

Keysight X-Series Signal Analyzers

This manual provides documentation for the following Analyzers:

PXA Signal Analyzer N9030A

MXA Signal Analyzer N9020A

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Real-Time
Spectrum
Analyzer
Measurement
Guide

Notices

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1 About the RTSA Option

The Real-time Spectrum Analyzer Measurement application uses ASICs and FPGAs to convert sampled signal data into signal spectra at a very high rate, nearly 300,000 spectra per second. Spectrum data is combined to create information-rich displays such as density (also called histograms). Alternatively, the stream of spectra can be sequentially tested against limits and logical criteria to produce a spectrum-specific and behavior-specific frequency-mask trigger (FMT).

In addition, PXAs and MXAs with the RTSA option offer the following:

- **Wider bandwidth:** As the signal bandwidths and spans to be analyzed continue to increase, greater bandwidth is necessary. The PXA and MXA have the required combination of IF bandwidth, signal sampling and signal process to handle 160 MHz continuously. This gap-free bandwidth applies not only to real-time spectrum analysis but also FMT, gap-free time capture and real-time magnitude calculations for IF magnitude triggering.
- **Better dynamic range:** The PXA and MXA allow small signals to be detected in the presence of large ones by providing up to 75 dB of spurious-free dynamic range across its full 160-MHz analysis bandwidth. Dynamic range is enhanced by the low noise floor of the PXA and, when dealing with very small signals, can be further enhanced by adding the low noise path (LNP) option, which improves sensitivity while simultaneously handling high-level signals.
- **Higher probability of intercept:** The term POI comes from the field of signal surveillance and reflects the likelihood that a transient signal will be detected. The PXA and MXA advanced processing architecture combines with its 160-MHz analysis bandwidth and wide dynamic range to provide 100 percent POI for signals with durations as short as 3.57 μ s.

Defining Real-time Analysis

In a spectrum or signal analyzer with a digital intermediate frequency (IF) section, Real-time operation is a state in which all signal samples are processed for some sort of measurement result or triggering operation. In most cases the measurement results are scalar, power or magnitude, corresponding to traditional spectrum measurements.

In addition to the gap-free analysis, a real-time RF analyzer may be defined as having four more key attributes:

- high-speed measurement
- consistent measurement speed
- frequency mask triggering
- advanced composite displays

In general, the stream of spectra from real-time processing can be used in one of two ways; the spectra can be combined into a composite spectrum display or successively compared to a limit mask to implement frequency-mask triggering. Both of these capabilities are present in the RTSA option.

2 Theory

The following topics are in this chapter:

“Real-time Analysis” on page 10

“Block Diagram” on page 10

“Real-time Operation” on page 11

“Overlap Processing” on page 12

Real-time Analysis

In real-time analyzers, measurement operations process all incoming information. For RF signal analysis this is usually sampled IF data.

Modern real-time analyzers can maintain real-time analysis indefinitely, though this is achieved in part by performing only streamlined signal processing such as power spectrum or magnitude. Some applications require only a limited period of real-time operation and can benefit from time capture and post-processing where additional measurement flexibility and vector operations such as demodulation are important.

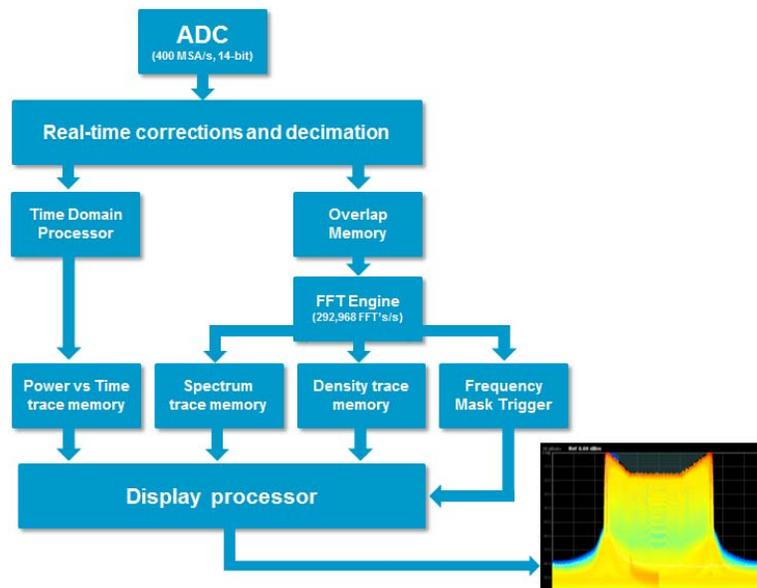
In the area of real-time, the required duration varies widely by application. The emphasis in some measurements is on long duration and live displays, while in others it is essential to avoid gaps and fully process every sample.

The processing power required for continuous real-time operation generally scales with the number of samples/second involved, and thus the analysis bandwidth. Therefore given a specific amount of processing power, there is a maximum bandwidth where the processing can keep up with the sampled data, and this is the analyzers real-time bandwidth (RTBW).

One often overlooked factor in real-time analysis is the resolution or bit depth of the samples and processing. For a given sample rate, for example, it will take significantly more processing power to handle 12-bit samples compared to that required for 8-bit samples.

Block Diagram

This is a simplified block diagram of the Real-time system implemented in the FPGA.



The ADC is running at 400 MSamples/s, 14 bit. Next is the real-time decimation and correction process. It is at this point that the paths are separated into the frequency and time domain. In the frequency domain the overlap memory is where the variable overlapping is handled before going into the FFT engine running at just under 293,000 FFTs/s. The memory is branched into different traces – Spectrum, Density and Power versus Time as well as the Frequency Mask Trigger, which monitors the real time stream of results and compares it to the mask that may have been set up.

These trace memories feed the information to the display processor to provide the required instrument display.

Windowing

Windowing functions are applied to the digital data before the FFT process. This reduces the effect of spectral leakage that could occur when using FFT analysis. The selected window function is dependent on the type of results needed from your measurement. The following filters are available for this function:

Gaussian

Flattop

Blackman-Harris

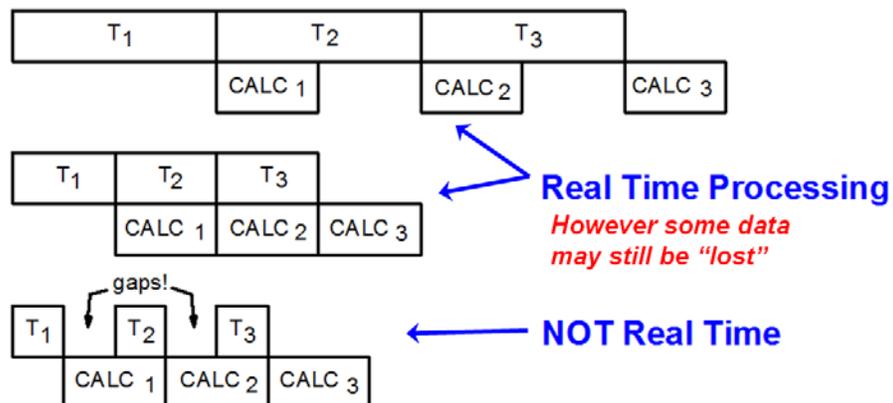
Rectangular

Hanning

Kaiser

Real-time Operation

Real-time operation occurs when the calculation speed is fast enough to ensure gap-free analysis of sampled data. In this case each CALC includes computation of an FFT or a power spectrum as well as averaging, display updates, and so on.



