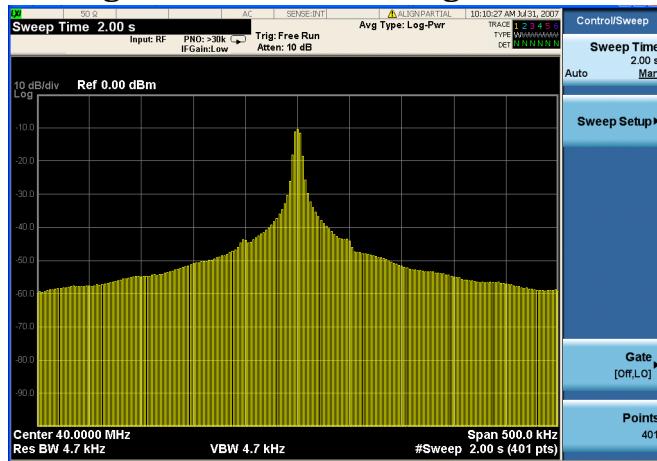
Press **Sweep Time, 2000, ms**.

For gated video, the calculated sweep time should be set to at least $(\# \text{ sweep points} - 1) \times \text{PRI}$ (pulse repetition interval) 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.

NOTE **Good practices for determining the minimum sweep time for gated video:**

In the event that the signal is not noisy, the sweep time can be set to less than $(\# \text{ sweep points} - 1) \times \text{PRI}$ (pulse repetition interval) (as calculated above). Instead of using PRI in the previous sweep time calculation, we can use the “gate off time” where sweep time equals $(\# \text{ sweep points} - 1) \times \text{gate off time}$. (Gate off time is defined as $\text{PRI} - \text{GL}$, where $\text{GL} = \text{Gate Length}$.) In our example we could use a sweep time of 400 points times 1 ms or $400 \text{ ms} - (401 - 1) \times (5\text{ms} - 4\text{ms}) = 400\text{ms}$. Increase the width of video bandwidth 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.

Figure 9-8. Viewing the Pulsed-RF FM Signal (without gating)



Step 4. Set the gate delay to 2 ms and the gate length to 1 ms. Check that the gate control is set to edge:

Press **Sweep/Control, Gate, More, Gate Control** (Edge).

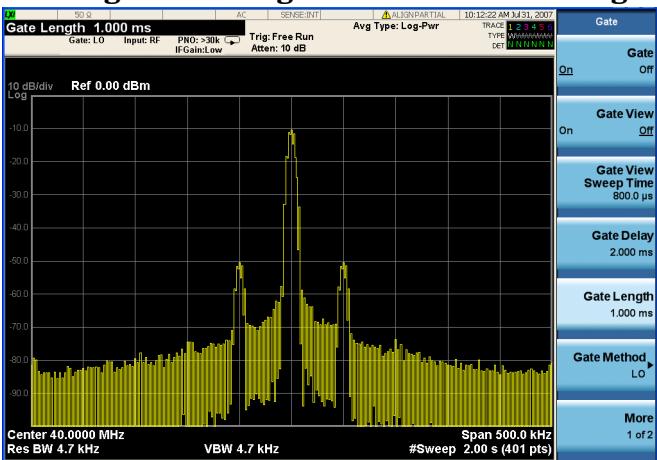
Press **More, Gate Delay, 2, ms.**

Press **Gate Length, 1, ms.**

Step 5. Turn the gate on:

Press **Sweep/Control, Gate, Gate (On).**

Figure 9-9. Viewing the FM Signal of a Pulsed RF Signal using Gated Video

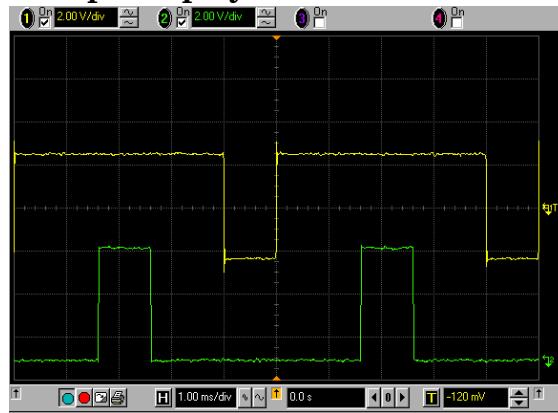


Step 6. Notice that the gated spectrum is much cleaner than the ungated spectrum (as seen in [Figure 9-8](#)). The spectrum you see is the same as a frequency modulated signal without being pulsed. To prove this, turn off the pulse modulation on ESG #1 by pressing **Pulse, Pulse** so that Off is selected. The displayed spectrum does not change.

Step 7. 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 9-10.](#) shows the oscilloscope display when the gate is positioned correctly (the bottom trace).

Figure 9-10. 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 157](#).

Step 1. Set the analyzer to the Spectrum Analyzer mode:

Press **Mode, Spectrum Analyzer, Mode Preset**.

Step 2. Set the analyzer center frequency, span and reference level:

Press **FREQ Channel, Center Freq, 40, MHz**.

Press **SPAN X Scale, Span, 500, kHz**.

Press **AMPTD Y Scale, Ref Level, 0, dBm**.

Step 3. Set the trigger to the external rear trigger input:

Press **Trigger, External 1**.

Step 4. Set the Gate Method to FFT and Gate to On:

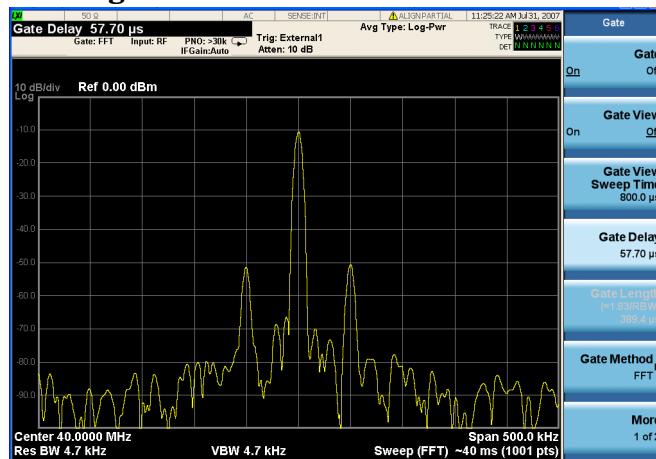
Press **Sweep/Control, Gate, Gate Method, FFT**

Press **Gate (On)**.

Step 5. Select the minimum resolution bandwidth required:

Press **BW, Res BW (Auto)**.

Figure 9-11. 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.

With the above analyzer settings, the RBW should be 4.7 kHz. Note that the measurement speed is faster than the gated LO example. Typically gated FFT is faster than gated LO for spans less than 10 MHz.

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. It is recommended to apply some small amount of trigger delay to allow time for the device under test to settle.

10 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).

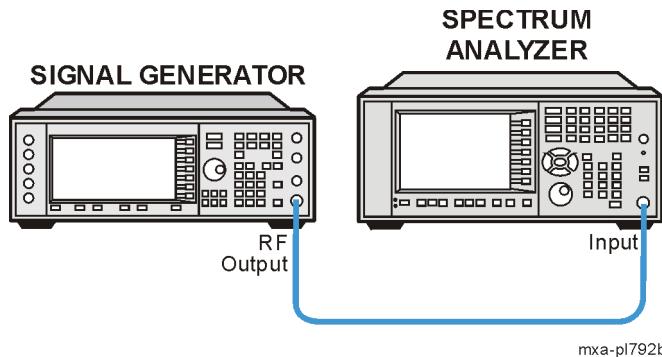
Measurement Procedure

Step 1. Setup the signal sources as follows:

Set the mode to W-CDMA
Set the frequency of the signal source to 1,920 MHz (Channel Number: $5 \times 1,920 = 9,600$).
Set the source amplitude to -20 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 10-5](#).

Figure 10-1. Setup for Obtaining Channel Power Measurement



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements:

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the radio standard and to toggle the device to mobile station:

Press **Mode Setup, Radio Std, 3GPP W-CDMA, 3GPP W-CDMA, Device (MS)**.

Step 6. Set the center frequency to 1.920 GHz:

Press **FREQ Channel, 1.920, GHz**.

Step 7. Initiate the channel power measurement:

Press **Meas, Channel Power**.

The Channel Power measurement result should look like [Figure 10-2](#). The graph window and the text window showing the absolute power and its mean power spectral density values over 5 MHz are displayed.

Figure 10-2. Channel Power Measurement Result



Step 8. To determine what keys are available 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.

Measurement Procedure

Step 1. Setup the signal sources as follows:

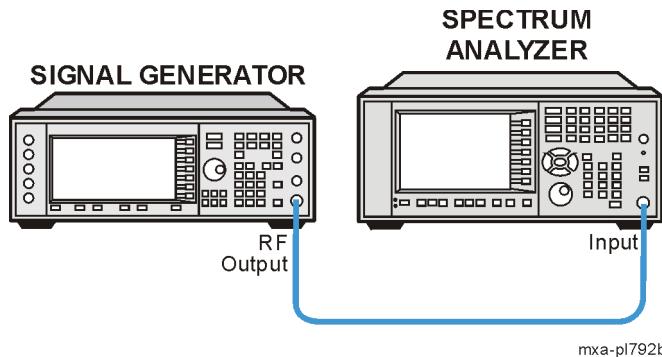
Set the mode to W-CDMA

Set the frequency of the signal source to 1,920 MHz (Channel Number: $5 \times 1,920 = 9,600$).

Set the source amplitude to -20 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 10-5](#).

Figure 10-3. Setup for Occupied Bandwidth Measurement



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements:

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the radio standard and to toggle the device to mobile station:

Press **Mode Setup, Radio Std, 3GPP W-CDMA, 3GPP W-CDMA, Device (MS)**.

Step 6. Set the center frequency to 1.920 GHz:

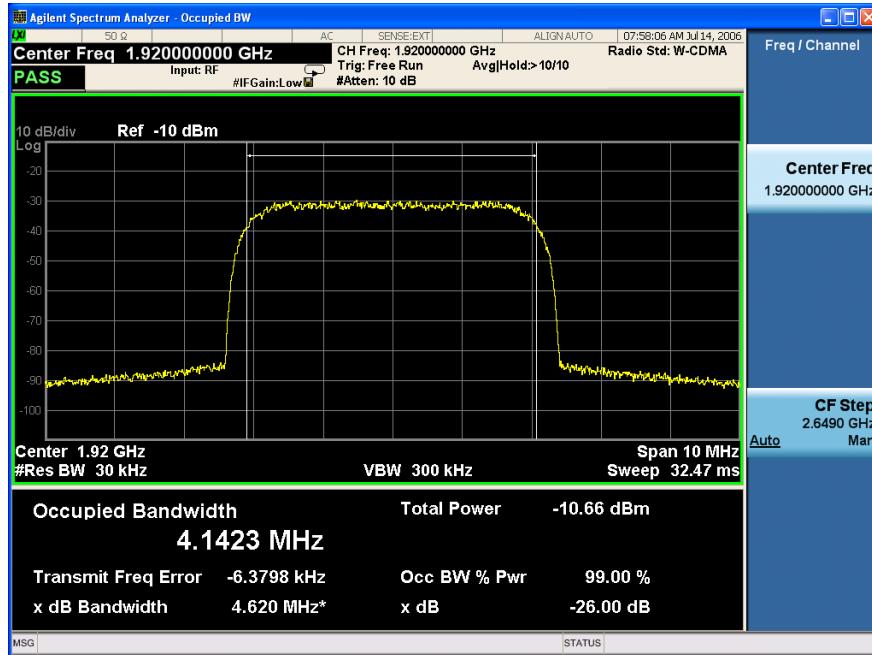
Press **FREQ Channel, Center Freq, 1.920, GHz**.

Step 7. Initiate the occupied bandwidth measurement:

Press **Meas, Occupied BW**.

The Occupied BW measurement result should look like the [Figure 10-4](#).

Figure 10-4. Occupied Bandwidth 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.

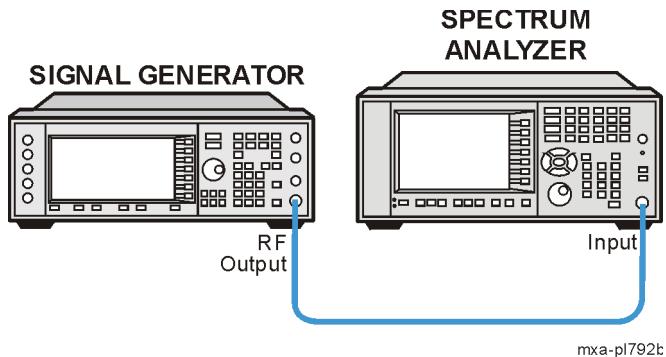
The following example shows how to make an ACP measurement on a W-CDMA base station signal broadcasting at 1.96 GHz. (A signal generator is used to simulate a base station.)

Step 1. Setup the signal sources as follows:

- Setup a W-CDMA signal
- Set the source frequency to 1.96 GHz.
- Set the source amplitudes to -10 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 10-5](#).

Figure 10-5. Setup for ACP Measurement



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements:

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the analyzer center frequency to 1.96 GHz:

Press **FREQ Channel, Center Freq, 1.96, GHz**.

Step 6. Set the analyzer radio mode to W-CDMA as a base station device:

Press **Mode Setup, Radio Std, 3GPP W-CDMA**.

Press **Mode Setup, Radio Std Setup, Device (BTS)**.

Step 7. Select the adjacent channel power one-button measurement from the measure menu and then optimize the attenuation setting suitable for the ACP measurement (see [Figure 10-6.](#)):

Press **Meas, ACP.**

Press **Meas Setup, AMPTD, Attenuation, Adjust Atten for Min Clip.**

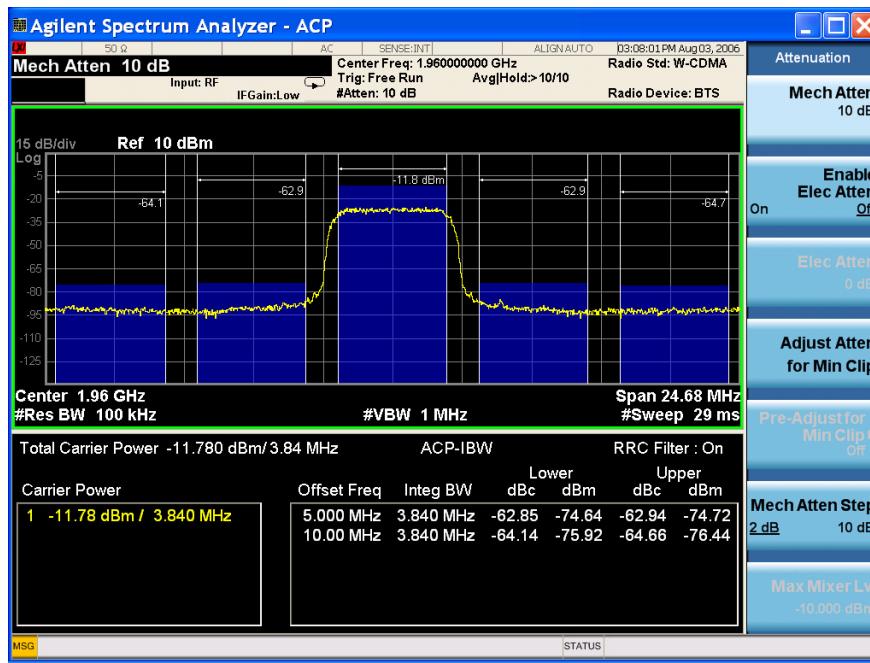
NOTE Adjust Atten for Min Clip protects against input signal overloads, but does not necessarily set the input attenuation and reference level for optimum measurement dynamic range.

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.

Step 8. To increase dynamic range, **Noise Correction** can be used to factor out the added power of the noise floor effects. Noise correction is very useful when measuring signals near the noise floor of the analyzer.

Press **Meas Setup, More, More, Noise Correction (On).**

Figure 10-6. ACP Measurement on a Base Station W-CDMA Signal



The frequency offsets, channel integration bandwidths, and span settings can all be modified from the default settings selected by the radio standard.

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

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.

Step 9. View the results using the full screen:

Press **Full Screen**.

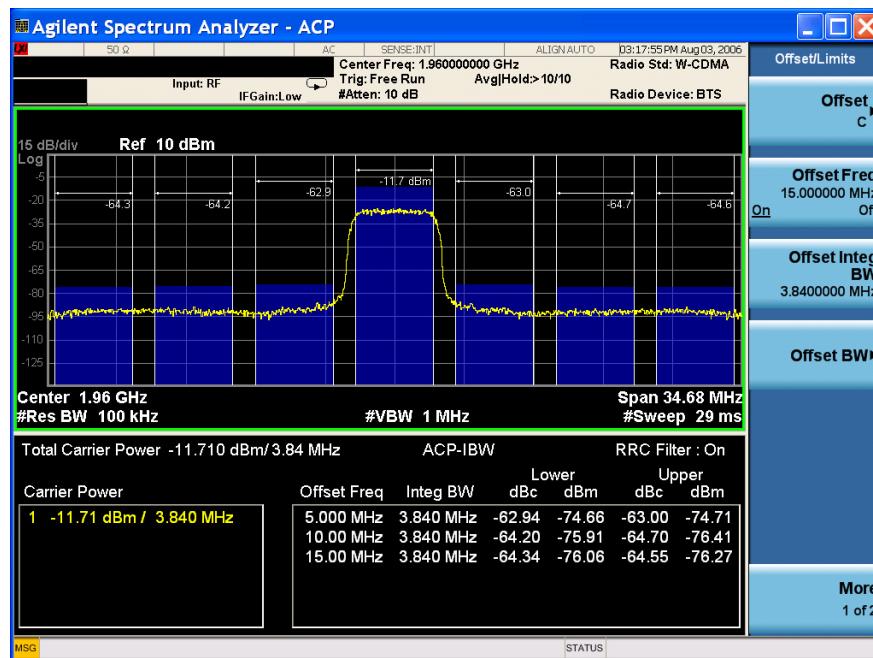
NOTE Press the **Full Screen** key again to exit the full screen display without changing any parameter values.

Step 10. 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 10-7](#). Three further pairs of offset frequencies (D, E and F) are also available.

Figure 10-7. Measuring a Third Adjacent Channel



Step 11. 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**.

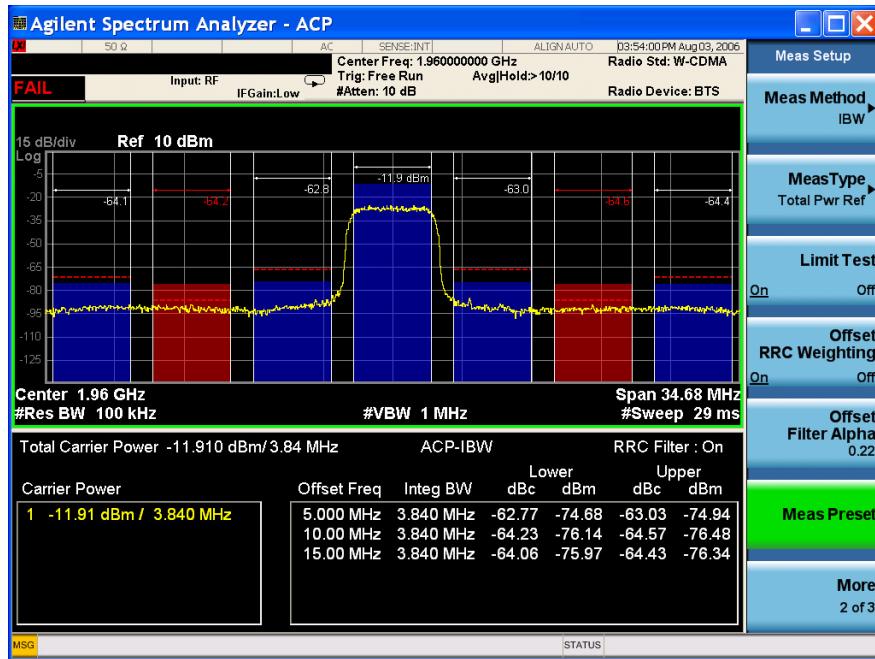
Step 12. Turn the limit test on:

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

In [Figure 10-8](#), 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.

Figure 10-8. 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.

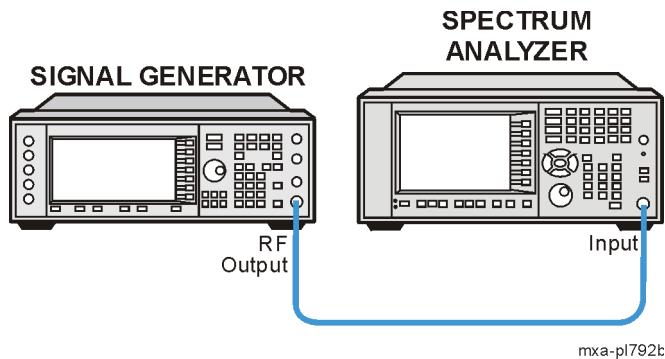
The following example shows how to make a CCDF measurement on a W-CDMA signal broadcasting at 1.96 GHz. (A signal generator is used to simulate a base station.)

Step 1. Setup the signal sources as follows:

- Setup a W-CDMA down link signal
- Set the source frequency to 1.96 GHz.
- Set the source amplitudes to -10 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 10-5](#).

Figure 10-9. Setup for CCDF Measurement



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements:

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the analyzer center frequency to 1.96 GHz:

Press **FREQ Channel, Center Freq, 1.96, GHz**.

Step 6. Set the analyzer radio mode to W-CDMA as a base station device:

Press **Mode Setup, Radio Std, 3GPP W-CDMA, 3GPP W-CDMA, Device (BTS)**.

Step 7. Select the CCDF one-button measurement from the measure menu and then optimize the attenuation level and attenuation settings suitable for the CCDF measurement:

Press **Meas, Power Stat CCDF**.

Press **AMPTD, Attenuation, Adjust Atten for Min Clip**.

Figure 10-10. Power Statistics CCDF Measurement on a W-CDMA Signal



Step 8. Store your current measurement trace for future reference:

Press **Trace/Detector, Store Ref Trace**.

When the power stat CCDF measurement is first made, the graphical display should show a signal typical of pure noise. This is labelled 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 [Figure 10-10](#).

Step 9. Display the stored trace:

Press **Trace/Detector, Ref Trace (On)**.

Step 10. Change the measurement bandwidth to 1 MHz:

Press **BW, Info BW, 1, MHz**.

The stored trace from your last measurement is displayed as a magenta plot (as shown in [Figure 10-11](#)), and allows direct comparison with your current

Measuring Digital Communications Signals
Making Statistical Power Measurements (CCDF)

measurement (yellow trace).

Figure 10-11. Storing and Displaying a Power Stat CCDF Measurement



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

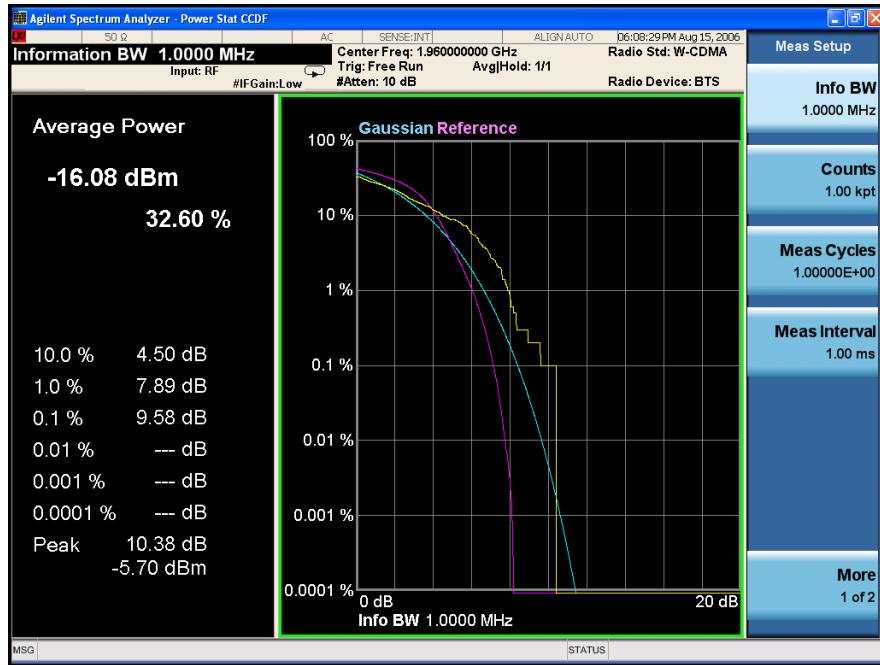
Step 11. Change the number of measured points from 10,000,000 (10.0Mpt) to 1,000 (1kpt):

Press **Meas Setup, Counts, 1, kpt.**

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 10-12](#).

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.

Figure 10-12. Reducing the Measurement Points to 1 kpt



Step 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 10-13](#).

Figure 10-13. Reducing the X Scale to 1 dB



Making Burst Power Measurements

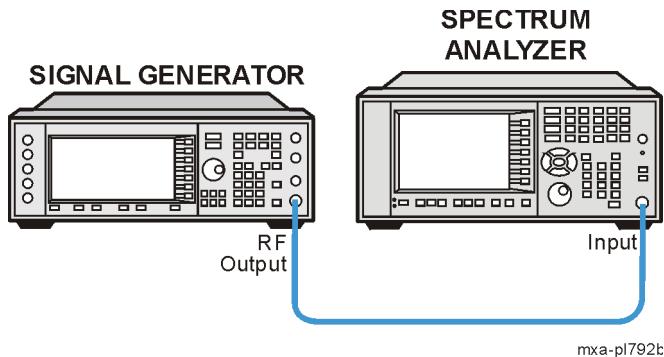
The following example demonstrates how to make a burst power measurement on a Bluetooth™ signal broadcasting at 2.402 GHz. (A signal generator is used to simulate a Bluetooth™ signal.)

Step 1. Setup the signal sources as follows:

- Setup a Bluetooth™ signal transmitting DH1 packets
- Set the source frequency to 2.402 GHz.
- Set the source amplitudes to –10 dBm.
- Set Burst on.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 10-5](#).

Figure 10-14. Setup for Burst Power Measurement



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements:

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the analyzer center frequency to 2.402 GHz:

Press **FREQ Channel, Center Freq, 2.402, GHz**.

Step 6. Set the analyzer radio mode to Bluetooth™ and check to make sure packet type DH1 is selected:

Press **Mode Setup, Radio Std, More, Bluetooth, Bluetooth, DH1**.

Step 7. Select the burst power one-button measurement from the measure menu and optimize the attenuation level:

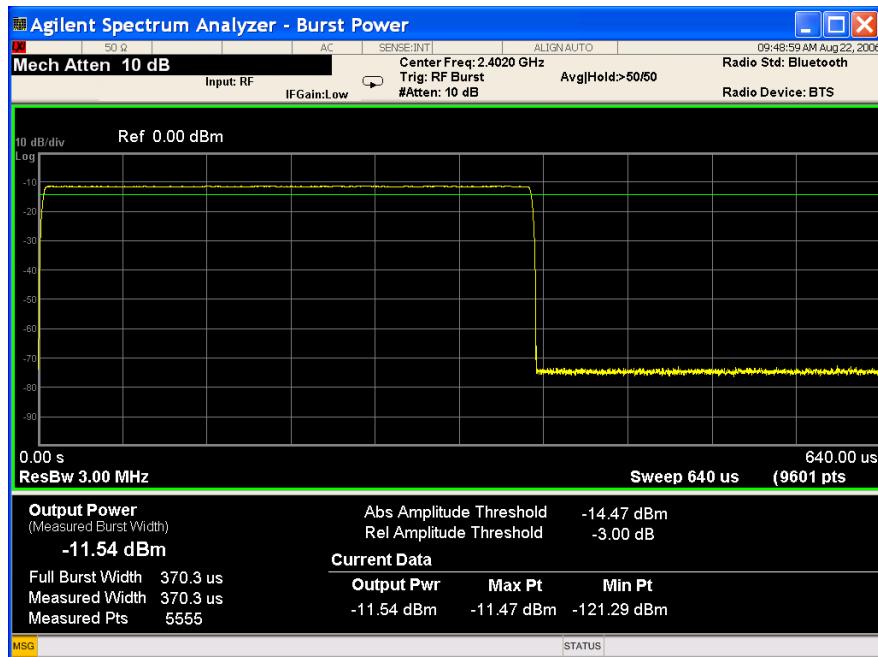
Press **Meas, Burst Power**.

Press **AMPTD, Attenuation, Adjust Atten for Min Clip**.

Step 8. View the results of the burst power measurement using the full screen (See [Figure 10-15.](#)):

Press **Full Screen**.

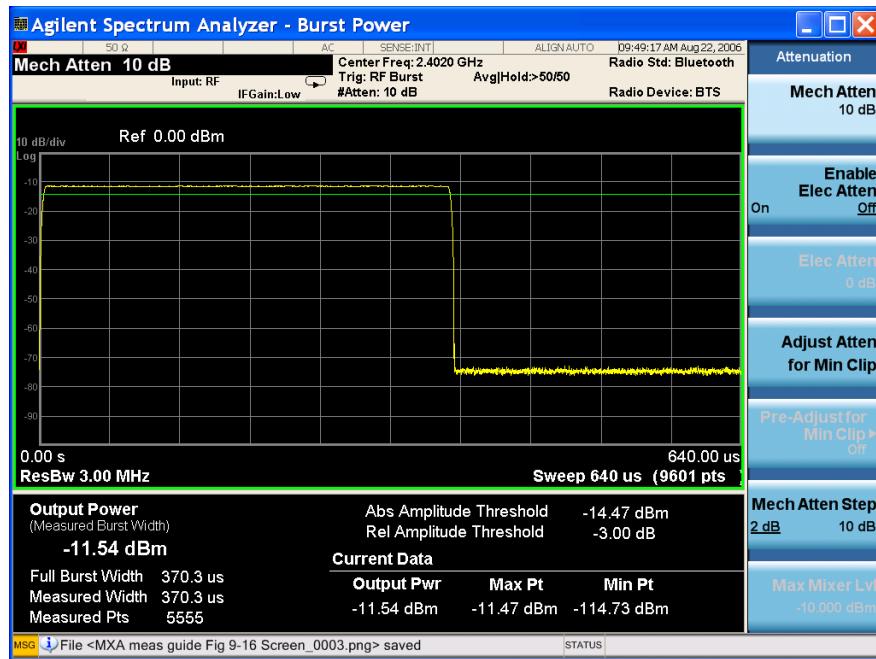
Figure 10-15. Full Screen Display of Burst Power Measurement Results



NOTE

Press the **Full Screen** key again to exit the full screen display without changing any parameter values. Refer to [Figure 10-16.](#)

Figure 10-16. Normal Screen Display of Burst Power Measurement Results



Step 9. Select one of the following three trigger methods to capture the bursted signal: Periodic Timer Triggering, Video, or 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 152.

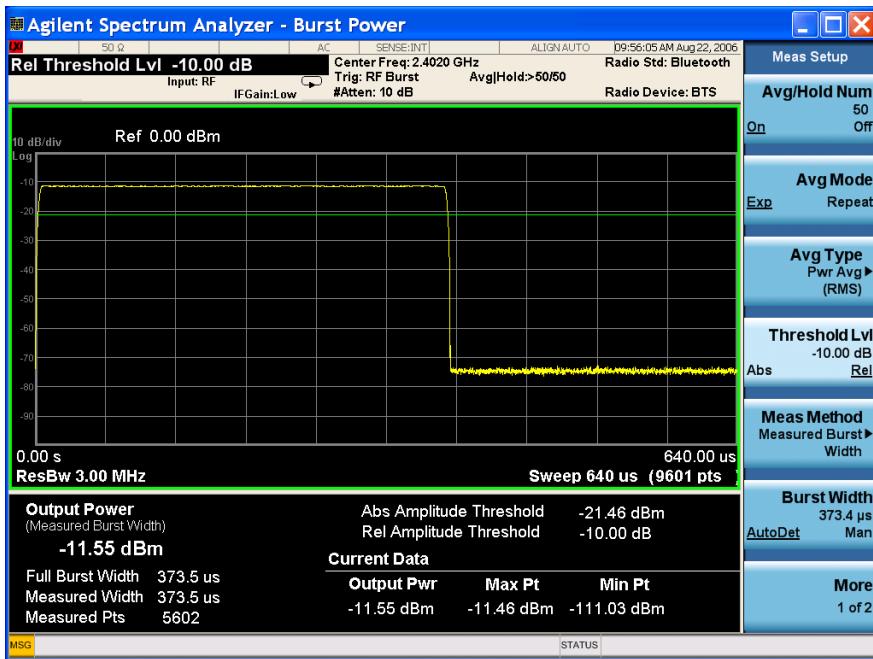
NOTE Although the trigger level allows the analyzer to detect the presence of a burst, the time samples contributing to the burst power measurement are determined by the threshold level, as described next.

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

Press **Meas Setup, Trigger 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 (for video triggering it is the upper 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 10-17](#).

Figure 10-17. Burst Power Measurement Results with Threshold Level Set



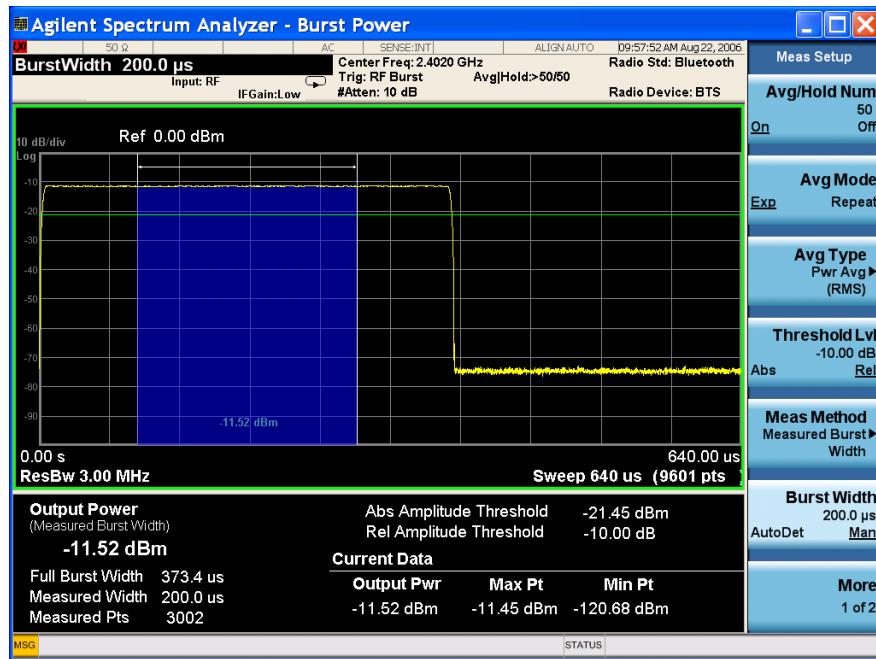
Step 11. Set the burst width to measure the central 200 μ s of the burst and enable bar graph:

Press **View/Display, Bar Graph (On)**

Press **Meas Setup, Meas Method, Measured Burst Width, Burst Width (Man), 200, μ s**.

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 [Figure 10-18](#).

Figure 10-18. 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.