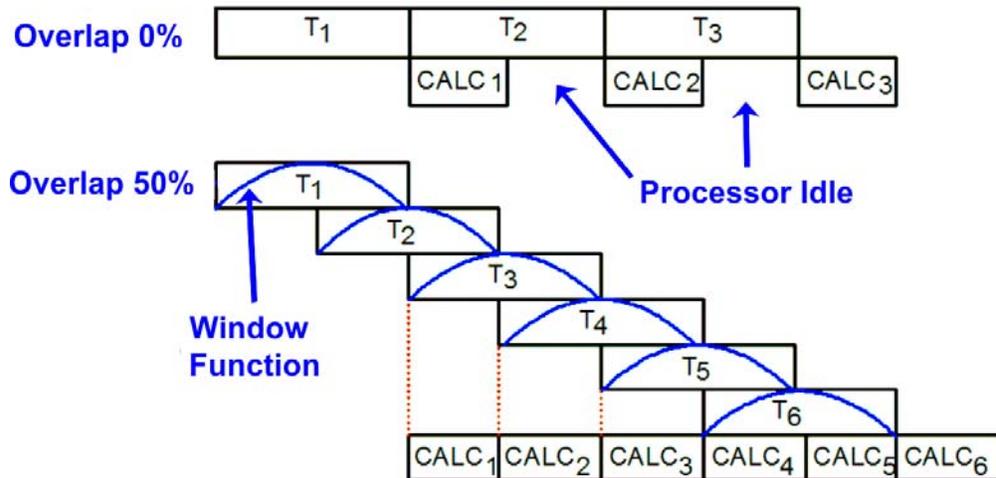
In this diagram T refers to the analyzer's time record for FFT processing. The analyzer collects a block of contiguous samples from the ADC that is digitizing the IF signal and then performs an FFT to obtain a power or vector spectrum. This sample block may vary in size or it may be fixed.

It is important to understand that the time length of the block T will be shorter when bandwidths are higher and sampling is faster.

The loss of data refers to the frequent case where the samples in a time record are "windowed" or attenuated at the beginning and end of the record, to avoid spectral leakage or to form the equivalent of different resolution bandwidth filters. This attenuation of data at the edges of the time record is often so significant that some samples are effectively lost. The solution to this problem is overlap processing.

Overlap Processing

Overlap processing provides significant benefits for signal analysis when processing is faster than sampling by performing additional FFTs with partially-new time records as samples come in.



In this diagram, 50% overlap is shown, where each new FFT is performed on 50% new samples and 50% from the most recent samples of the previously processed data. Potential overlap percentages vary continuously from 0% to 100% in increments of 1 sample. Actual overlap varies depending on the analyzer and software settings, and may or may not be set-able.

With significant overlap it is possible to configure analysis so that all samples are processed for some FFT result with no or minimal attenuation or de-emphasis due to windowing. Overlap can thus improve probability of intercept (POI) and accuracy.

3 Signal Detection and Analysis

A major benefit of real-time analyzers is the ability to find elusive signals and signal behavior quickly and reliably, whether the goal is to discover or characterize the signals, or to understand detail as an element of troubleshooting or optimization.

This chapter contains the following topics:

“Spectrum Measurements” on page 14

“Probability of Intercept (POI)” on page 22

“Power vs. Time Measurement” on page 27

“Saving Spectrogram Data” on page 39

“Display Views - Spectrum Measurement” on page 31

Spectrum Measurements

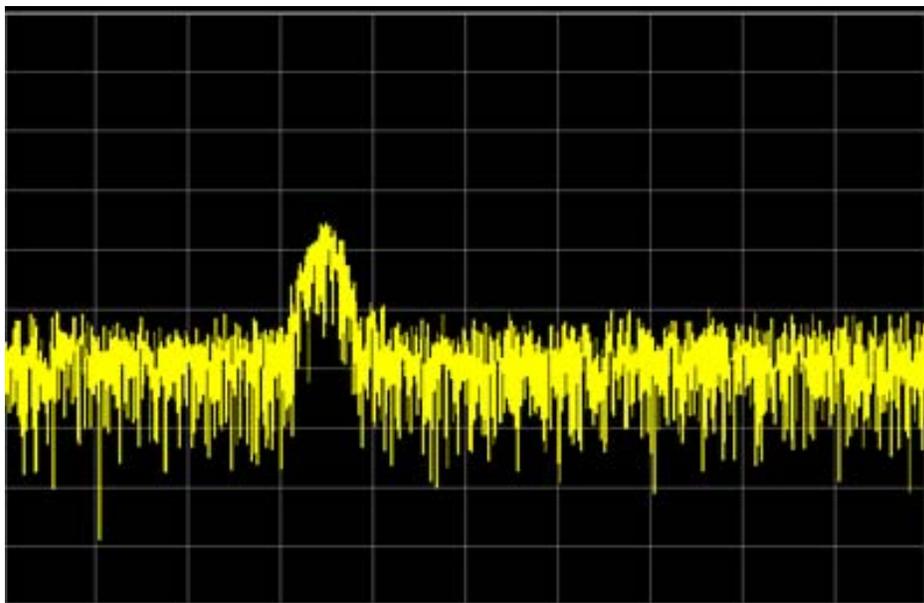
Swept spectrum vs. Real-time spectrum measurements

Real-time spectrum measurements offer an advantage over swept measurements because there is no loss of data. This is important when you are interested in finding elusive signals or small signals that are near the noise floor.

Swept analysis will find events that are stable in the frequency domain and display the amplitude, but no phase information is gathered. The following graphics are examples of swept spectrum analysis of a signal in the ISM 2.45 GHz band. This band is lightly regulated with WLAN the dominate occupant sharing with Bluetooth, cordless phones, microwave ovens and other devices.