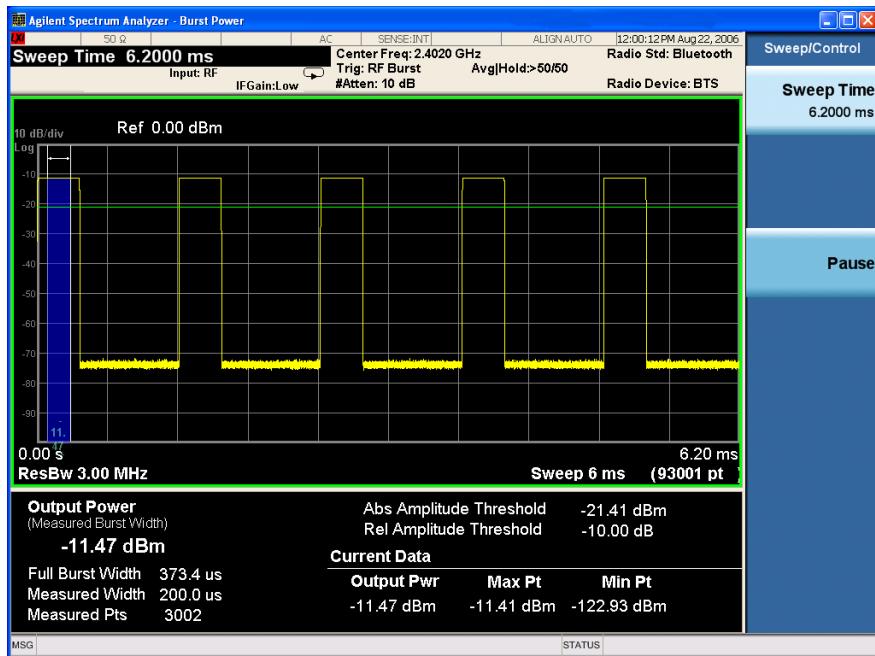
NOTE The Bluetooth™ standard states that power measurements should be taken over at least 20% to 80% of the duration of the burst.

Step 12. Increase the sweep time to display more than one burst at a time:

Press **Sweep/Control, Sweep Time, 6200, μs** (or **6.2, ms**).

The screen display shows several bursts in a single sweep as in [Figure 10-19](#). The burst power measurement measures the mean power of the first burst, indicated by the vertical white lines and blue power bar.

Figure 10-19. 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.

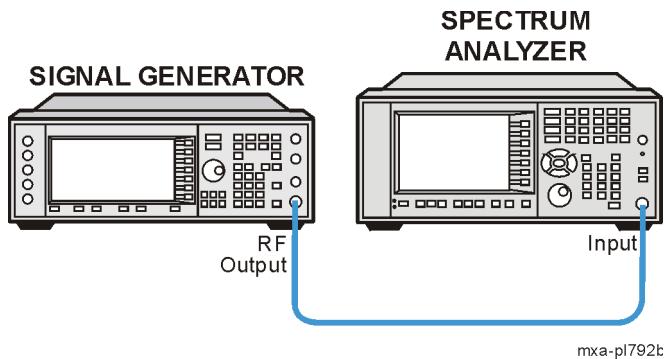
Measurement Procedure

Step 1. Setup the signal sources as follows:

Setup a multitone signal with 8 tones with a 2.0 MHz frequency spacing.
Set the source frequency to 1.950 GHz.
Set the source amplitudes to -50 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 10-5](#).

Figure 10-20. Setup for Spurious Emissions Measurement



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements:

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the analyzer center frequency to 1.950 GHz:

Press **FREQ Channel, Center Freq, 1.950, GHz**.

Step 6. Select the spurious emissions one-button measurement from the measure menu:

Press **Meas, More, Spurious Emissions**.

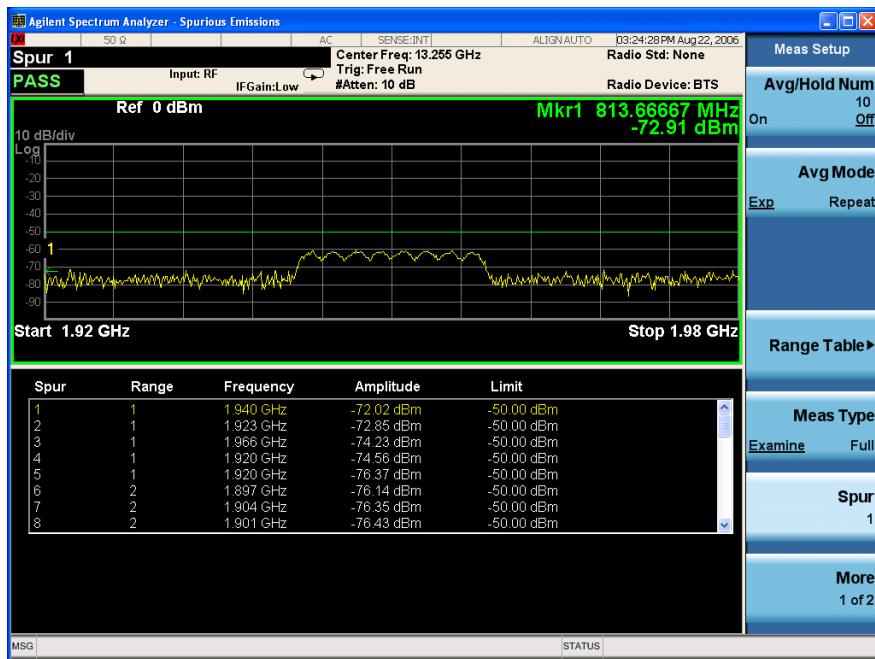
Step 7. You may Focus the display on a specific spurious emissions signal:

Press **Meas Setup, Spur, 1, Enter** (or enter the number of the spur of interest).

Press **Meas Type** to highlight **Examine**.

The Spurious Emission result should look like [Figure 10-21](#). 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.

Figure 10-21. Spurious Emission Measurement Result



Step 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.

Measurement Procedure

Step 1. Setup the signal sources as follows:

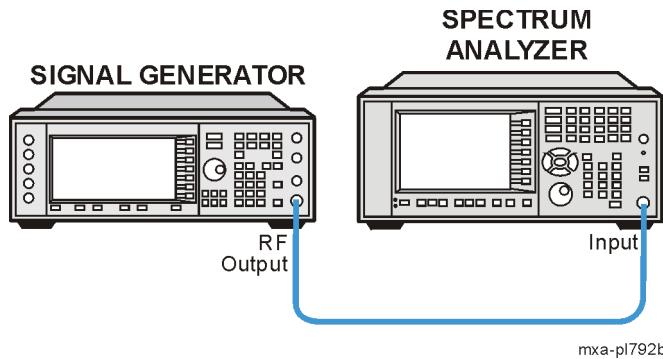
Setup a W-CDMA uplink signal

Set the source frequency to 1,920 MHz (Channel Number: $5 \times 1,920 = 9,600$).

Set the source amplitudes to 0 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 10-5](#).

Figure 10-22. Setup for Spectrum Emissions Mask Measurement



Step 3. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements:

Press **Mode, Spectrum Analyzer**.

Step 4. Preset the analyzer:

Press **Mode Preset**.

Step 5. Set the analyzer center frequency to 1.920 GHz:

Press **FREQ Channel, Center Freq, 1.920, GHz**.

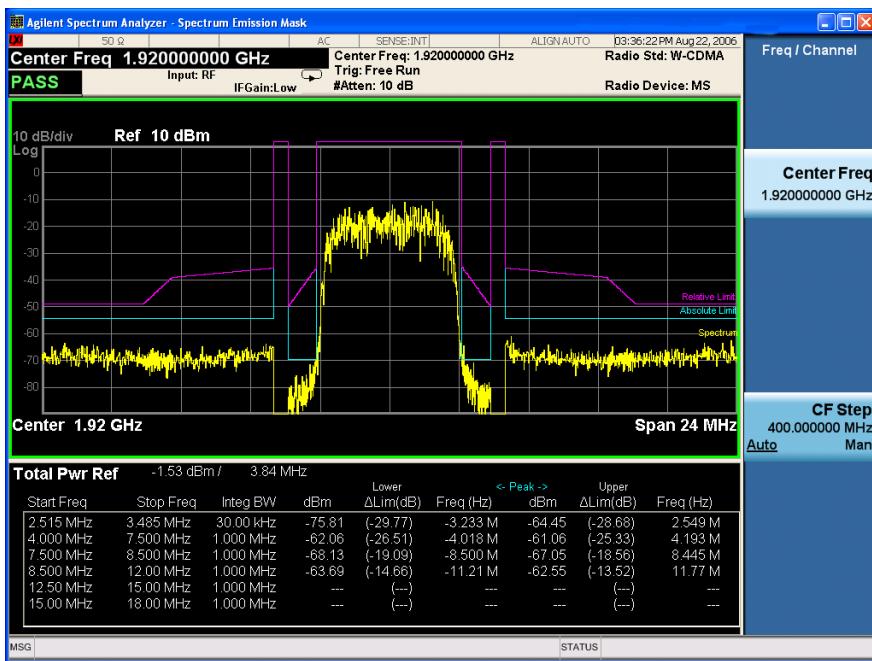
Step 6. Set the analyzer radio mode to W-CDMA as a mobile station device:

Press **Mode Setup, Radio Std, 3GPP W-CDMA, 3GPP W-CDMA, Device (MS)**.

Step 7. Initiate the spectrum emission mask measurement.

Press **Meas, More, Spectrum Emission Mask**.

Figure 10-23. Spectrum Emission Mask Measurement Result - (Default) View



The Spectrum Emission Mask measurement result should look like Figure 10-23. 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.

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.

11 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 174](#) 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 1. Connect an Agilent ESG RF signal source to the analyzer RF INPUT. Setup the signal sources as follows:

- Set the source frequency to 300 MHz.
- Set the source amplitudes to -10 dBm.
- Set the AM depth to 80%.
- Set the AM rate to 1 kHz.
- Turn AM on.

Step 2. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 3. Preset the analyzer:

Press **Mode Preset**.

Step 4. Set the center frequency, span, RBW and the sweep time:

- Press **FREQ Channel, Center Freq, 300, MHz**.
- Press **SPAN X Scale, Span, 500, kHz**.
- Press **BW, Res BW, 30, kHz**.
- Press **Sweep/Control, Sweep Time, 20, ms**.

Step 5. Change the y-scale type to linear:

- Press **AMPTD Y Scale, Scale Type (Lin)**.
- The y-axis units will automatically set to volts

Step 6. Position the signal peak near the first graticule below the reference level:

Press **AMPTD Y Scale, Ref Level**, (rotate front-panel knob).

Step 7. Set the analyzer in zero span to make time-domain measurements:

- Press **SPAN X Scale, Zero Span**.
- Press **Sweep/Control, Sweep Time, 5, ms**.

Step 8. Use the video trigger to stabilize the trace:

Press **Trigger, Video**.

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 [Figure 11-1](#).

NOTE 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.

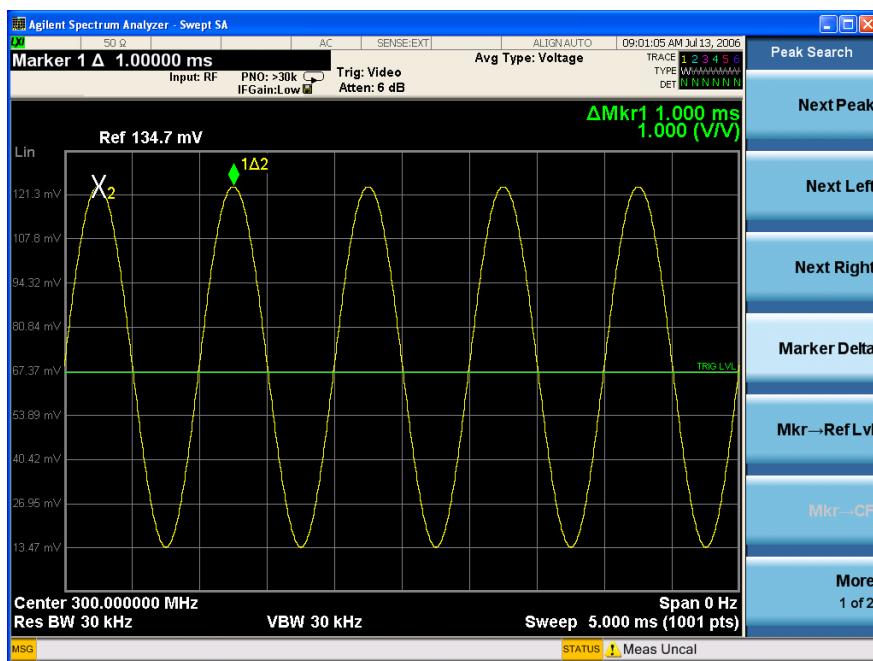
Press **Trigger, Video, Trigger Level**, (rotate front-panel knob).

Step 9. Measure the AM rate using delta markers:

Press **Peak Search, Marker Delta, Next Right** or **Next Left**.

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)

Figure 11-1. Measuring Time Parameters



NOTE Make sure the delta markers above are placed on adjacent peaks. See [Figure 11-1](#). The frequency or the AM rate is 1 divided by the time between adjacent peaks:

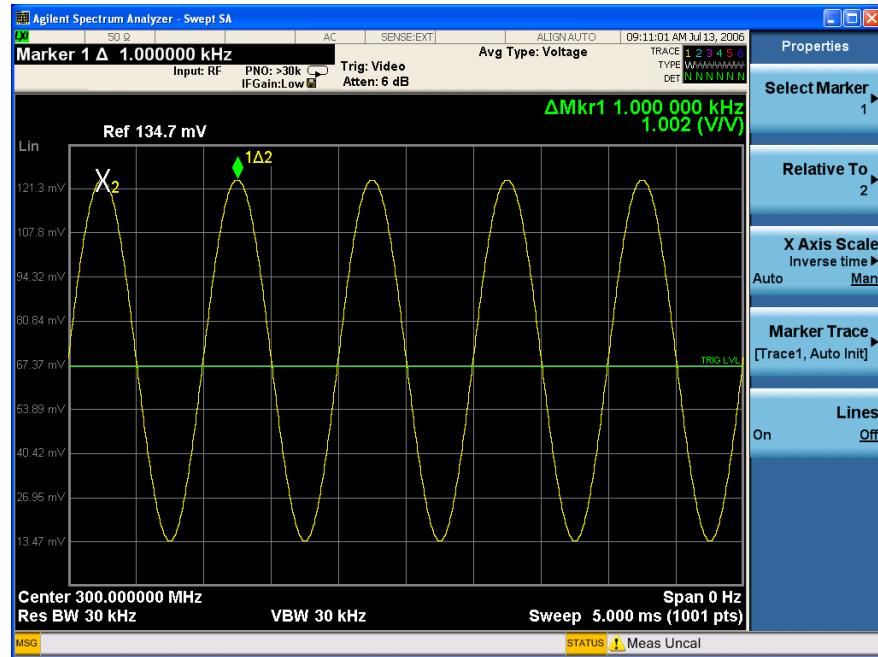
$$\text{AM Rate} = 1/1.0 \text{ ms} = 1 \text{ kHz}$$

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

Demodulating AM Signals
Measuring the Modulation Rate of an AM Signal

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

Figure 11-2. 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 1. Connect an Agilent ESG RF signal source to the analyzer RF INPUT. Setup the signal sources as follows:

- Set the source frequency to 300 MHz.
- Set the source amplitudes to -10 dBm.
- Set the AM depth to 80%.
- Set the AM rate to 1 kHz.
- Turn AM on.

Step 2. Set the analyzer to the Spectrum Analyzer mode and enable the spectrum analyzer measurements

Press **Mode, Spectrum Analyzer**.

Step 3. Preset the analyzer:

Press **Mode Preset**.

Step 4. Set the center frequency, span, RBW and the sweep time:

- Press **FREQ Channel, Center Freq, 300, MHz**.
- Press **SPAN X Scale, Span, 500, kHz**.
- Press **BW, Res BW, 30, kHz**.
- Press **Sweep/Control, Sweep Time, 20, ms**.

Step 5. Set the y-axis units to volts:

Press **AMPTD Y Scale, More, Y-Axis Units, V (Volts)**.

Step 6. Position the signal peak near the reference level:

Press **AMPTD Y Scale, Ref Level**, (rotate front-panel knob).

Step 7. Change the y-scale type to linear:

Press **AMPTD Y Scale, Scale Type (Lin)**.

Step 8. Set the analyzer in zero span to make time-domain measurements:

- Press **SPAN X Scale, Zero Span**.
- Press **Sweep/Control, Sweep Time, 5, ms**.

Step 9. Place the analyzer in free run trigger mode:

Press **Trigger, Free Run**.

Step 10. Increase the sweep time and decrease the VBW so that the waveform is displayed as a flat horizontal signal:

Demodulating AM Signals

Measuring the Modulation Index of an AM Signal

Press **Sweep/Control, Sweep Time, 5, s.**
 Press **BW, Video BW, 30, Hz.**

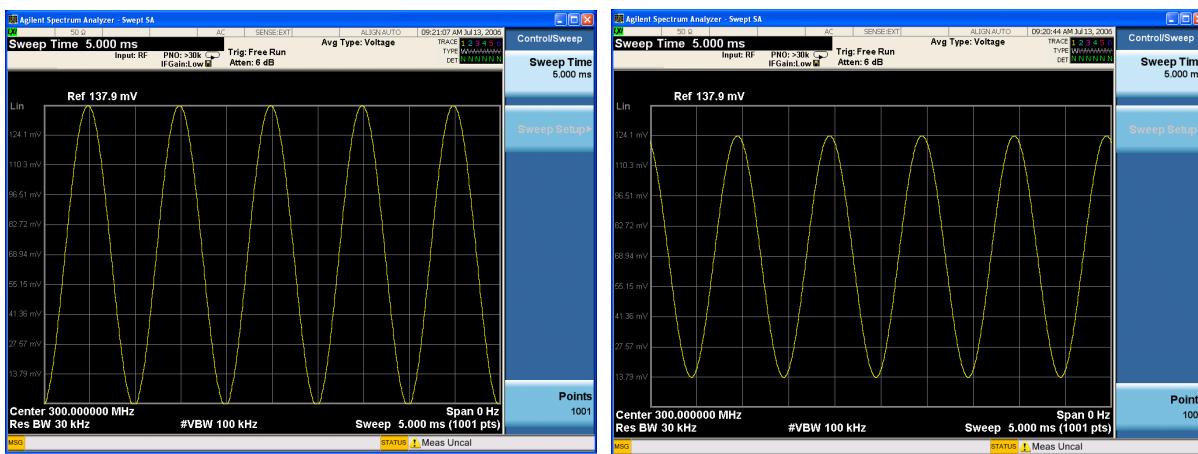
Step 11. Center the flat waveform at the mid-point of the y-axis and then widen the VBW and decrease the sweep time to display the waveform as a sine wave:

Press **AMPTD Y Scale, Ref Level**, (rotate front-panel knob).
 Press **BW, Video BW, 100, kHz**.
 Press **Sweep/Control, Sweep Time, 5, ms.**

Step 12. Measure the modulation index of the AM signal:

To measure the modulation index as % AM, read the trace as follows (see [Figure 11-3](#) 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%.

Figure 11-3. AM Signal Measured in the Time Domain



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

12 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 1. Setup the signal source as follows:

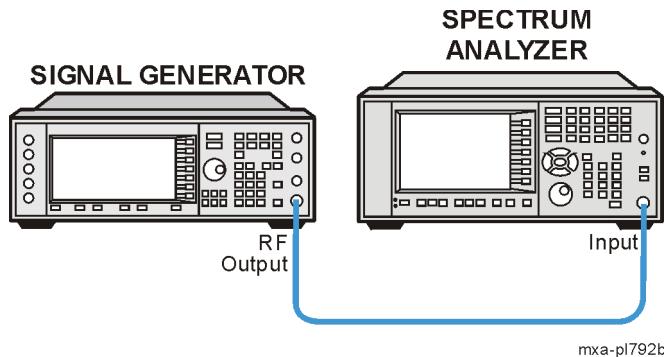
Set the mode to W-CDMA 3GPP with 4 carriers.

Set the frequency of the signal source to 1.0 GHz.

Set the source amplitude to -10 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 12-4](#).

Figure 12-1. Setup for IQ Analysis



Step 3. Set the analyzer to IQ Analyzer mode and enable IQ data availability:

Press **Mode, IQ Analyzer (Basic)**

Step 4. Preset the analyzer mode:

Press **Mode Preset**

Step 5. Set the measurement center frequency:

Press **Freq Channel, 1, GHz**

Step 6. Set the measurement span/analysis bandwidth:

Press **Span X Scale, 10, MHz** (25 MHz if option B25 installed)

Step 7. Enable the Complex Spectrum measurement:

Press **Meas, Complex Spectrum** Refer to the default view in [Figure 12-2](#). or [Figure 12-3](#).

IQ Analyzer Measurement
Complex Spectrum Measurement

Figure 12-2. Spectrum and I/Q Waveform (Span 10 MHz)

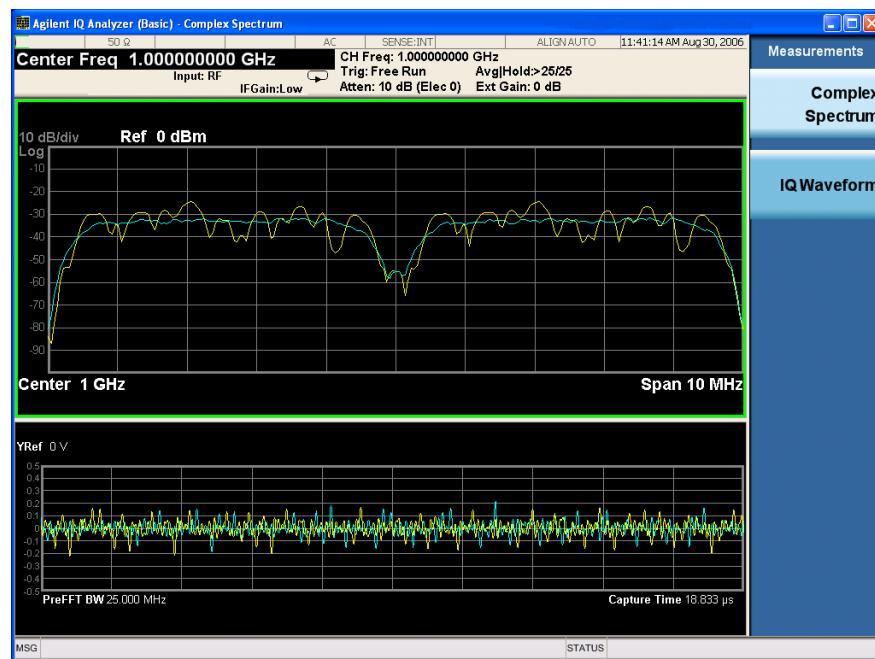


Figure 12-3. Spectrum and I/Q Waveform (Span 25 MHz)



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 1. Setup the signal source as follows:

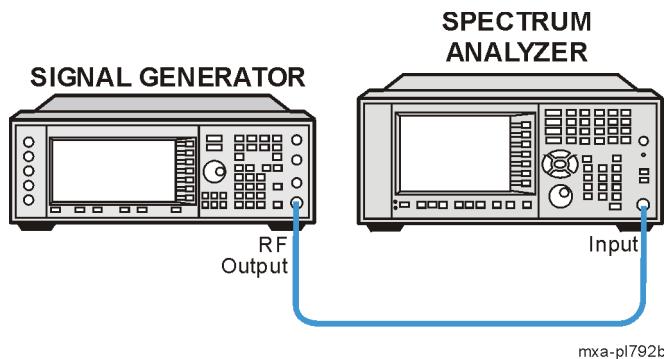
Set the mode to W-CDMA 3GPP with 4 carriers.

Set the frequency of the signal source to 1.0 GHz.

Set the source amplitude to -10 dBm.

Step 2. Connect the source RF OUTPUT to the analyzer RF INPUT as shown in [Figure 12-4](#).

Figure 12-4. Setup for IQ Analysis



Step 3. Set the analyzer to IQ Analyzer mode and enable IQ data availability:

Press **Mode, IQ Analyzer (Basic)**

Step 4. Preset the analyzer mode:

Press **Mode Preset**

Step 5. Set the measurement center frequency:

Press **Freq Channel, 1, GHz**

Step 6. Set the measurement span/analysis bandwidth:

Press **Span X Scale, 10, MHz** (25 MHz if option B25 installed)

Step 7. Enable the IQ Waveform measurement:

Press **Meas, IQ Waveform**

Step 8. View the RF envelope:

Press **View/Display, RF Envelope**

IQ Analyzer Measurement
IQ Waveform (Time Domain) Measurement

Step 9. Set the analysis bandwidth:

Press **BW, Info BW, 10, MHz** (25 MHz if option B25 installed)

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 [Figure 12-5.](#) or [Figure 12-6.](#)

Figure 12-5. IQ Waveform Measurement - Time domain View (10 MHz BW)

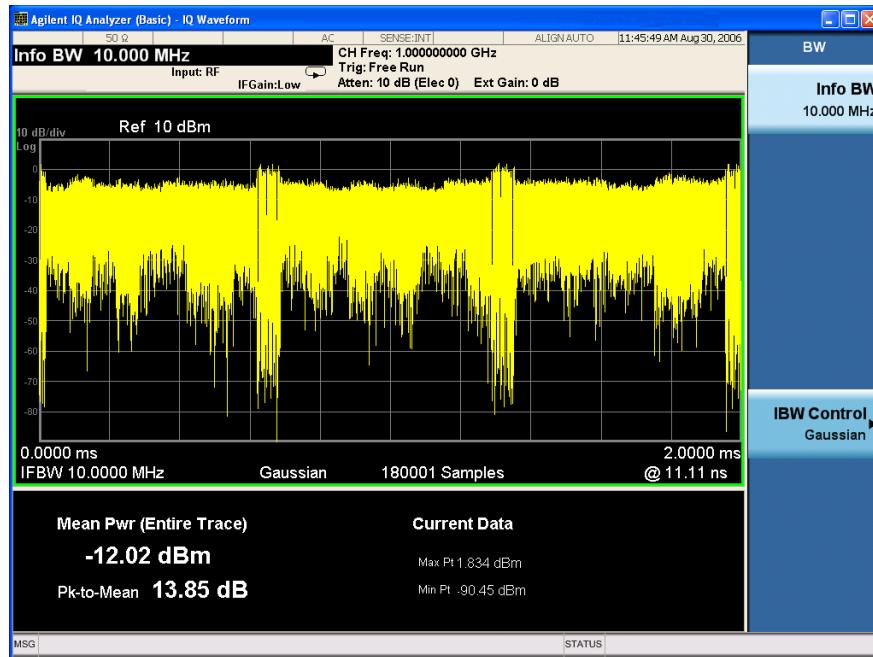
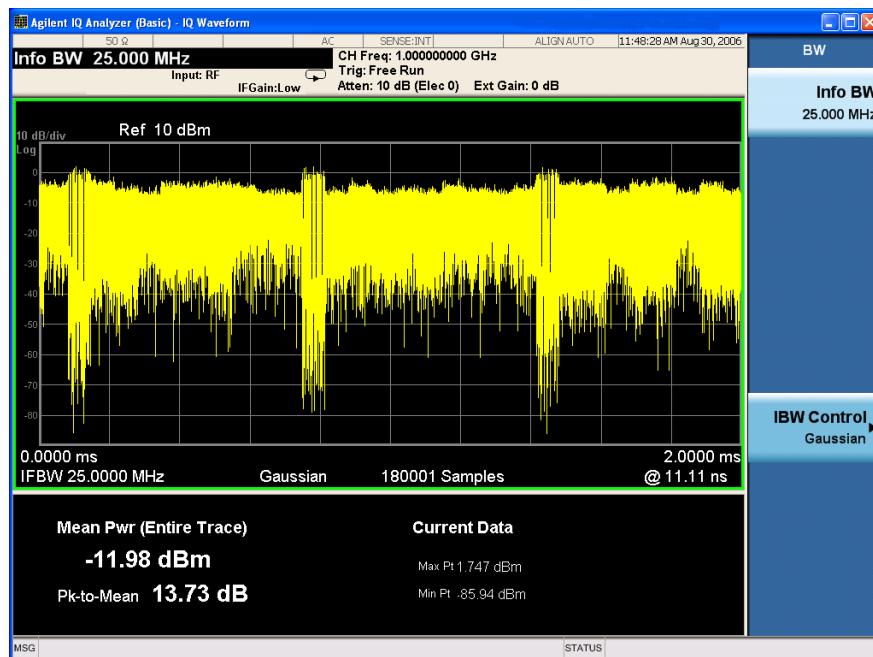


Figure 12-6. IQ Waveform Measurement - Time domain View (25 MHz BW)



Step 10. View the IQ Waveform:

Press **View/Display, IQ Waveform**

Step 11. Set the time scale:

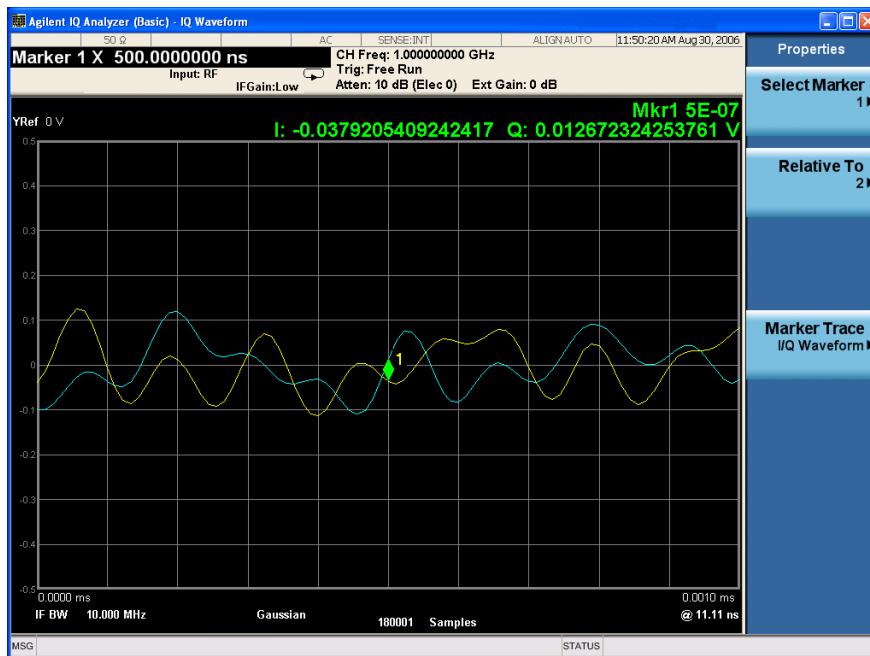
Press **Span X Scale, Scale/Div, 100, ns**

Step 12. Enable markers:

Press Marker, Properties, Marker Trace, IQ Waveform, 500, ns

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 [Figure 12-7](#).

Figure 12-7. IQ Waveform Measurement - with Markers



IQ Analyzer Measurement

IQ Waveform (Time Domain) Measurement

13 Concepts

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

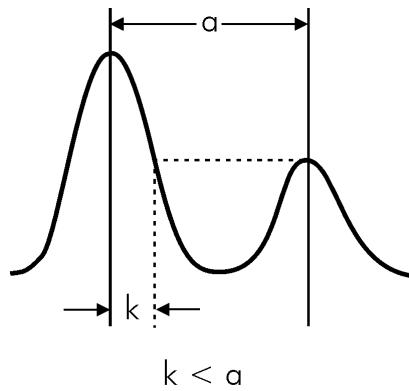
When dealing with the resolution of signals that are close together and not equal in amplitude, you must consider the shape of the IF filter of the analyzer, as well as its 3 dB bandwidth. (See [“Resolving Signals of Equal Amplitude” on page 150](#) for more information.) The shape of a filter is defined 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 13-1](#).) 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 13-1. RBW Requirements for Resolving Small Signals



Trigger Concepts

NOTE 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.

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 13-2.** shows the action of the periodic timer trigger. Before reviewing the figure, we'll explain some uses for the periodic trigger.

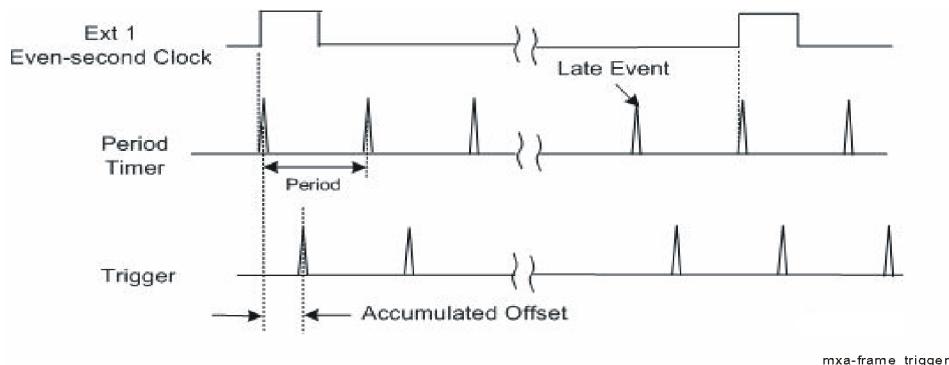
A common application is measuring periodic burst RF signals for which a trigger signal is not easily available. For example, we might be measuring a TDMA radio which bursts every 20 ms. Let's assume that the 20 ms period is very consistent. Let's also assume that we do not have an external trigger source 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 mistigger. 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 in the **Offset** function section.)

Figure 13-2. 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**.

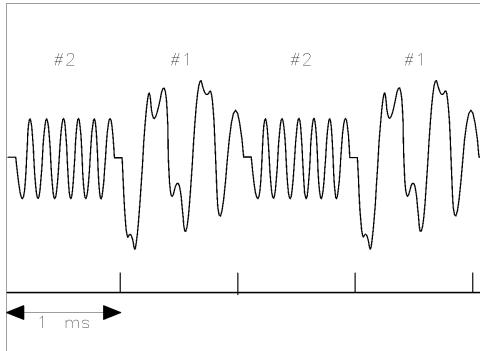
Time Gating Concepts

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. [“Making Time-Gated Measurements” on page 95](#) demonstrates time gating examples.

[Figure 13-3.](#) 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 13-3. Simplified Digital Mobile-Radio Signal in Time Domain

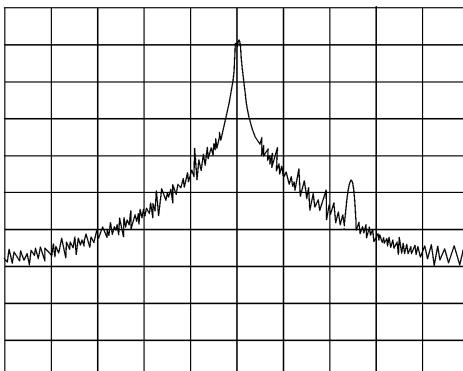


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We want to measure the unique frequency spectrum of each transmitter.

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 13-4](#). The signal analyzer shows the combined spectrum; you cannot tell which part of the spectrum results from which signal.

Figure 13-4. Frequency Spectra of the Combined Radio Signals



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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 13-5](#).

Figure 13-5. Time-Gated Spectrum of Radio 1

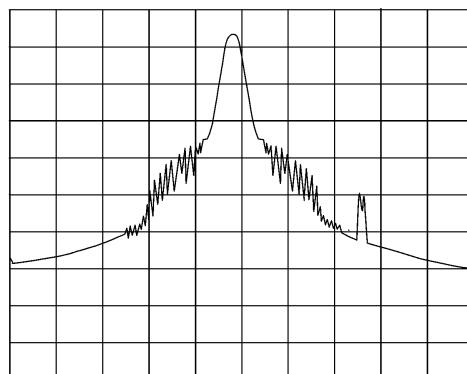
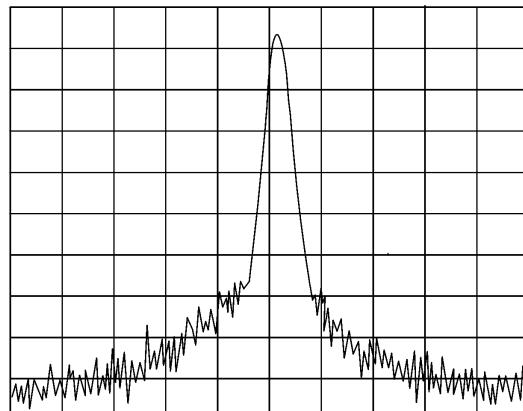


Figure 13-6. Time-Gated Spectrum of Radio 2



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 13-9](#) and [Figure 13-8](#). 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.