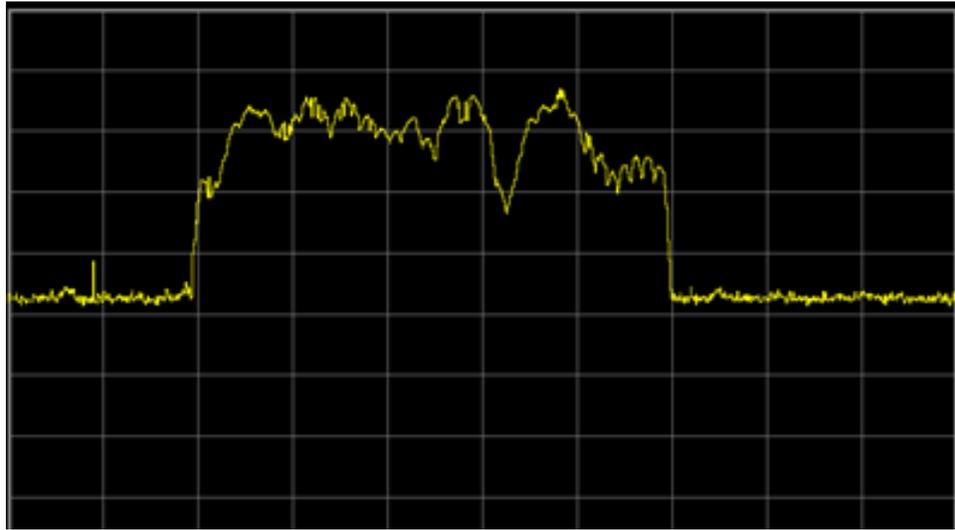
Depending on the degree of spectrum/time occupancy, a single sweep from a swept spectrum analyzer may show nothing or a portion of one or more signal bursts. It can be very difficult to interpret such a measurement.

Figure 3-1 Single Sweep



Peak hold is a useful tool for understanding some aspects of the signal environment and a long measurement with peak hold will eventually catch most of the signals in the band. However, long peak hold measurements often result in some signals in the band obscuring others. Swept spectrum analysis is not a very productive way to understand the activity in this band. Refer to the following graphic.

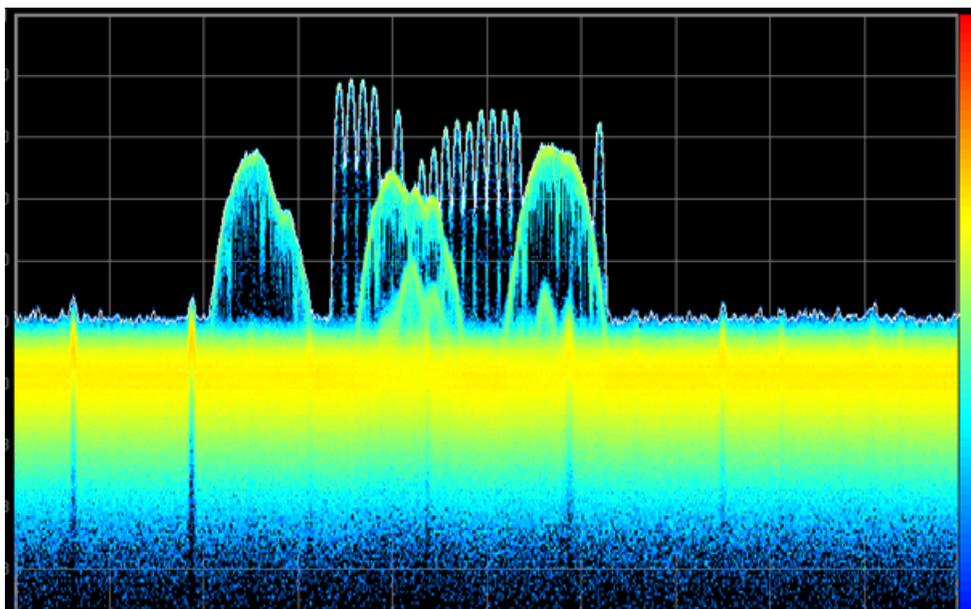
Figure 3-2 Peak Hold (long duration)



When the results are viewed in a “Density (Histogram) display, the real-time analyzer provides a good understanding of this frequency band and the signals in it. Since the measurements are gap free and all signal samples are represented in the display, it is possible to see most of the signals in the band at a glance or over a short measurement time. Individual display updates combine thousands of spectra and shows the signal dynamics and unexpected behavior.

Note that the action of combining 10,000 spectra into one display update can cause signals present at different times to be displayed on the same spectrum update. The signals that appear to be multi-tone in the following graphic are actually Bluetooth frequency hop patterns. The signal is never actually transmitted on multiple frequencies at once.

Figure 3-3 Real-time Density view



In the “**Spectrogram**” display, the same spectral data is shown with a time dimension added to the spectrum display.

Top view:

Individual lines of the bottom view are shown as amplitude vs. frequency.

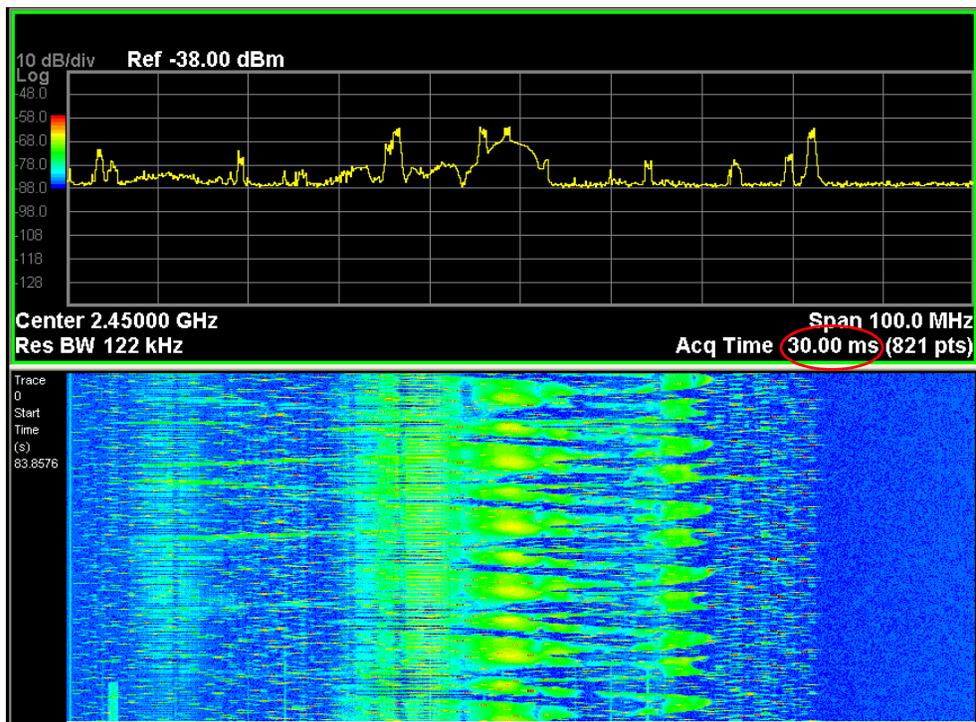
Bottom view:

The individual spectrum lines are real time, but in most cases are formed (as controlled by the analyzer’s detector setting) from a number of individual FFT calculations. In this configuration each line represents about 10,000 FFT spectrum calculations. Amplitude is represented by color, as visualized in the top view.

This combination of many spectra to form one spectrum update causes repeated Bluetooth hops over a limited channel pattern to form a set of vertical lines near the top of the spectrogram display.