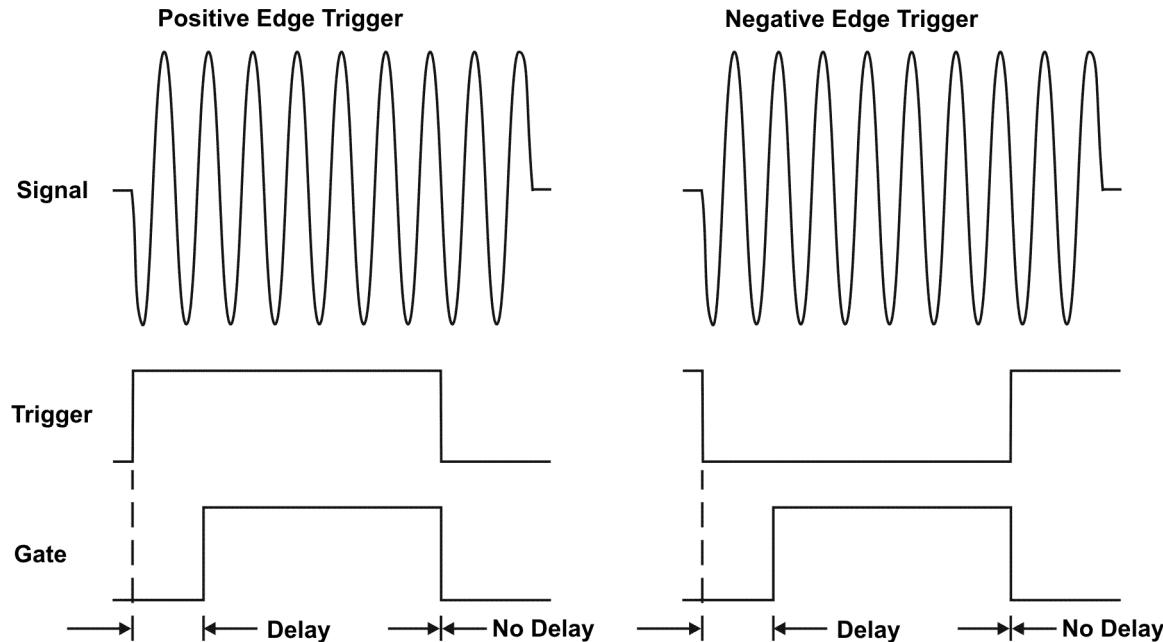
There are typically two main types of gating conditions, *edge* and *level*:

- 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 13-7](#)).

- 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 13-7. Edge Trigger Timing Relationships



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

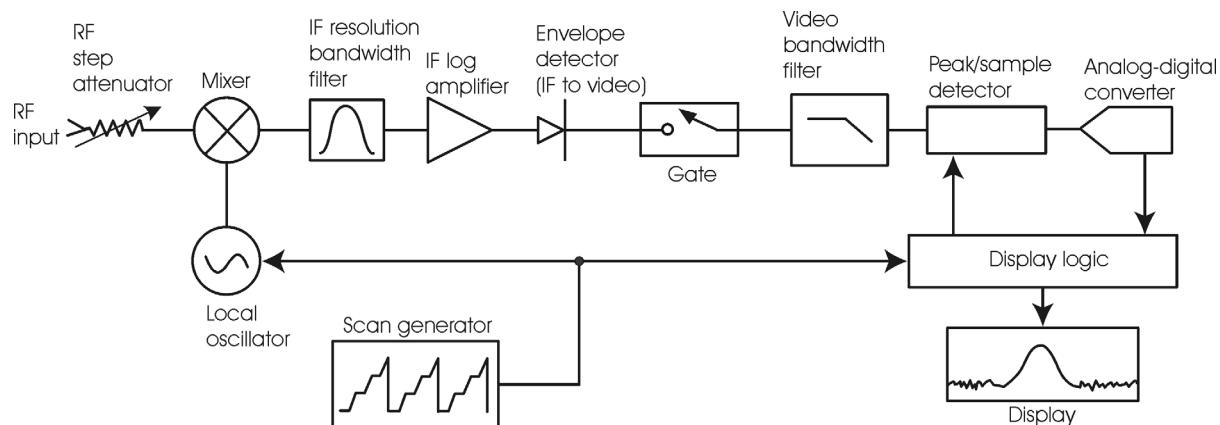
Gated Video Concepts

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 13-8](#), 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.

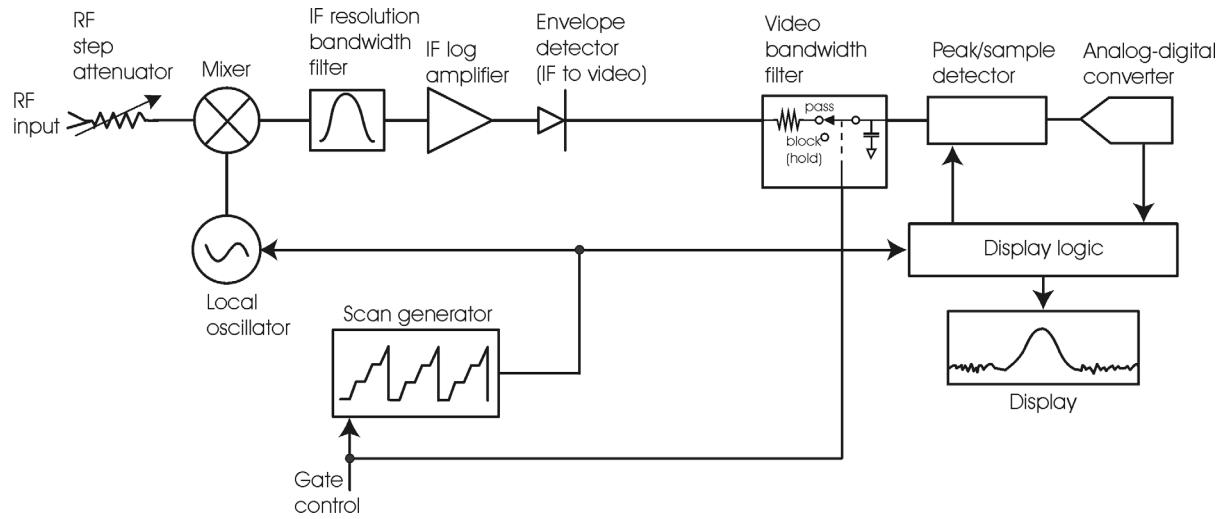
Figure 13-8. Gated Video Signal Analyzer Block Diagram



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 13-9](#), 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 13-9. 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.

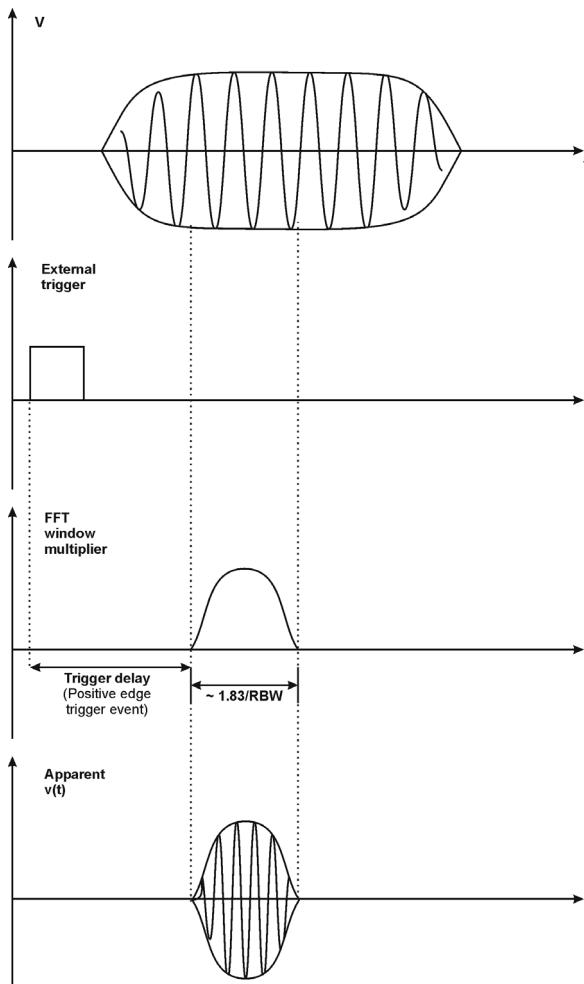
The process of making a spectrum measurement with FFTs is inherently a “gated” process, in that the spectrum is computed from a time record of short duration, much like a gate signal in swept-gated analysis.

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

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

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 13-10. 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).

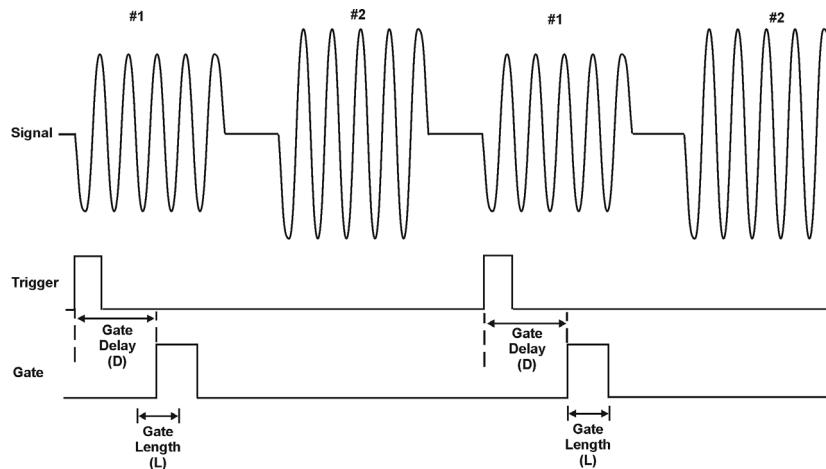
The timing interactions between the three signals are best understood if you observe them in the time domain (see [Figure 13-11](#).).

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.

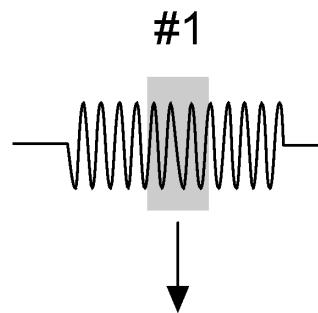
To measure signal 1, the gate must be on only during the pulses from signal 1. The gate will be off at all other times, thus excluding all other signals. To position the gate, set the gate delay and gate length, as shown in [Figure 13-11](#)., so that the gate is on only during some central part of the 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 13-11. Timing Relationship of Signals During Gating



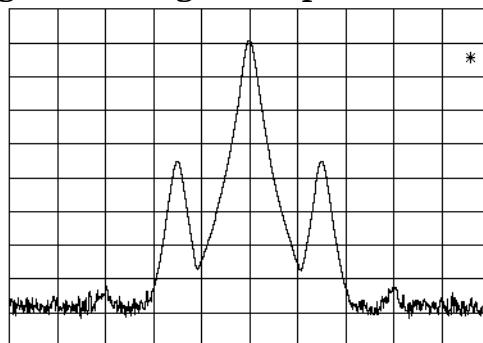
Once the signal analyzer is set up to perform the gate measurement, the spectrum of signal 1 is visible and the spectrum of signal 2 is excluded, as shown if [Figure 13-13](#). In addition, when viewing signal 1, you also will have eliminated the pulse spectrum generated from the pulse edges. Gating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

Figure 13-12. Signal within pulse #1 (time-domain view)



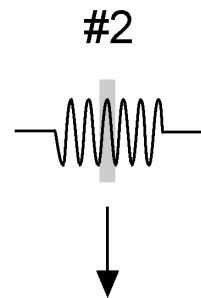
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Figure 13-13. Using Time Gating to View Signal 1 (spectrum view)



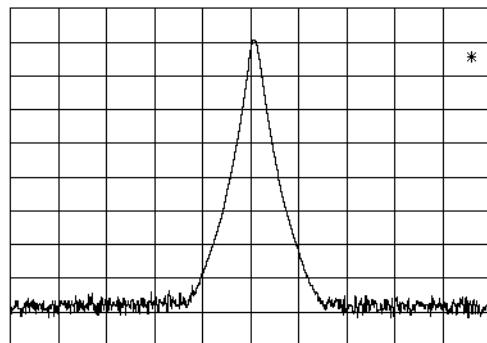
Moving the gate so that it is positioned over the middle of signal 2 produces a result as shown in [Figure 13-15](#). Here, you see only the spectrum within the pulses of signal 2; signal 1 is excluded.

Figure 13-14. Signal within pulse #2 (time-domain view)



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Figure 13-15. 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.

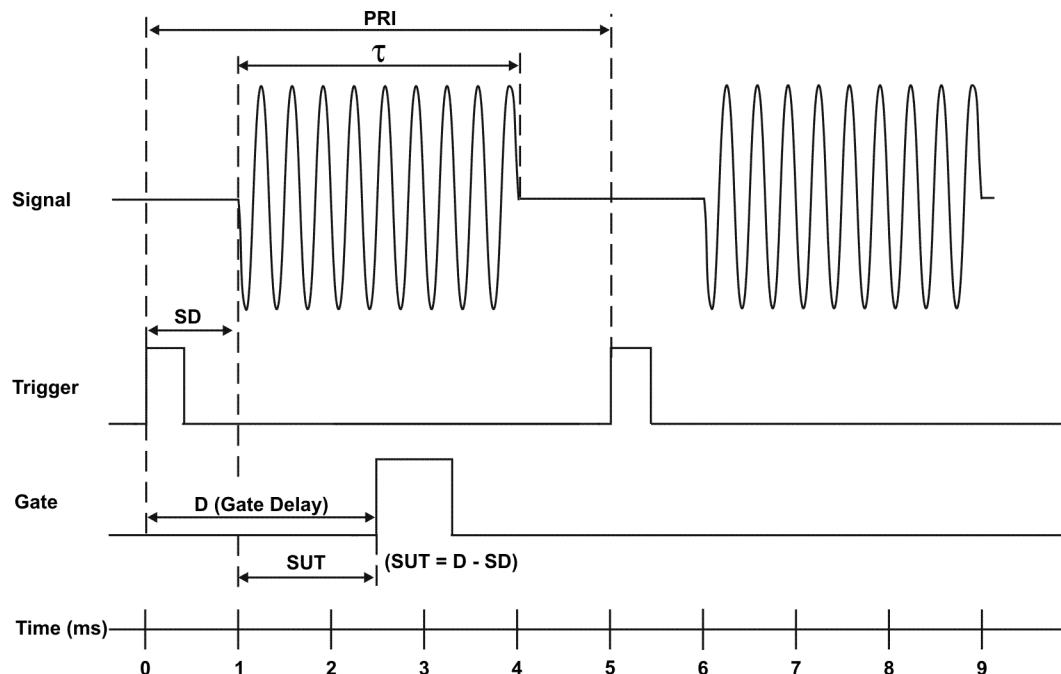
This example shows you how to use time gating to measure a very specific signal. Most signals requiring time gating are fairly complex and in some cases extra steps may be required to perform a measurement.

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 τ
- 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 13-16. Time-domain Parameters



In [Figure 13-16](#), the parameters are:

- Pulse repetition interval (PRI) is 5 ms.
- Pulse width (τ) 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 $(\text{sweep points} - 1) * (\text{PRI} - \tau)$.

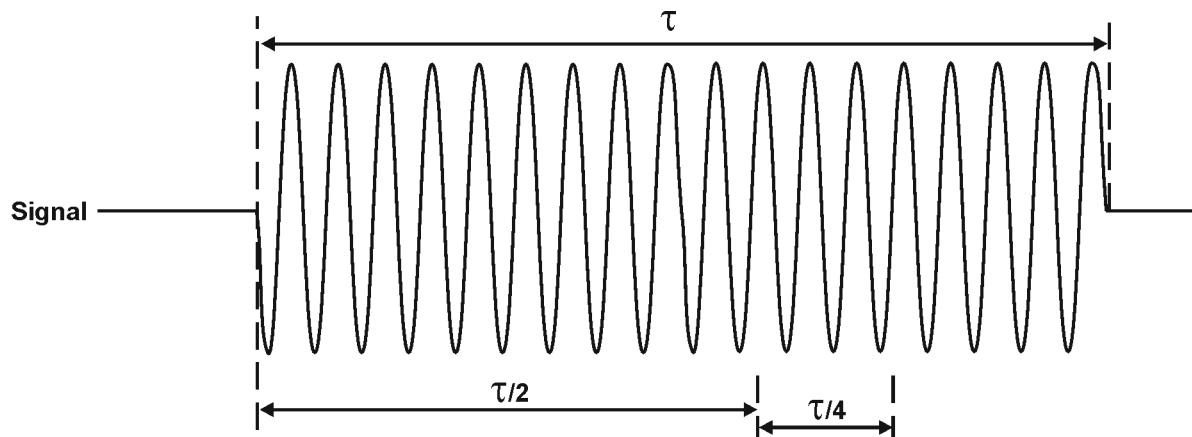
Step 3. Locate the signal under test on the display of the signal analyzer. Set the center frequency and span to view the signal characteristics that you are interested in measuring. Although the analyzer is not yet configured for correct gated measurements, you will want to determine the approximate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

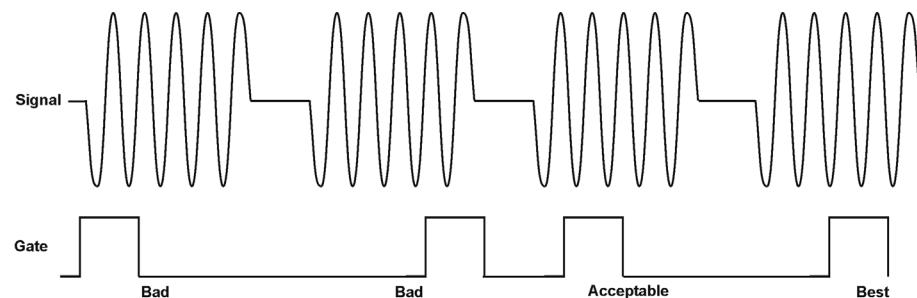
Generally, the gate should be positioned over a part of the signal that is stable, not over a pulse edge or other transition that might disturb the spectrum. Starting the gate at the center of the pulse gives a setup time of about half the pulse width. Setup time describes the length of time during which 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 13-17](#).

Figure 13-17. 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 13-18. 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/resolution bandwidth (see [step 5](#) for RBW calculations).