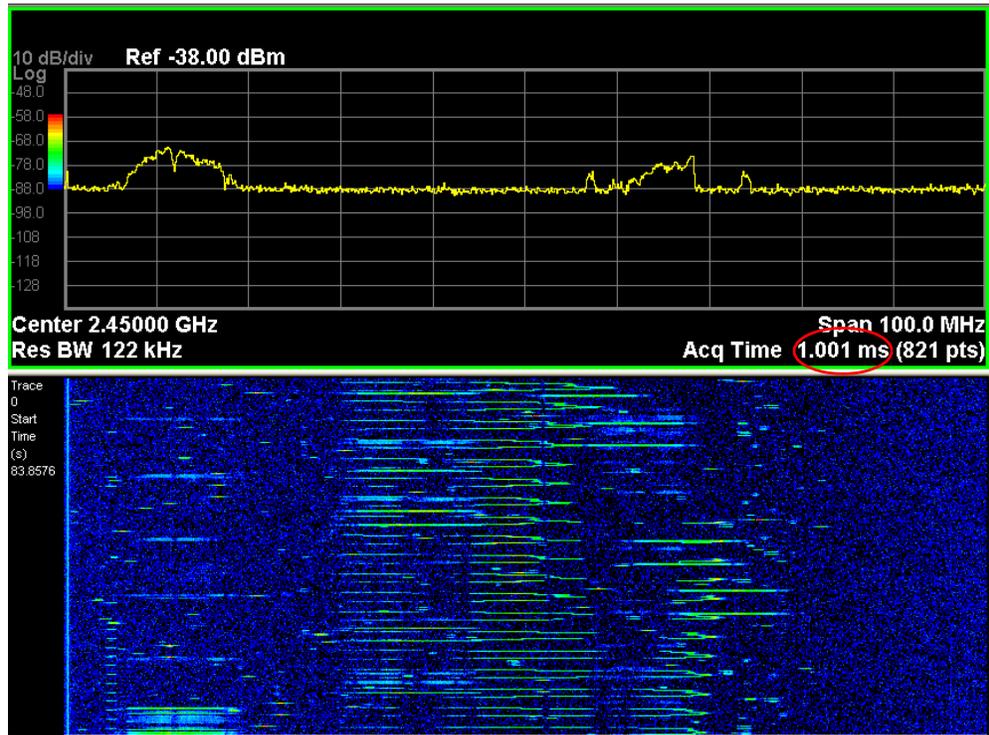
The time axis view of the spectrogram can reveal important aspects of signal behavior of the spectral environment. Note the group of bursts in the bottom half of the spectrogram, between the rightmost WLAN signals. Note also the diagonal bar in the spectrogram at the same point in time but moving from the leftmost WLAN signal across the center one. This appears to be from some sort of channel scanning and is occasionally visible in the density displays.

Figure 3-4 Real-time Spectrogram view: 30 ms frequency acquisition time



A short acquisition time has the opposite effect of the longer time of the previous example, and thus a single spectrogram display (or buffer) will represent a shorter time period, with finer time resolution.

Figure 3-5 Real-time Spectrogram view: 1 ms frequency acquisition time



The short acquisition time can have a large effect on the appearance and content of the spectrogram display or buffer. The buffer and display will cover a proportionally shorter span of time and may not show some longer-term phenomena, but the additional time resolution can reveal important spectral behavior that would otherwise be obscured.

Here the increased time resolution allows the individual WLAN bursts and Bluetooth hops to be much better resolved. It becomes clear that even the Bluetooth hops that overlap the WLAN bursts in frequency often do not overlap in time, and that collisions are not as frequent as the previous display would suggest.

Note, however, that each spectrum line in the spectrogram and in the trace above still represents hundreds of individual FFT results from the real-time measurement engine.

To summarize, when the signal or behavior in question is short in duration or infrequent in occurrence or is unexpected, the large amount of data processed and represented by a real-time analyzer can provide the best chance of detection.

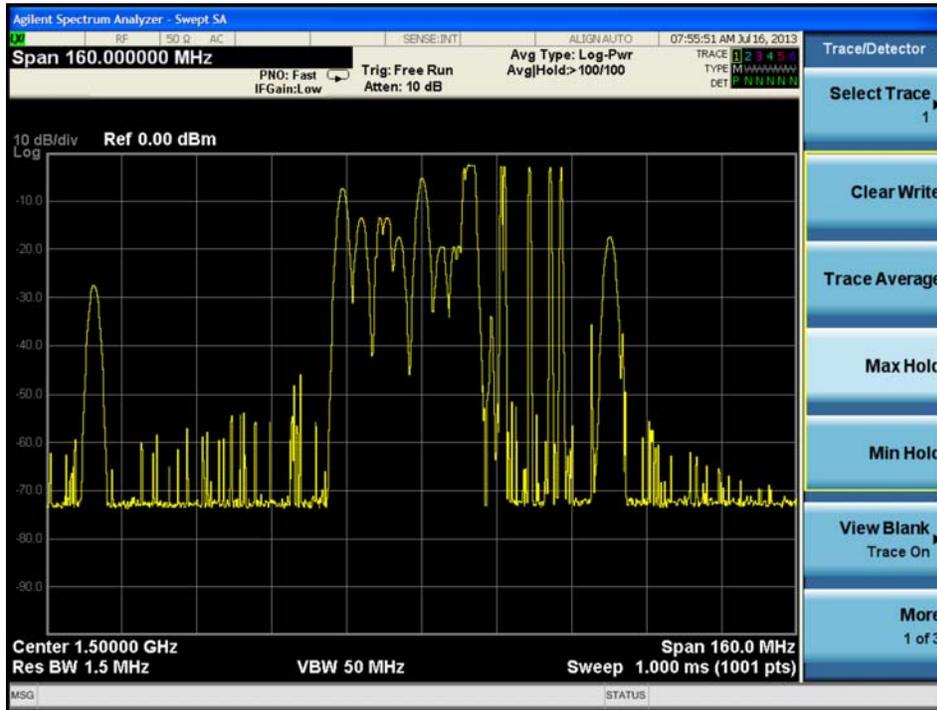
Finding Low Duty Cycle Signals

To demonstrate the following procedure, we are using a preconfigured signal containing eight CW and three W-CDMA 1DPCH elements.