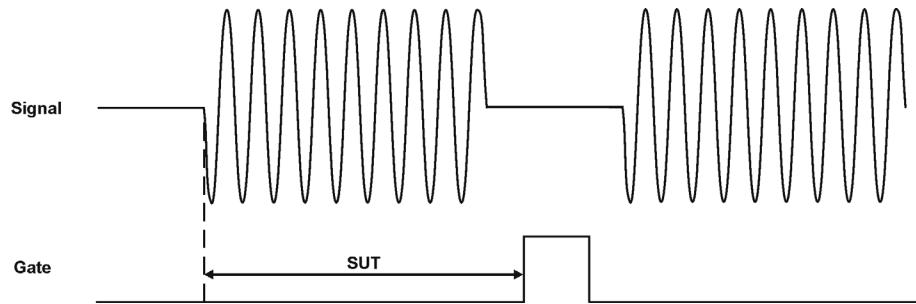
As an example, if you want to use a 1 kHz resolution bandwidth for measurements, you will need to allow a setup time of at least 3.84 ms.

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 13-19. Setup Time for Interpulse Measurement

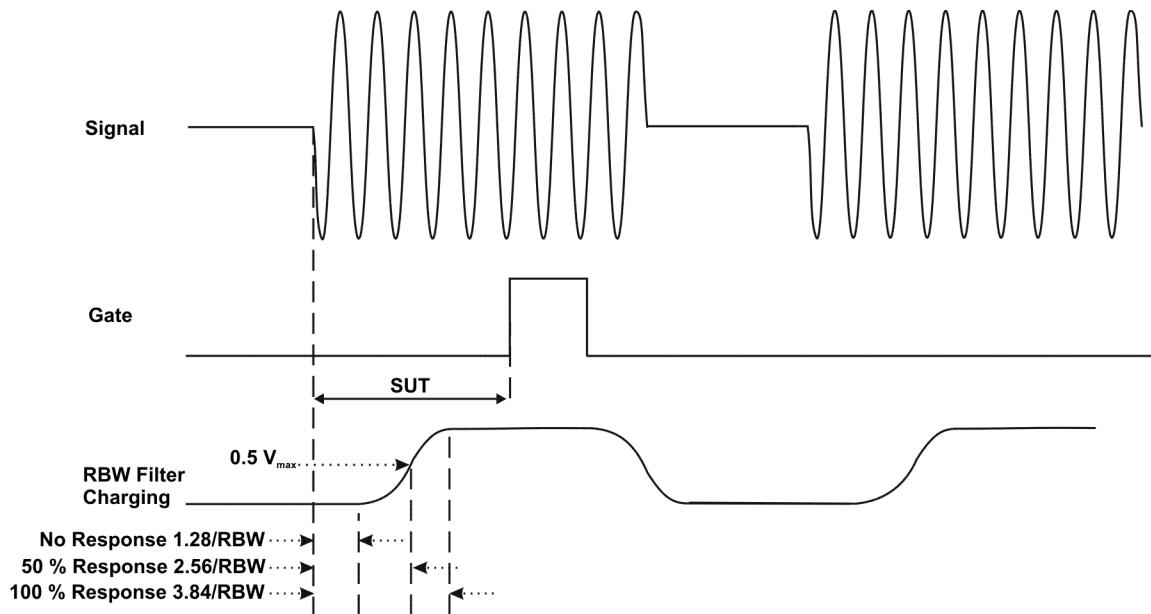


Step 5. The resolution bandwidth will need to be adjusted for gated LO and gated video. The video bandwidth will only need to be adjusted for gated video.

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 13-20. 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.

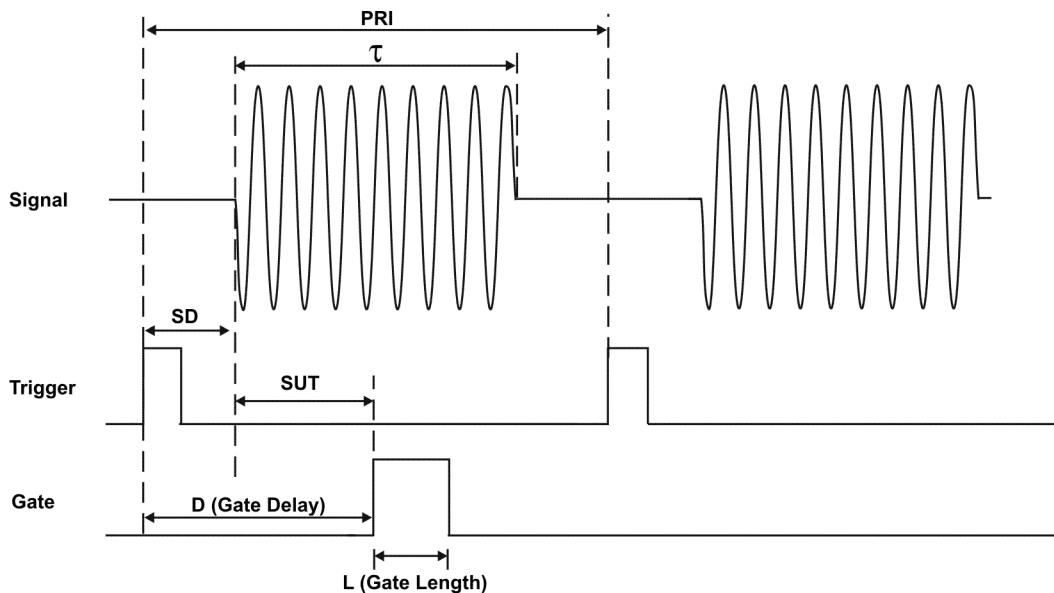
“Quick Rules” for Making Time-Gated Measurements

This section summarizes the rules described in the previous sections.

Table 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 $(\text{number of sweep points} - 1) \times \text{pulse repetition interval (PRI)}$:	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 bandwidth 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 Bandwidth	Set the resolution bandwidth: $\text{RBW} > 19.5/\tau$	The resolution bandwidth must be wide enough so that the charging time for the resolution bandwidth filters is less than the pulse width of the signal.

Figure 13-21. 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 (τ). If you know these parameters, you can begin by picking some standard settings. **Table 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 2. Suggested Initial Settings for Known Pulse Width (τ) and Zero Signal Delay

Pulse width (τ)	Gate Delay (SD + $\tau/5$)	Resolution Bandwidth (>19.5/ τ)	Gate Length (0.7 x $\tau/4$)
4 μ s	0.8 μ s	4.875 MHz	0.7 μ s
10 μ s	2 μ s	1.95 MHz	1.753 μ s
50 μ s	10 μ s	390 kHz	8.75 μ s
63.5 μ s	12.7 μ s	307 kHz	11.11 μ s
100 μ s	20 μ s	195 kHz	17.5 μ s
500 μ s	100 μ s	39 kHz	87.5 μ s
1 ms	200 μ s	19.5 kHz	0.175 μ s
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 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 Gate View to make sure the gate delay is timed properly.
Gate does not trigger.	1) Gate trigger voltage may be wrong. 2) Gate may not be activated. 3) Gate Source 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 and oscilloscope using high input impedance, not 50 Ω). 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 Ω
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

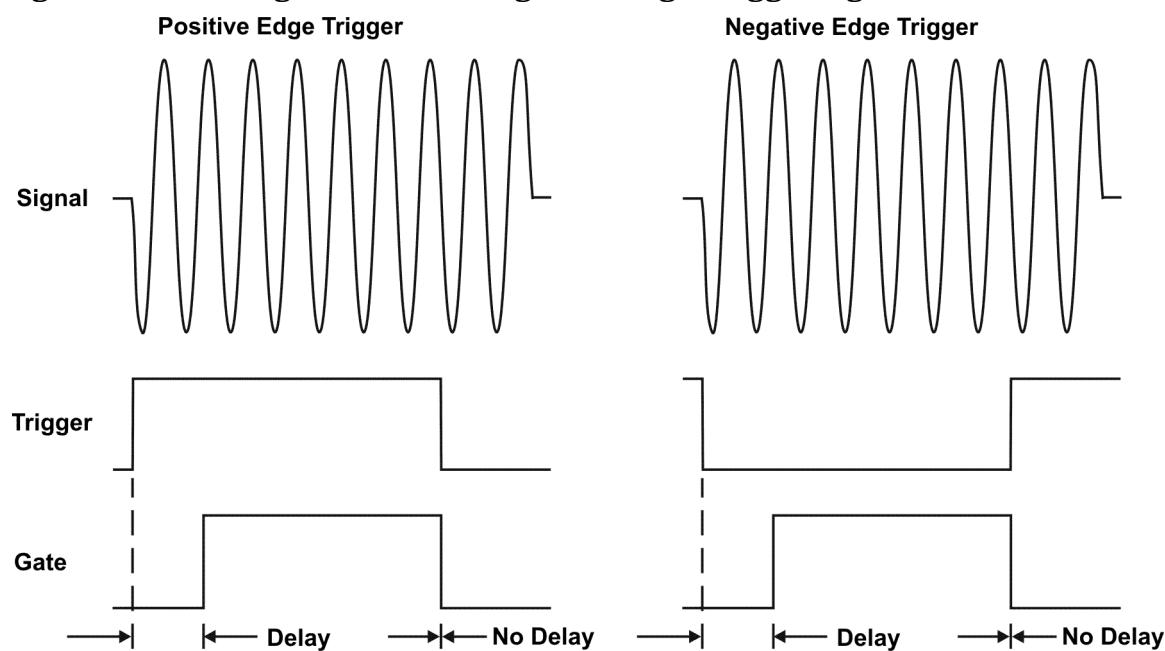
Depending on the trigger signal that you are working with, you can trigger the gate in one of two separate modes: edge or level. This gate-trigger function is separate from the normal external trigger capability of the signal analyzer, which initiates a sweep of a measurement trace based on an external 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 13-22](#). 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 13-22. 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 MXA.

Unlike older analyzers, MXA can make competent measurements of noise density using the noise marker with all detectors, not just those that are ideal for noise measurements. Thus, MXA 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 MXA and an older analyzer where both use the peak detector, the MXA answer will be approximately correct, while the older analyzer will need a correction factor. That correction factor is discussed in Agilent 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.

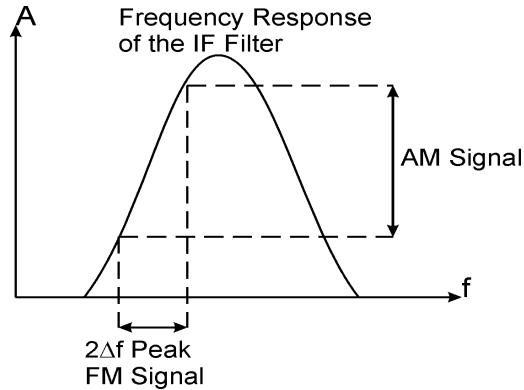
The following functions establish a clear display of the waveform:

- 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 13-23](#).

Figure 13-23. 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.

14 Programming Examples

- The programming examples were written for use on an IBM compatible PC.
- The programming examples use C, Visual Basic, or VEE programming languages.
- The programming examples use VISA interfaces (GPIB, LAN, or USB).
- Some of the examples use the IVI-COM drivers.

Interchangeable Virtual Instruments COM (IVI-COM) drivers: Develop system automation software easily and quickly. IVI-COM drivers take full advantage of application development environments such as Visual Studio using Visual Basic, C# or Visual C++ as well as Agilent's Test and Measurement Toolkit. You can now develop application programs that are portable across computer platforms and I/O interfaces. With IVI-COM drivers you do not need to have in depth test instrument knowledge to develop sophisticated measurement software. IVI-COM drivers provide a compatible interface to all. COM environments. The IVI-COM software drivers can be found at the URL:

<http://www.agilent.com/find/ivi-com>

- Most of the examples are written in C, Visual Basic, VEE, or LabVIEW using the Agilent VISA transition library.

The Agilent I/O Libraries Suite must be installed and the GPIB card, USB to GPIB interface, or Lan interface USB interface configured. The latest Agilent I/O Libraries Suite is available: www.agilent.com/find/iolib

- The STATus subsystem of commands is used to monitor and query hardware status. These hardware registers monitor various events and conditions in the instrument. Details about the use of these commands and registers can be found in the manual/help in the Utility Functions section on the STATus subsystem.

Visual Basic is a registered trademark of Microsoft Corporation.

Available Programming Examples

The following examples work with a Spectrum Analyzer. These examples use one of the following programming languages: Visual Basic® 6, Visual Basic.NET®, MS Excel®, C++, ANSI C, C#.NET, and Agilent VEE Pro.

These examples are available in either the “progexamples” directory on the Agilent Technologies Spectrum Analyzer documentation CD-ROM or the “progexamples” directory in the analyzer. The file names for each example is listed at the end of the example description. The examples can also be found on the Agilent Technologies, Inc. web site at URL:

http://www.agilent.com/find/sa_programming

NOTE These examples have all been test and validated as functional in the Spectrum Analyzer mode. They have not been tested in all other modes. However, they should work in all other modes except where exceptions are noted.

Programming using Visual Basic® 6, Visual Basic.NET® and MS Excel®:

- *Transfer Screen Images* from your Spectrum Analyzer using Visual Basic 6

This example program stores the current screen image on the instrument flash memory as “D:\PICTURE.PNG”. It then transfers the image over GPIB or LAN and stores the image on your PC in the current directory as “PICTURE.PNG”. The file “D:\PICTURE.PNG” is then deleted on the instrument flash memory.

File name: _screen.bas

- *Binary Block Trace* data transfer from your Spectrum Analyzer using Visual Basic 6

This example program queries the IDN string from the instrument and then reads the trace data in Spectrum Analysis mode in binary format (Real,32 or Real,64 or Int,32). The data is then stored to a file “bintrace.txt”. This data transfer method is faster than the default ASCII transfer mode, because less data is sent over the bus.

File name: bintrace.bas

Programming using C++, ANSI C and C#.NET:

- *Serial Poll for Sweep Complete* using C++

This example demonstrates how to:

1. Perform an instrument sweep.
2. Poll the instrument to determine when the operation is complete.
3. Perform an instrument sweep.

File name: _Sweep.c

- *Service Request Method (SRQ)* determines when a measurement is done by waiting for

SRQ and reading Status Register using C++.

This example demonstrates how:

1. Set the service request mask to assert SRQ when either a measurement is uncalibrated or an error message has occurred,
2. Initiate a sweep and wait for the SRQ interrupt,
3. Poll all instruments and report the nature of the * interrupt on the spectrum analyzer.

The STATus subsystem of commands is used to monitor and query hardware status. These hardware registers monitor various events and conditions in the instrument. Details about the use of these commands and registers can be found in the manual/help in the Utility Functions section on the STATus subsystem.

File name: _SRQ.C

- *Relative Band Power Markers* using C++

This example demonstrates how to set markers as Band Power Markers and obtain their band power relative to another specified marker.

File name: _BPM.c

- *Trace Detector / Couple Markers* using C++

This example demonstrates how to:

1. Set different types of traces (max hold, clear and write, min hold)
2. Set markers to specified traces
3. Couple markers

Note: The Spectrum Analyzer is capable of multiple simultaneous detectors (i.e. peak detector for max hold, sample for clear and write, and negative peak for min hold).

File name: _tracecouple.c

- *Phase Noise* using C++

This example demonstrates how to:

1. Remove instrument noise from the phase noise
2. Calculate the power difference between 2 traces

File name: _phasenoise.c

Programming using Agilent VEE Pro:

- *Transfer Screen Images* from my Spectrum Analyzer using Agilent VEE Pro

This example program stores the current screen image on the instrument flash memory as “D:\scr.png”. It then transfers the image over GPIB and stores the image on your PC in the desired directory as “capture.gif”. The file “D:\scr.png” is then deleted on the instrument flash memory.

File name: _ScreenCapture.vee

- *Transfer Trace Data* data transfer using Agilent VEE Pro

Programming Examples
[Available Programming Examples](#)

This example program transfers the trace data from your Spectrum Analyzer. The program queries the IDN string from the instrument and supports Integer 32, real 32, real 64 and ASCII data. The program returns 1001 trace points for the signal analyzer.

File name: transfertrace.vee

Programming Fundamentals

- “SCPI Language Basics” on page 186
- “Improving Measurement Speed” on page 193
- “Programming in C Using the VTL” on page 196

SCPI Language Basics

This section is not intended to teach you everything about the SCPI (Standard Commands for Programmable Instruments) programming language. The SCPI Consortium or IEEE can provide that level of detailed information. For more information refer to the websites for the IEEE Standard 488.1 (IEEE Standard Digital Interface for Programmable Instrumentation).

Topics covered in this chapter include:

- “[Command Keywords and Syntax](#)” on page 186
- “[Creating Valid Commands](#)” on page 186
- “[Special Characters in Commands](#)” on page 188
- “[Parameters in Commands](#)” on page 188
- “[Putting Multiple Commands on the Same Line](#)” on page 191

Command Keywords and Syntax

A typical command is made up of keywords set off by colons. The keywords are followed by parameters that can be followed by optional units.

Example: SENSe:FREQuency:STARt 1.5 MHZ

The instrument does not distinguish between upper and lower case letters. In the documentation, upper case letters indicate the short form of the keyword. The lower case letters, indicate the long form of the keyword. Either form may be used in the command.

Example: Sens:Freq:Star 1.5 mhz

is the same as SENSe:FREQ:start 1.5 MHz

NOTE The command SENSe:FREQU:STAR would not be valid because FREQU is neither the short, nor the long form of the command. Only the short and long forms of the keywords are allowed in valid commands.