Procedure

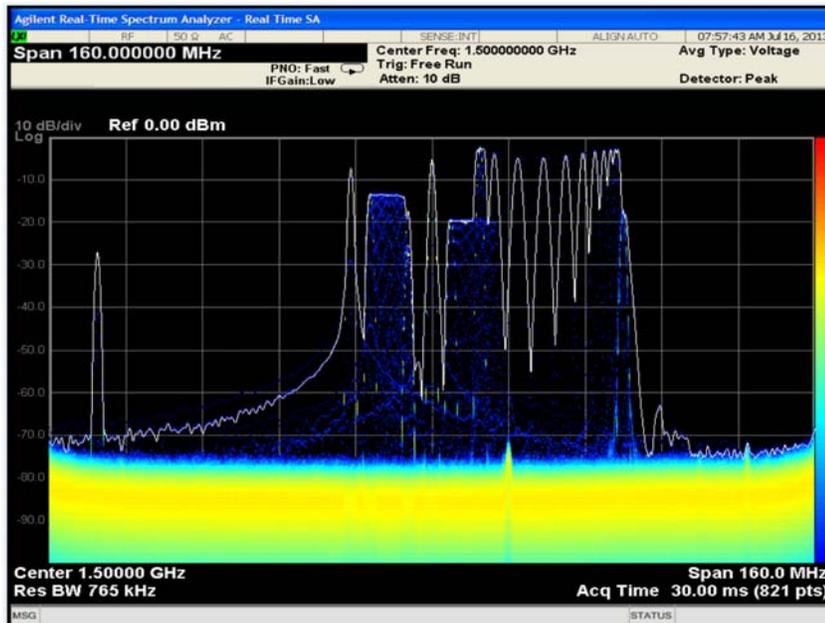
Step	Action	Notes
1 Configure the instruments		
2 Preset the MXG and PXA instruments	a. Press the Preset key.	
3 Configure the MXG	a. Press FREQ, 1.5, GHz , b. Press AMPTD, -10, dBm , c. RF to On.	
4 Configure the PXA	a. Press Mode Spectrum Analyzer . b. Press FREQ, 1.5, GHz . c. Press SPAN, 160, MHz .	
5 Start the list sweep on the MXG	a. Press Sweep, Sweep Type, List, More, Configure List Sweep and select the desired file . b. Press Sweep, Sweep, Frequency to On. Amplitude to On, Waveform to On.	
6 Adjust the PXA view	a. Press Trace detector, Max Hold .	This view takes more time, but will capture more signals.

Step	Action	Notes
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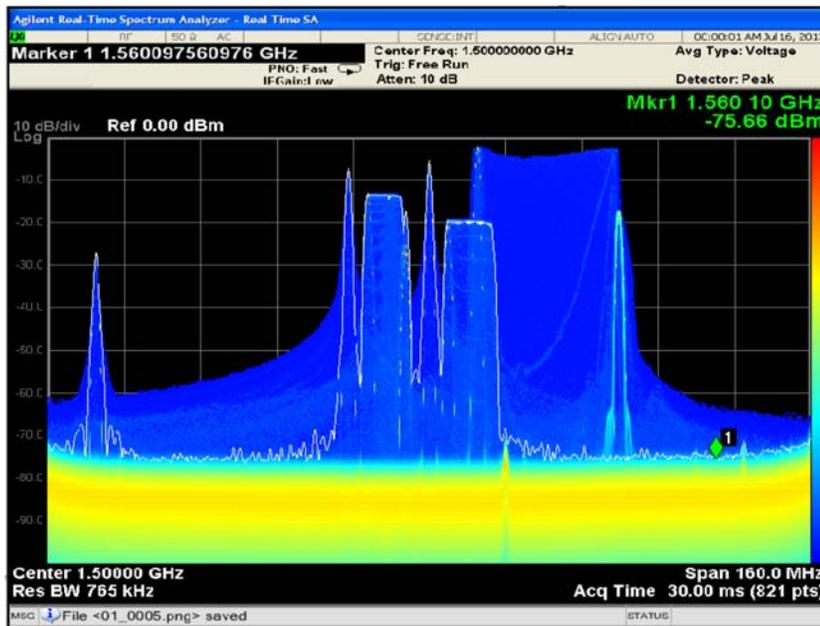
This shows a highly dynamic signal that is a challenge to view and measure. Note that in this view some signals are obscured by others.

- | | | |
|---|--------------------------------------|--|
| 7 | Change the PXA to the Real-time mode | <ol style="list-style-type: none"> Press Mode, Real-Time Spectrum Analysis, Mode Preset. Press FREQ, 1.5, GHz. Press SPAN, 160, MHz. |
|---|--------------------------------------|--|



Signal Detection and Analysis
Finding Low Duty Cycle Signals

Step	Action	Notes
8 Change the persistence setting	a. Press View/Display, Density, Persistence, 1.5, s.	Persistence is a trade-off between a fast-reacting display and extending time to see very rare events.
9 Add a marker	a. Press Marker and navigate to 1.566 GHz.	



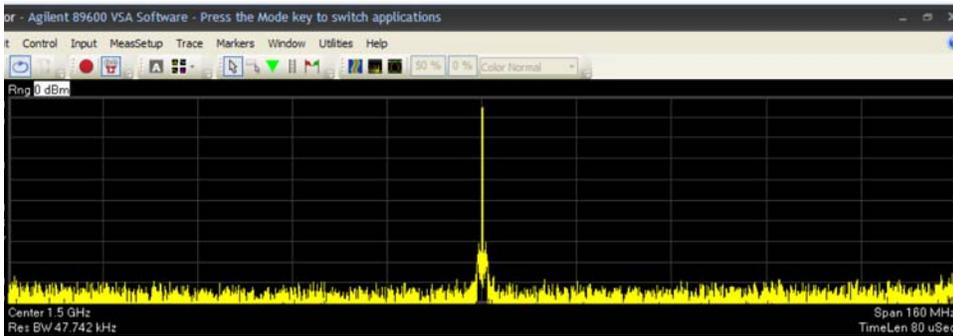
The high dynamic range enables you to see a -75 dBm signal. You can use the 89600 VSA time capture function to explore the list sweep sequence in detail.

10 (Optional) Open the VSA application	a. Press Mode, 89601 VSA, 89601B.	This may take some time to load the first time.
11 Preset the VSA	a. Select File, Preset, Setup.	
12 Configure the VSA	<ul style="list-style-type: none"> a. Select Meas Setup, Frequency and enter 1.5 in the Center input box. b. Select ResBW, and select 12801 from the Frequency Points drop-down list. c. Select Arbitrary from the ResBW Mode drop-down list. d. Select Time and enter 30% in the Max Overlap (Avg Off) input box. 	The Span input box should show 160 MHz.

Step

Action

Notes



The capture playback process is entirely gap-free and allows almost infinite settings of overlap. Playback will allow you to see and measure the list sweep sequence in any way desired.

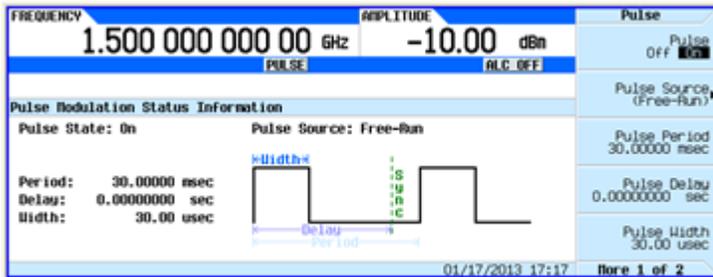
Probability of Intercept (POI)

A major benefit of real-time analyzers is the ability to find elusive signals and signal behavior quickly and reliably, whether the goal is to discover or characterize the signals, or to understand detail as an element of troubleshooting or optimization.

The following procedure shows that the Real-Time Spectrum Analyzer measurement application is capable of capturing a signal with a small pulse width, 3.57 μ s, with 100% amplitude accuracy..

Procedure

Step	Action	Notes
1	Preset the MXG	a. Press the Preset key
2	Set up a pulse on the MXG	a. Press FREQ, 1.5, GHz, AMPTD, -10, dBm, RF to On. b. Press Pulse, Pulse Period, 30, msec, Pulse Width, 30, μsec, Pulse to On. c. Press AMPTD, ALC to Off.

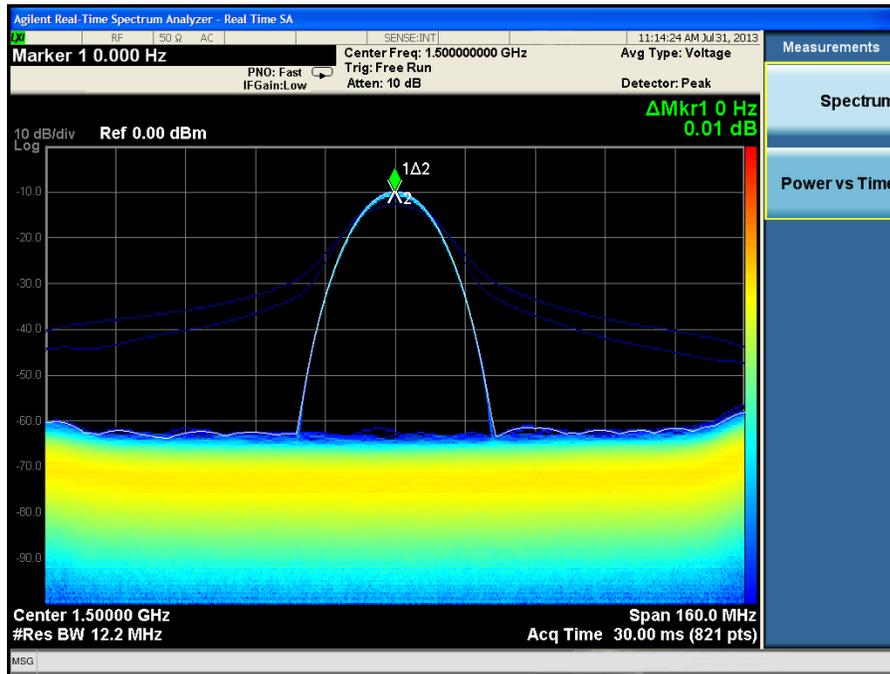


3 Configure the instruments

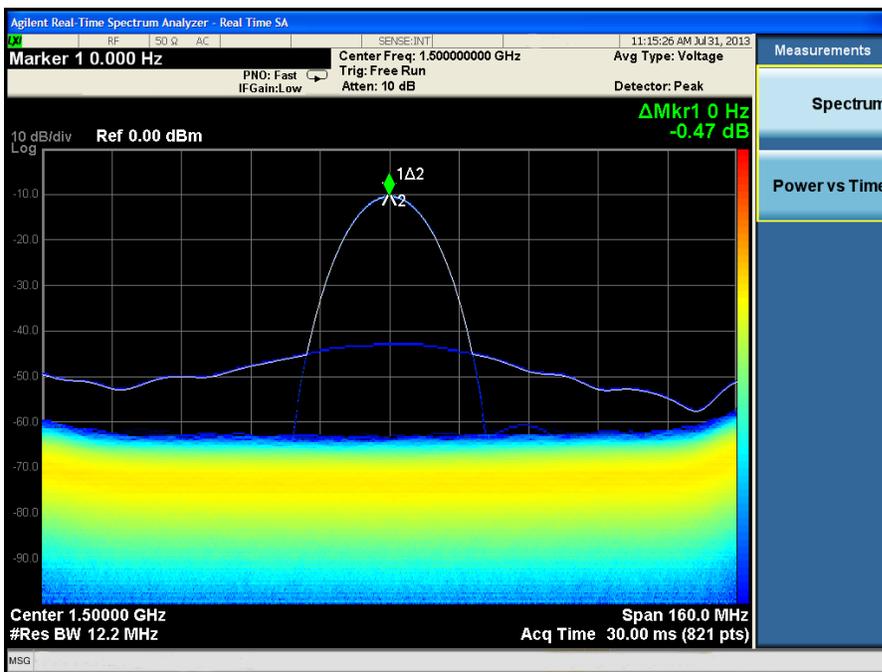


4	Select the Real-time mode on the PXA	a. Press Mode, Real-Time Spectrum Analysis, Mode Preset.	
5	Configure the PXA	a. Press FREQ, 1.5, GHz. b. Press SPAN, 160, MHz. c. Press BW, Res BW, Res BW6. d. Press Peak Search, Marker, Delta	
6	Select measurement	a. Press Meas, Spectrum.	This is the default measurement.

Step	Action	Notes
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7	Change the pulse width on the MXG	a. Press Pulse, Pulse Width, 3.57, μsec.
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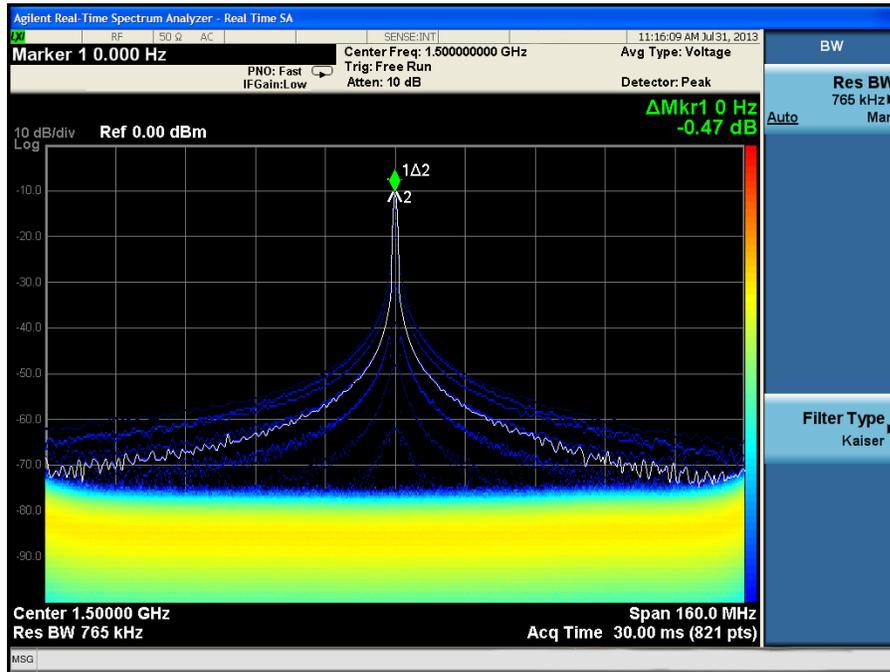


The Marker Delta remains around 0 dB on each acquisition.