Creating Valid Commands

Commands are not case sensitive and there are often many different ways of writing a

particular command. These are examples of valid commands for a given command syntax:

Command Syntax	Sample Valid Commands
[SENSe:] BANDwidth[:RESolution] <freq>	<p>The following sample commands are all identical. They will all cause the same result.</p> <ul style="list-style-type: none"> • Sense:Band:Res 1700 • BANDWIDTH:RESOLUTION 1.7e3 • sens:band 1.7KHZ • SENS:band 1.7E3Hz • band 1.7kHz • bandwidth:RES 1.7e3Hz
MEASure:SPECtrum[n] ?	<ul style="list-style-type: none"> • MEAS:SPEC? • Meas:spec? • meas:spec3? <p>The number 3 in the last meas example causes it to return different results than the commands above it. See the command description for more information.</p>
[:SENSe] :DETector[:FUNCTION] NEGative POSitive SAMPLE	<ul style="list-style-type: none"> • DET:FUNC neg • Detector:Func Pos
INITiate:CONTinuous ON OFF 1 0	<p>The sample commands below are identical.</p> <ul style="list-style-type: none"> • INIT:CONT ON • init:continuous 1

Special Characters in Commands

Special Character	Meaning	Example
	A vertical stroke between parameters indicates alternative choices. The effect of the command is different depending on which parameter is selected.	Command: TRIGger:SOURCE EXTernal INTernal LINE The choices are external, internal, and line. Ex: TRIG:SOURCE INT is one possible command choice.
	A vertical stroke between keywords indicates identical effects exist for both keywords. The command functions the same for either keyword. Only one of these keywords is used at a time.	Command: SENSe:BWIDth BWIDth:OFFSet Two identical commands are: Ex1: SENSE:BWIDTH:OFFSET Ex2: SENSE:BAND:OFFSET
[]	Keywords in square brackets are optional when composing the command. These implied keywords will be executed even if they are omitted.	Command: [SENSe:] BANDwidth[:RESolution] :AUTO The following commands are all valid and have identical effects: Ex1: bandwidth:auto Ex2: band:resolution:auto Ex3: sense:bandwidth:auto
< >	Angle brackets around a word, or words, indicates they are not to be used literally in the command. They represent the needed item.	Command: SENS:FREQ <freq> In this command example the word <freq> should be replaced by an actual frequency. Ex: SENS:FREQ 9.7MHz.
{ }	Parameters in braces can optionally be used in the command either not at all, once, or several times.	Command: MEASure:BW <freq>{,level} A valid command is: meas:BW 6MHz, 3dB, 60dB

Parameters in Commands

There are four basic types of parameters: booleans, keywords, variables and arbitrary block program data.

OFF|ON|0|1

(Boolean) This is a two state boolean-type parameter. The numeric value 0 is equivalent to OFF. Any numeric value other than 0 is equivalent to ON. The numeric values of 0 or 1 are commonly used in the command instead of OFF or ON. Queries of the parameter always return a numeric value of 0 or 1.

keyword The keywords that are allowed for a particular command are defined in the command syntax description.

Units Numeric variables may include units. The valid units for a command

depend on the variable type being used. See the following variable descriptions. The indicated default units will be used if no units are sent. Units can follow the numerical value with, or without, a space.

Variable A variable can be entered in exponential format as well as standard numeric format. The appropriate range of the variable and its optional units are defined in the command description.

The following keywords may also be used in commands, but not all commands allow keyword variables.

- DEFault - resets the parameter to its default value.
- UP - increments the parameter.
- DOWN - decrements the parameter.
- MINimum - sets the parameter to the smallest possible value.
- MAXimum - sets the parameter to the largest possible value.

The numeric value for the function MINimum, MAXimum, or DEFault can be queried by adding the keyword to the command in its query form. The keyword must be entered following the question mark.

Example query: SENSE:FREQ:CENTER? MAX

Variable Parameters

<integer>	is an integer value with no units.
<real>	Is a floating point number with no units.
<freq>	
<bandwidth>	Is a positive rational number followed by optional units. The default unit is Hertz. Acceptable units include: Hz, kHz, MHz, GHz.
<time>	
<seconds>	Is a rational number followed by optional units. The default units are seconds. Acceptable units include: ks, s, ms, μ s, ns.
<voltage>	Is a rational number followed by optional units. The default units are Volts. Acceptable units include: V, mV, μ V, nV
<current>	Is a rational number followed by optional units. The default units are Amperes. Acceptable units include: A, mA, μ A, nA.
<power>	Is a rational number followed by optional units. The default units are W. Acceptable units include: mAW, kW, W, mW, μ W, nW, pW.
<ampl>	Is a rational number followed by optional units. The default units are dBm. Acceptable units include: dBm, dBmV, dB μ V.
<rel_power>	
<rel_ampl>	Is a positive rational number followed by optional units. The default units are dB. Acceptable units include: dB.
<percent>	Is a rational number between 0 and 100. You can either use no units or use

PCT.

<angle>

<degrees> Is a rational number followed by optional units. The default units are degrees. Acceptable units include: DEG, RAD.

<string> Is a series of alpha numeric characters.

<bit_pattern> Specifies a series of bits rather than a numeric value. The bit series is the binary representation of a numeric value. There are no units.

Bit patterns are most often specified as hexadecimal numbers, though octal, binary or decimal numbers may also be used. In the SCPI language these numbers are specified as:

- Hexadecimal, #Hdddd or #hddd where 'd' represents a hexadecimal digit 0 to 9 and 'a' to 'f'. So #h14 can be used instead of the decimal number 20.
- Octal, #Odddddd or #odddd where 'd' represents an octal digit 0 to 7. So #o24 can be used instead of the decimal number 20.
- Binary, #Boooooooooooo or #boooooooooooo where 'd' represents a 1 or 0. So #b10100 can be used instead of the decimal number 20.

Block Program Data

Some parameters consist of a block of data. There are a few standard types of block data. Arbitrary blocks of program data can also be used.

<trace> Is an array of rational numbers corresponding to displayed trace data. See FORMat:DATA for information about available data formats.

A SCPI command often refers to a block of current trace data with a variable name such as: Trace1, Trace2, or Trace3, depending on which trace is being accessed.

<arbitrary block data> Consists of a block of data bytes. The first information sent in the block is an ASCII header beginning with #. The block is terminated with a semi-colon. The header can be used to determine how many bytes are in the data block. There are no units. You will not get block data if your data type is ASCII, using FORMat:DATA ASCII command. Your data will be comma separated ASCII values.

Block data example: suppose the header is #512320.

- The first digit in the header (5) tells you how many additional digits/bytes there are in the header.
- The 12320 means 12 thousand, 3 hundred, 20 data bytes follow the header.
- Divide this number of bytes by your current data format (bytes/data point), either 8 (for real,64), or 4 (for real,32). For this example, if you are using real64 then there are 1540 points in the block.

Putting Multiple Commands on the Same Line

Multiple commands can be written on the same line, reducing your code space requirement. To do this:

- Commands must be separated with a semicolon (;).
- If the commands are in different subsystems, the key word for the new subsystem must be preceded by a colon (:).
- If the commands are in the same subsystem, the full hierarchy of the command key words need not be included. The second command can start at the same key word level as the command that was just executed.

SCPI Termination and Separator Syntax

All binary trace and response data is terminated with <NL><END>, as defined in Section 8.5 of IEEE Standard 488.2-1992, *IEEE Standard Codes, Formats, Protocols and Common Commands for Use with ANSI/IEEE Std 488.1-1987*. New York, NY, 1992. (Although one intent of SCPI is to be interface independent, <END> is only defined for IEEE 488 operation.)

The following are some examples of good and bad commands. The examples are created from a theoretical instrument with the simple set of commands indicated below:

```

[:SENSe]
:POWer
[:RF]
:ATTenuation 40dB

:TRIGger
[:SEQUence]
:EXTernal [1]
:SLOPe
    POSitive

[:SENSe]
:FREQuency
:START
:POWer
[:RF]
:MIXer
:RANGE
[:UPPer]

```

Bad Command	Good Command
PWR:ATT 40dB	POW:ATT 40dB
The short form of POWER is POW, not PWR.	

Bad Command	Good Command
FREQ:STAR 30MHz;MIX:RANG -20dBm	FREQ:STAR 30MHz;POW:MIX:RANG -20dBm
The MIX:RANG command is in the same :SENSE subsystem as FREQ, but executing the FREQ command puts you back at the SENSE level. You must specify POW to get to the MIX:RANG command.	
FREQ:STAR 30MHz;POW:MIX RANG -20dBm	FREQ:STAR 30MHz;POW:MIX:RANG -20dBm
MIX and RANG require a colon to separate them.	
:POW:ATT 40dB;TRIG:FREQ:STAR 2.3GHz	:POW:ATT 40dB;:FREQ:STAR 2.3GHz
:FREQ:STAR is in the :SENSE subsystem, not the :TRIGGER subsystem.	
:POW:ATT?:FREQ:STAR?	:POW:ATT?;:FREQ:STAR?
:POW and FREQ are within the same :SENSE subsystem, but they are two separate commands, so they should be separated with a semicolon, not a colon.	
:POW:ATT -5dB;:FREQ:STAR 10MHz	:POW:ATT 5dB;:FREQ:STAR 10MHz
Attenuation cannot be a negative value.	

Improving Measurement Speed

There are a number of things you can do in your programs to make them run faster:

- “Turn off the display updates” on page 193
- “Use binary data format instead of ASCII” on page 193
- “Minimize the number of GPIB transactions” on page 194
- “Consider using USB or LAN instead of GPIB” on page 194
- “Minimize DUT/instrument setup changes” on page 194
- “Avoid automatic attenuator setting” on page 194
- “Avoid using RFBurst trigger for single burst signals” on page 195

Turn off the display updates

`:DISPLAY:ENABLE OFF` turns off the display. That is, the data may still be visible, but it will no longer be updated. Updating the display slows down the measurement. For remote testing, since the computer is processing the data rather than a person, there is no need to display the data on the analyzer screen.

Use binary data format instead of ASCII

The ASCII data format is the instrument default since it is easier for people to understand and is required by SCPI for `*RST`. However, data input/output is faster using the binary formats.

`:FORMAT:DATA REAL,64` selects the 64-bit binary data format for all your numerical data queries. You may need to swap the byte order if you are using a PC rather than UNIX. `NORMAl` is the default byte order. Use `:FORMAT:BORDER SWAP` to change the byte order so that the least significant byte is sent first. (`Real,32` which is smaller and somewhat faster, should only be used if you do not need full resolution for your data. Some frequency data may require full 64-bit resolution.)

When using the binary format, data is sent in a block of bytes with an ASCII header. A data query would return the block of data in the following format: `#DNNN<nnn binary data bytes>`

To parse the data:

- Read two characters (#D), where D tells you how many N characters follow the D character.
- Read D characters, the resulting integer specifies the number of data bytes sent.
- Read the bytes into a real array.

For example, suppose the header is `#512320`.

- The first character/digit in the header (5) tells you how many additional digits there are in the header.
- The 12320 means 12 thousand, 3 hundred, 20 data bytes follow the header.
- Divide this number of bytes by your current data format (bytes/data point), 8 for `real,64`. For this example, there are 1540 data points in the block of data.

Minimize the number of GPIB transactions

When you are using the GPIB for control of your instrument, each transaction requires driver overhead and bus handshaking, so minimizing these transactions reduces the time used.

- You can reduce bus transactions by sending multiple commands per transaction. See the information on “Putting Multiple Commands on the Same Line” in the SCPI Language Basics section.
- If you are making the same measurement multiple times with small changes in the measurement setup, use the READ command. It is faster than using INITiate and FETCh.

Consider using USB or LAN instead of GPIB

USB and LAN allow faster data input and output. This is especially important if you are moving large blocks of data. You will not get this improved throughput using LAN if there is excessive LAN traffic (that is, your test instrument is connected to a very busy enterprise LAN). You may want to use a private LAN that is only for your test system.

Minimize DUT/instrument setup changes

- Some instrument setup parameters are common to multiple measurements. You should look at your measurement process with an eye toward minimizing setup changes. If your test process involves nested loops, make sure that the inner-most loop is the fastest. Also, check if the loops could be nested in a different order to reduce the number of parameter changes as you step through the test.
- Are you using the measurements under the **Meas** key? Remember that if you have already set your Meas Setup parameters for a measurement, and you want to make another one of these measurements later, use READ:<meas>?. The MEASure:<meas>? command resets all the settings to the defaults, while READ changes back to that measurement without changing the setup parameters from the previous use.
- Are you using the Measurements under the **Meas** key? Remember that *Mode Setup* parameters remain constant across all the measurements in that mode (for example, center/channel frequency, amplitude, radio standard, input selection, trigger setup). You do not have to re-initialize them each time you change to a different measurement.

Avoid unnecessary use of *RST

Remember that while *RST does not change the current Mode, it presets all the measurements and settings to their factory defaults. This forces you to reset your analyzer measurement settings even if they use similar mode setup or measurement settings. See [Minimize DUT/instrument setup changes](#). (Also note that *RST may put the instrument in single measurement/sweep for some modes.)

Avoid automatic attenuator setting

Many of the one-button measurements use an internal process for automatically setting the value of the attenuator. It requires measuring an initial burst to identify the proper attenuator setting before the next burst can be measured properly. If you know the amount

of attenuation or the signal level needed for your measurement, just set it.

Note that spurious types of measurements must be done with the attenuator set to automatic (for measurements like: output RF spectrum, transmit spurs, adjacent channel power, spectrum emission mask). These types of measurements start by tuning to the signal, then they tune away from it and must be able to reset the attenuation value as needed.

Avoid using RF Burst trigger for single burst signals

RF Burst triggering works best when measuring signals with repetitive bursts. For a non-repetitive or single burst signals, use the IF (video) trigger or external trigger, depending on what you have available.

RF Burst triggering depends on its establishment of a valid triggering reference level, based on previous bursts. If you only have a single burst, the peak detection nature of this triggering function, may result in the trigger being done at the wrong level/point generating incorrect data, or it may not trigger at all.

Are you making a single burst measurement? To get consistent triggering and good data for this type of measurement application, you need to synchronize the triggering of the DUT with the analyzer. You should use the analyzer internal status system for this.

The first step in this process is to initialize the status register mask to look for the “waiting for trigger” condition (bit 5). Use `:STATUS:OPERATION:ENABLE 32`

Then, in the measurement loop:

1. `:STATUS:OPERATION:EVENT?` This query of the operation event register is to clear the current register contents.
2. `:READ:PVT?` initiates a measurement (in this example, for GSM power versus time) using the previous setup. The measurement will then be waiting for the trigger.

Make sure the attenuation is set manually. Do NOT use automatic attenuation as this requires an additional burst to determine the proper attenuation level before the measurement can be made.

3. Create a small loop that will serial poll the instrument for a status byte value of binary 128. Then wait 1 msec (100 ms if the display is left on/enabled) before checking again, to keep the bus traffic down. These two commands are repeated until the condition is set, so we know that the trigger is armed and ready.
4. Trigger your DUT to send the burst.
5. Return the measurement data to your computer.

NOTE This process cannot be done with the current VXI plug-n-play driver implementation. You will need to use the previous SCPI commands.

Programming in C Using the VTL

The programming examples that are provided are written using the C programming language and the Agilent VTL (VISA transition library). This section includes some basic information about programming in the C language. Note that some of this information may not be relevant to your particular application. (For example, if you are not using VXI instruments, the VXI references will not be relevant).

Refer to your C programming language documentation for more details. (This information is taken from the manual “VISA Transition Library”, part number E2090-90026.) The following topics are included:

- “Typical Example Program Contents” on page 196
- “Linking to VTL Libraries” on page 197
- “Compiling and Linking a VTL Program” on page 197
- “Example Program” on page 198
- “Including the VISA Declarations File” on page 199
- “Opening a Session” on page 199
- “Device Sessions” on page 199
- “Addressing a Session” on page 201
- “Closing a Session” on page 202

Typical Example Program Contents

The following is a summary of the VTL function calls used in the example programs.

visa.h	This file is included at the beginning of the file to provide the function prototypes and constants defined by VTL.
ViSession	The ViSession is a VTL data type. Each object that will establish a communication channel must be defined as ViSession.
viOpenDefaultRM	You must first open a session with the default resource manager with the viOpenDefaultRM function. This function will initialize the default resource manager and return a pointer to that resource manager session.
viOpen	This function establishes a communication channel with the device specified. A session identifier that can be used with other VTL functions is returned. This call must be made for each device you will be using.
viPrintf	
viScanf	These are the VTL formatted I/O functions that are patterned after those used in the C programming language. The viPrintf call sends the IEEE 488.2 *RST command to the instrument and puts it in a known state. The viPrintf call is used again to query for the device identification (*IDN?). The viScanf call is then used to read the results.
viClose	This function must be used to close each session. When you close a device session, all data structures that had been allocated for the session will be de-allocated. When you close the default manager session, all sessions opened using the default manager session will be closed.

Linking to VTL Libraries

Your application must link to one of the VTL import libraries:

32-bit Version:

C:\VXIPNP\WIN95\LIB\MSC\VISA32.LIB for Microsoft compilers

C:\VXIPNP\WIN95\LIB\BC\VISA32.LIB for Borland compilers

16-bit Version:

C:\VXIPNP\WIN\LIB\MSC\VISA.LIB for Microsoft compilers

C:\VXIPNP\WIN\LIB\BC\VISA.LIB for Borland compilers

See the following section, “[Compiling and Linking a VTL Program](#)” for information on how to use the VTL run-time libraries.

Compiling and Linking a VTL Program

32-bit Applications

The following is a summary of important compiler-specific considerations for several C/C++ compiler products when developing WIN32 applications.

For Microsoft Visual C++ version 2.0 compilers:

- Select Project | Update All Dependencies from the menu.
- Select Project | Settings from the menu. Click on the C/C++ button. Select Code Generation from the Use Run-Time Libraries list box. VTL requires these definitions for WIN32. Click OK to close the dialog boxes.
- Select Project | Settings from the menu. Click on the Link button and add visa32.lib to the Object / Library Modules list box. Optionally, you may add the library directly to your project file. Click OK to close the dialog boxes.
- You may wish to add the include file and library file search paths. They are set by doing the following:
 1. Select Tools | Options from the menu.
 2. Click Directories to set the include file path.
 3. Select Include Files from the Show Directories For list box.
 4. Click Add and type in the following: C:\VXIPNP\WIN95\INCLUDE
 5. Select Library Files from the Show Directories For list box.
 6. Click Add and type in the following: C:\VXIPNP\WIN95\LIB\MSC

For Borland C++ version 4.0 compilers:

- You may wish to add the include file and library file search paths. They are set under the Options | Project menu selection. Double-click on Directories from the Topics list box and add the following:

C:\VXIPNP\WIN95\INCLUDE
C:\VXIPNP\WIN95\LIB\BC

16-bit Applications

The following is a summary of important compiler-specific considerations for the Windows compiler.