8	Change the PXA bandwidth	a. Press BW, Res BW, Auto.
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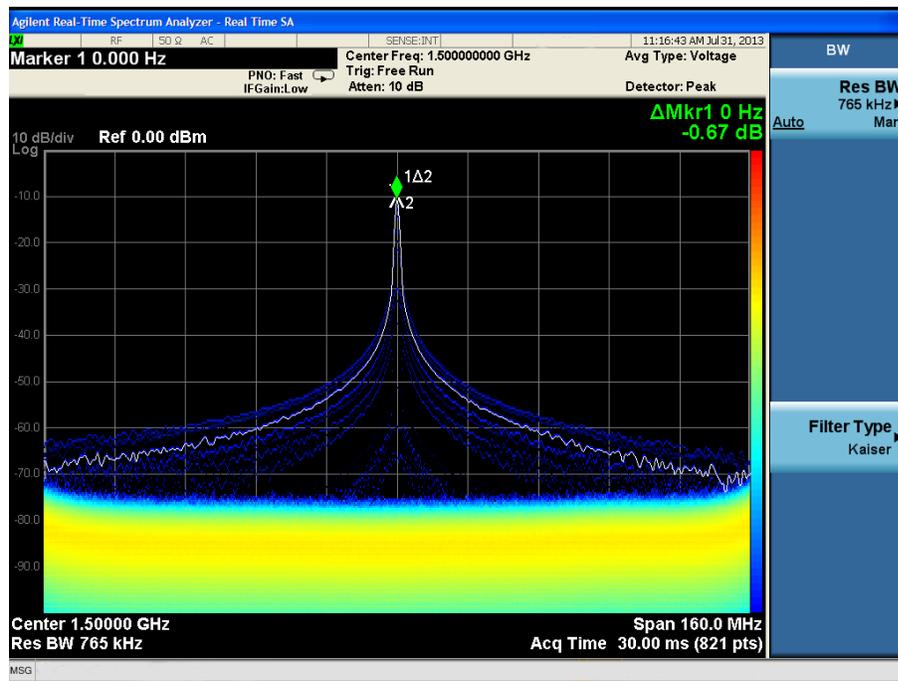
Signal Detection and Analysis
Probability of Intercept (POI)

Step	Action	Notes
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Changing to a narrower BW will still capture the pulse.

9	Change the pulse width on the MXG	a. Press Pulse, Pulse Width, 2, μsec.
---	-----------------------------------	---

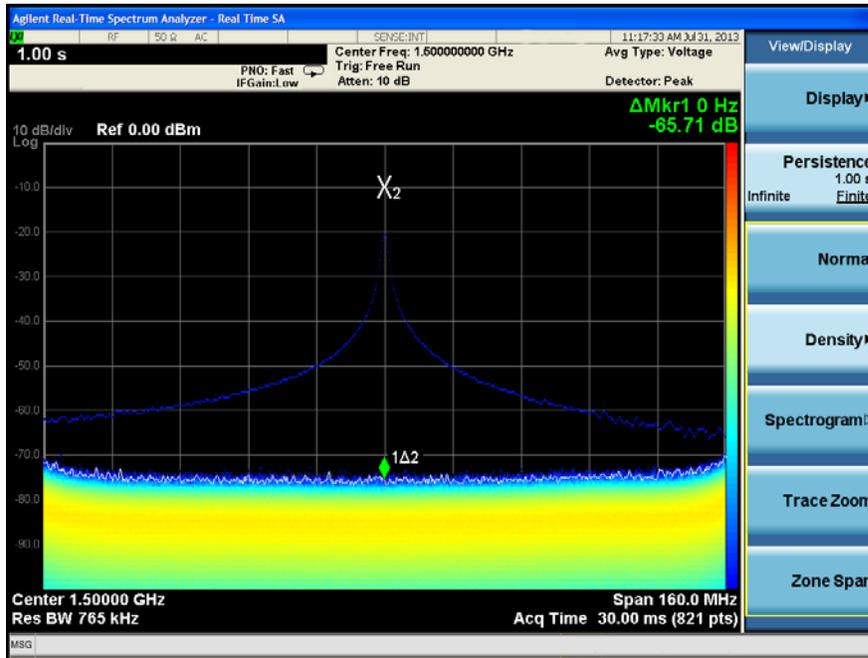


Changing to a narrower pulse width will still capture the pulse, but an incorrect amplitude is being reported.

10	Change the pulse period on the MXG	a. Press Pulse, Pulse Period, 1, sec.
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Step	Action	Notes
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11	Change the PXA view	a. Press View/Display, Persistence, 1, s.
----	---------------------	--



These changes still guarantee 100% POI

12	Change the pulse width on the MXG	a. Press Pulse, Pulse Width, 20, ns.
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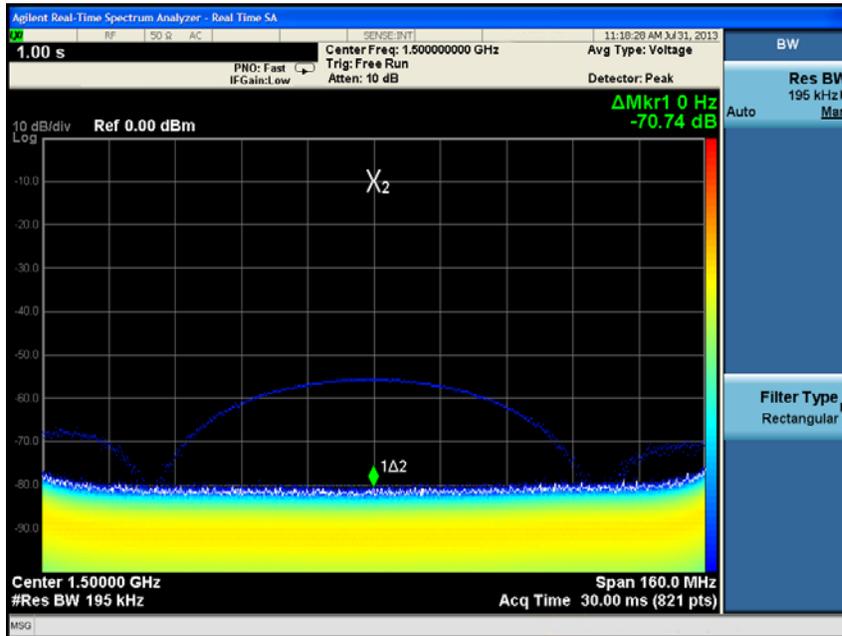
13	Change the PXA filter type	a. Press BW, Res BW, Res BW 1, Filter Type, Rectangular.
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Signal Detection and Analysis
Probability of Intercept (POI)

Step

Action

Notes



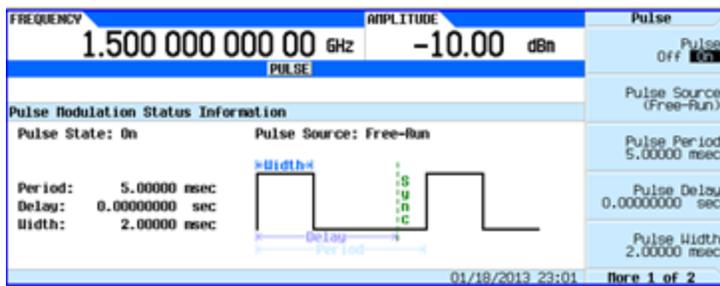
Even the narrow pulse is still captured. The Rectangular filter is used to stabilize the amplitude reading.