For Microsoft Visual C++ version 1.5:

- To set the memory model, do the following:
 1. Select Options | Project.
 2. Click Compiler, then select Memory Model from the Category list.
 3. Click the Model list arrow to display the model options, and select Large.
 4. Click OK to close the Compiler dialog box.
- You may wish to add the include file and library file search paths. They are set under the Options | Directories menu selection:

C:\VXIPNP\WIN\INCLUDE
C:\VXIPNP\WIN\LIB\MSC

Otherwise, the library and include files should be explicitly specified in the project file.

Example Program

This example program queries a GPIB device for an identification string and prints the results. Note that you must change the address.

```
/*idn.c - program filename */

#include "visa.h"
#include <stdio.h>

void main ()
{
    /*Open session to GPIB device at address 18 */
    ViOpenDefaultRM (&defaultRM);
    ViOpen (defaultRM, GPIB0::18::INSTR", VI_NULL,
            VI_NULL, &vi);

    /*Initialize device */
    viPrintf (vi, "*RST\n");

    /*Send an *IDN? string to the device */
    printf (vi, "*IDN?\n");

    /*Read results */
    viScanf (vi, "%t", &buf);

    /*Print results */
    printf ("Instrument identification string: %s\n", buf);

    /* Close sessions */
}
```

```
    viClose (vi);
    viClose (defaultRM);
}
```

Including the VISA Declarations File

For C and C++ programs, you must include the `visa.h` header file at the beginning of every file that contains VTL function calls:

```
#include "visa.h"
```

This header file contains the VISA function prototypes and the definitions for all VISA constants and error codes. The `visa.h` header file includes the `visatype.h` header file.

The `visatype.h` header file defines most of the VISA types. The VISA types are used throughout VTL to specify data types used in the functions. For example, the `viOpenDefaultRM` function requires a pointer to a parameter of type `ViSession`. If you find `ViSession` in the `visatype.h` header file, you will find that `ViSession` is eventually typed as an unsigned long.

Opening a Session

A session is a channel of communication. Sessions must first be opened on the default resource manager, and then for each device you will be using. The following is a summary of sessions that can be opened:

- A **resource manager session** is used to initialize the VISA system. It is a parent session that knows about all the opened sessions. A resource manager session must be opened before any other session can be opened.
- A **device session** is used to communicate with a device on an interface. A device session must be opened for each device you will be using. When you use a device session you can communicate without worrying about the type of interface to which it is connected. This insulation makes applications more robust and portable across interfaces. Typically a device is an instrument, but could be a computer, a plotter, or a printer.

NOTE

All devices that you will be using need to be connected and in working condition prior to the first VTL function call (`viOpenDefaultRM`). The system is configured only on the *first* `viOpenDefaultRM` per process. Therefore, if `viOpenDefaultRM` is called without devices connected and then called again when devices are connected, the devices will not be recognized. You must close **ALL** resource manager sessions and re-open with all devices connected and in working condition.

Device Sessions

There are two parts to opening a communications session with a specific device. First you must open a session to the default resource manager with the `viOpenDefaultRM` function. The first call to this function initializes the default resource manager and returns a session to that resource manager session. You only need to open the default manager session once. However, subsequent calls to `viOpenDefaultRM` returns a session to a unique session to

the same default resource manager resource.

Next, you open a session with a specific device with the `viOpen` function. This function uses the session returned from `viOpenDefaultRM` and returns its own session to identify the device session. The following shows the function syntax:

```
viOpenDefaultRM (sesn);  
viOpen (sesn, rsrcName, accessMode, timeout, vi);
```

The session returned from `viOpenDefaultRM` must be used in the `sesn` parameter of the `viOpen` function. The `viOpen` function then uses that session and the device address specified in the `rsrcName` parameter to open a device session. The `vi` parameter in `viOpen` returns a session identifier that can be used with other VTL functions.

Your program may have several sessions open at the same time by creating multiple session identifiers by calling the `viOpen` function multiple times.

The following summarizes the parameters in the previous function calls:

<code>sesn</code>	This is a session returned from the <code>viOpenDefaultRM</code> function that identifies the resource manager session.
<code>rsrcName</code>	This is a unique symbolic name of the device (device address).
<code>accessMode</code>	This parameter is not used for VTL. Use <code>VI_NULL</code> .
<code>timeout</code>	This parameter is not used for VTL. Use <code>VI_NULL</code> .
<code>vi</code>	This is a pointer to the session identifier for this particular device session. This pointer will be used to identify this device session when using other VTL functions.

The following is an example of opening sessions with a GPIB multimeter and a GPIB-VXI scanner:

```
ViSession defaultRM, dmm, scanner;  
. . .  
viOpenDefaultRM (&defaultRM);  
viOpen (defaultRM, "GPIB0::22::INSTR", VI_NULL,  
        VI_NULL, &dmm);  
viOpen (defaultRM, "GPIB-VXI0::24::INSTR", VI_NULL,  
        VI_NULL, &scanner);  
. . .  
viClose (scanner);  
viClose (dmm);  
viClose (defaultRM);
```

The above function first opens a session with the default resource manager. The session returned from the resource manager and a device address is then used to open a session with the GPIB device at address 22. That session will now be identified as **dmm** when using other VTL functions. The session returned from the resource manager is then used again with another device address to open a session with the GPIB-VXI device at primary address 9 and VXI logical address 24. That session will now be identified as **scanner** when

using other VTL functions. See the following section for information on addressing particular devices.

Addressing a Session

As seen in the previous section, the *rsrcName* parameter in the *viOpen* function is used to identify a specific device. This parameter is made up of the VTL interface name and the device address. The interface name is determined when you run the VTL Configuration Utility. This name is usually the interface type followed by a number. The following table illustrates the format of the *rsrcName* for the different interface types

Interface	Syntax
VXI	VXI [<i>board</i>]::VXI <i>logical address</i> [::INSTR]
GPIB-VXI	GPIB-VXI [<i>board</i>]::VXI <i>logical address</i> [::INSTR]
GPIB	GPIB [<i>board</i>]:: <i>primary address</i> [:: <i>secondary address</i>][::INSTR]

The following describes the parameters used above:

board This optional parameter is used if you have more than one interface of the same type. The default value for *board* is 0.

VXI logical address This is the logical address of the VXI instrument.

primary address This is the primary address of the GPIB device.

secondary address This optional parameter is the secondary address of the GPIB device. If no secondary address is specified, none is assumed.

INSTR This is an optional parameter that indicates that you are communicating with a resource that is of type **INSTR**, meaning instrument.

NOTE If you want to be compatible with future releases of VTL and VISA, you must include the INSTR parameter in the syntax.

The following are examples of valid symbolic names:

XI0::24::INSTR Device at VXI logical address 24 that is of VISA type INSTR.

VXI2::128 Device at VXI logical address 128, in the third VXI system (VXI2).

GPIB-VXI0::24 A VXI device at logical address 24. This VXI device is connected via a GPIB-VXI command module.

GPIB0::7::0 A GPIB device at primary address 7 and secondary address 0 on the GPIB interface.

The following is an example of opening a device session with the GPIB device at primary address 23.

```
ViSession defaultRM, vi;  
. . .  
viOpenDefaultRM (&defaultRM);  
viOpen (defaultRM, "GPIB0::23::INSTR", VI_NULL, VI_NULL, &vi);  
. . .  
viClose (vi);  
viClose (defaultRM);
```

Closing a Session

The `viClose` function must be used to close each session. You can close the specific device session, which will free all data structures that had been allocated for the session. If you close the default resource manager session, all sessions opened using that resource manager will be closed.

Since system resources are also used when searching for resources (`viFindRsrc`) or waiting for events (`viWaitOnEvent`), the `viClose` function needs to be called to free up find lists and event contexts.

Numerics

10 MHz reference, turning on 10
50 ohm load 13
50 ohm/75 ohm minimum loss pad 13
75 ohm matching transformer 13

A

AC probe 13, 14
Accessories 13
accessories
 50 ohm load 13
 50 ohm/75 ohm minimum loss pad 13
 75 ohm matching transformer 13
AC probe 13, 14
broadband preamplifiers 14
GPIB cable 14
power splitters 15
RF limiters 14
transient limiters 14
ACP key
 MEAS key 117
 Meas key 117
ACP measurement 116
active function 20
Adjacent Channel Power measurement 116
AM demodulation
 time-domain demodulation,
 manually calculating 174
AM signal demodulation 136
amplifiers 14
analyzer distortion products 68
angle parameter (variables) 190
annotations, display 22
arbitrary block data 190
arrow keys, using 9
attenuation
 input, reducing 46
 setting automatically 48
 setting manually 47
averaging
 description 54
 types 54

B

band power marker 86
bit_pattern parameter (variables) 190
block data
 arbitrary 190
 identifying block size 190
 parsing output 190

Bluetooth power measurement 124
boolean parameter (commands) 188
broadband preamplifiers 14
Burst Power key
 Meas key 124
Burst Power measurement 124

C

C language
 addressing sessions 201
 closing sessions 202
 compiling and linking 197
 creating 196
 example 198
 opening session 199
 sessions 199
 using VISA library 196
 using VISA transition library 197, 199
cable
 GPIB 14
CCDF measurement 120
CCDP key
 Meas key 121
Channel Power key
 Meas key 112
Channel power measurement 112
channel power measurement
 noise-like signals 84
commands
 boolean parameter 188
 keyword parameter 188
 multiple on a line 191
 parameters 188
 syntax 186
 termination, IEEE 191
 units parameter 188
 valid commands 186
 variable parameter 189
 variable parameter keywords 189
comparing signals
 two signals 28
 two signals not on the same screen 30
complex spectrum measurement 175
Concepts
 AM demodulation 174
 FM demodulation 174
concepts
 gated FFT (PSA) 159
 gated LO (PSA) 158
 gated video (ESA) 158
IF filter, defined 150

resolving signals of equal amplitude 150
resolving small signals hidden by large signals 150
time gating 155
connectors, front panel 18
copyrights 2

D

data
 arbitrary blocks 190
data, entering from front panel 9
DC probes
 use of 13, 14
degree parameter (variables) 190
delta band marker function 41
delta marker 28
demodulating
 AM 136
 AM overview 136
detectors, average 52
display annotations 22
distortion measurements
 identifying distortion products 68
 identifying TOI distortion 71
 overview 68
distortion products 68
drifting signals 65

E

Enter key, using 9
equipment 12
ESD safety accessories 15
examples
 AM demodulation
 manual demodulation 136
 average detector, using 52
 averaging, trace 54
 distortion
 identify distortion products 68
 TOI 71
 frequency accuracy 11
 frequency drift 62
 input attenuation, reducing 46
 marker counter 58
 measuring
 low-level signals 52
 noise
 band power marker 81
 channel power, using 84
 noise marker 78
 overview 76
 signal to noise 76
 resolution bandwidth, reducing 49
 signals

low-level, overview 46
off-screen, comparing 30
on-screen, comparing 28
resolving, equal amplitude 32
resolving, small signals hidden by large signals 36
signals, viewing 10
time gating
 ESA-E time gate 106
 PSA gated FFT 109
 PSA gated sweep 103
 trace averaging 54
 tracking a signal 65
external reference (10 MHz), turning on 10

F
factory preset, description 10
finding hidden signals 150
FM demodulation
 time-domain demodulation, manually calculating 174
frequency accuracy, increasing 11
frequency count, using 11
frequency parameter (variables) 189
frequency readout resolution increased 58
front panel
 connectors and keys 18
 display annotations 22
 entering data 9
 symbols 26

G
gate delay
 setting the gate delay, time gating 166
gate length
 setting the gate length, time gating 166
gated FFT (PSA), concepts 159
gated LO (PSA), concepts 158
gated video (ESA), concepts 158
GPIB cable 14

H
harmonic distortion
 measuring low-level signals 30
hold, maximum 63

I
identifying distortion products 68
IEEE command termination 191
initial setting for time gating 170
input attenuation, reducing 46

integer variable (variables) 189
intermodulation distortion, third order 71
interval power marker function 41
iq waveform measurement 176

K
key overview 20
keypad, using 9
keys 18
keyword parameter (commands) 188
knob, using 9

L
licenses 2
limiters
 RF and transient 14
load, 50 ohm 13
low-level signals
 harmonics, measuring 30
 input attenuation, reducing 46
 resolution bandwidth, reducing 49
 sweep time, reducing 52
 trace averaging 54

M
marker
 frequency and amplitude, reading 10
 moving
 to peak 10
 to reference level 10
 with knob or arrow key 10
 turning off 11
marker annotation
 change with frequency count 11
 location 10
marker counter example
 marker frequency resolution 58
marker function
 delta band 41
 interval power 41
markers
 band power 81
 delta 28
 noise marker 76, 78
 span pair 81
markers, advanced
 band power 86
markers, advances
 noise marker 86
Max Hold key 63
maximum hold 63

MEAS key
 ACP key 117
Meas key
 ACP key 117
 Burst Power key 124
CCDP key 121
Channel Power key 112
Occupied BW key 114
Spectrum Emission Mask key 133
measure complex modulation power 41
measurement
 ACP or spurious emissions mask 177
 occupied bandwidth 179
 spectrum shape 179
 spectrum emission mask 178
measurements
 distortion 68
 identifying 68
 TOI 71
 frequency drift 62, 65
 increasing speed 193
noise
 band power marker 81
 channel power 84
 noise marker 78
 overview 76
 signal to noise 76
time gating 95
 ESA-E time gate 106
 PSA gated FFT 109
 PSA gated sweep 103

menu keys 20
moving signals 65

N
navigating
 tables 21
noise marker 86
noise measurements
 band power marker, using 81
 channel power, using 84
 noise marker, using 78
 overview 76
 signal to noise 76
 sweep time, reducing 52
noise power measurement near noise floor 91
numeric keypad, using 9

O
occupied bandwidth
 99.0% bandwidth 179
measurement method 179
purpose 179

total absolute power 179
Occupied Bandwidth
 measurement 114
Occupied BW key
 Meas key 114
output data, identifying block size
 190
overview, keys and key menus 20
overviews
 distortion 68
 low-level signal 46
 noise 76
 resolving signals 150
 time gating 155

P
parameter (variables) 189
parameters (commands) 188
parameters, variable 189
percent parameter (variables) 189
phase parameter (variables) 190
positioning the gate, time gating
 166
power amplifiers 14
power diff
 trace math function 91
power parameter (variables) 189
power splitters 15
preamplifiers 14
preset
 factory 10
 types 10
 user, creating 10
probes
 AC and DC 13, 14
programming
 command parameters 188
 command syntax 186
 example using C language 198
 SCPI basics 186
 using C language 196
 valid commands 186

R
RBW selections 51
rear panel
 symbols 26
rear panel features 24
reference level, setting 10
reference, turning on 10 MHz 10
relative power parameter
 (variables) 189
resolution bandwidth
 adjusting 49
 resolving signals 150
resolving signals
 small signals hidden by large
 signals 150
 resolving two signals
 equal amplitude 32, 150
 resolving, equal amplitude 150
results data, identifying block size
 190
RF limiters 14
RPG, using 9
rules for time gating 169

S
SCPI language
 basic info 186
 command parameters 188
 command syntax 186
 keyword parameters 188
 valid commands 186
screen annotation 22
signal parameters for a
 time-gated measurement 164
signal tracking
 example 65
 marker tracking 39
 using to resolve signals 39
signals
 low-level, overview 46
 off-screen, comparing 30
 on-screen, comparing 28
 resolving, overview 150
 separating, overview 150
signals, increasing accuracy 11
signals, viewing 10
softkeys, auto and man mode 9
softkeys, basic types 9
Span Zoom key 63
Spectrum (Frequency Domain)
 key 175
Spectrum analysis measurement
 application 111
 channel power 84
spectrum emission mask
 in-band and out-of-band
 spurious emissions 178
 integration bandwidth method
 178
 measurement method 178
 offset or region frequency pairs
 178
 purpose 178
 reference channel integration
 bandwidth 178
 spectral regrowth 178
Spectrum Emission Mask key
 Meas key 133
Spectrum Emission Mask
 measurement 133
spectrum measurement
 method 175
splitters 15
static safety accessories 15
Statistical Power measurement
 120
string parameter (variables) 190
sweep time and sensitivity trade
 off 51
sweep time for a time-gated
 measurement 106, 165
sweep time, changing 52
symbols, on front and rear panels
 26

T
tab key 21
table
 navigation 21
test equipment 12
third order intermodulation
 distortion example 71
throughput, improving 193
time gating
 description 155
 ESA-E time gate, using 106
 example 95
 gated FFT (PSA), concepts 159
 gated LO (PSA), concepts 158
 gated video (ESA), concepts 158
 how time gating works 157
 initial settings 170
 keys 165
 positioning the gate 104, 166
 PSA gated FFT, using 109
 PSA gated sweep, using 103
 rules 169
 setting sweep time 170
 setting the gate length 166
 setting the resolution
 bandwidth 167, 168
 setting the span 165, 168
 setting the video bandwidth 167
 signal parameters 164
 steps for measuring unknown
 signals 164
 sweep time 106, 165
triggering
 edge mode 172
 level mode 172
 negative edge 172
 positive edge 172
troubleshooting 171
time gating measurement 95
time parameter (variables) 189
trace data format 190
trace math function

Index

power diff [91](#)
tracking unstable signals [65](#)
transient limiter [14](#)
troubleshooting
 time-gated measurements [171](#)

U

unit softkeys, using [9](#)
units parameter (commands) [188](#)
unstable signals [65](#)
user preset
 creating [10](#)
 description [10](#)

V

variable parameter (commands)
 [189](#)
variables
 angle parameter [190](#)
 bit_data parameter [190](#)
 degree parameter [190](#)
 frequency parameter [189](#)
 integer parameter [189](#)
 parameters [189](#)
 percent parameter [189](#)
 phase parameter [190](#)
 power parameter [189](#)
 relative power parameter [189](#)
 string parameter [190](#)
 time parameter [189](#)
 voltage parameter [189](#)
VISA library [197, 199](#)
voltage parameter (variables) [189](#)
VTL, compiling and linking C
 language [197](#)

W

waveform
 method [176](#)
Waveform (Time Domain) key [176](#)