Power vs. Time Measurement

This section demonstrates how to set up and perform a power vs. time measurement using an MXG and a PXA with the Real-Time Spectrum Analyzer option.

Procedure

Step	Action	Notes	
1	Preset the MXG	a. Press the Preset key	
2	Set up a pulse on the MXG	a. Press FREQ, 1.5, GHz, AMPTD, -10, dBm, RF to On. b. Press Pulse, Pulse Period, 5, msec, Pulse Width, 2, msec, Pulse to On. c. Press AMPTD, ALC to Off.	These steps set up a 5 m second pulse period with a pulse width of 2 m seconds.



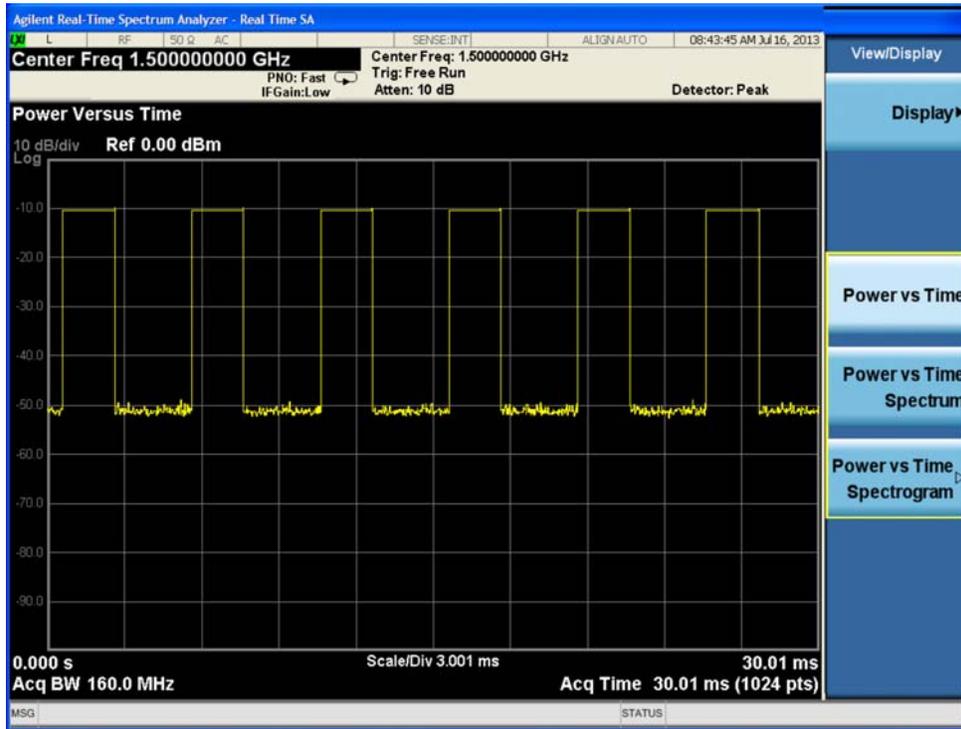
3 Configure the instruments



4	Select the PXA Real-time mode	a. Press Mode, Real-Time Spectrum Analysis, Mode Preset.	
5	Configure the PXA	a. Press FREQ, 1.5, GHz. b. Press SPAN, 160, MHz. c. Press BW, Res BW, Res BW Auto. d. Press Filter Type, Kaiser	
6	Select the measurement on the PXA	a. Press Meas, Power vs Time	This signal provides 6 stable pulses on the display without any triggering since the acquisition time of 30 ms is 6 times the pulse period of 5 ms and this is a real-time view of power versus time.

Signal Detection and Analysis
Power vs. Time Measurement

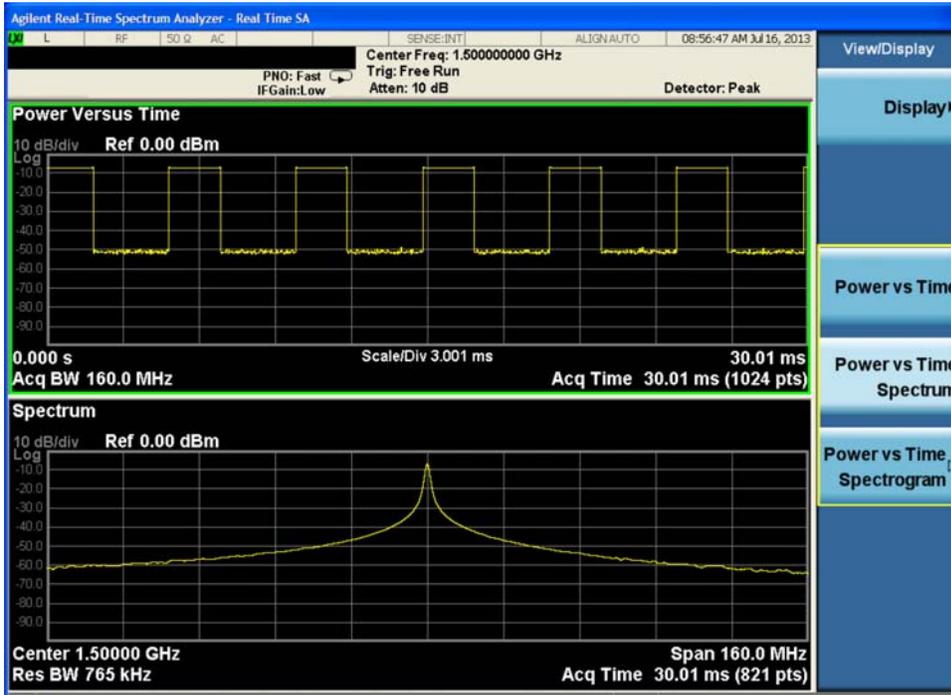
Step	Action	Notes
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This view shows the RF envelope power over a defined time period. The horizontal axis represents time and the vertical axis represents amplitude.

- | | |
|--|--|
| 7 Add AM and FM to the pulse signal on the MXG | <ul style="list-style-type: none"> a. Press AMPTD, ALC to On. b. Press FM, AM Source, Func Gen 1, FM Dev, 8, MHz, More, Setup FM Source, FM Rate, 0.3, Hz, Return, Return, FM Off On to On. c. Press AM, AM Source, Func Gen 2, AM Depth, 90, %, More, Setup AM Source, AM Rate, 0.4, Hz, Return, Return, AM Off On to On. |
| 8 Change to the spectrum view on the PXA | <ul style="list-style-type: none"> a. Press View/Display, Power vs Time Spectrum. |

Step	Action	Notes
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This view shows a combination of two different displays. The top window shows the Power vs. Time trace and the bottom window shows the Spectrum trace. In the bottom window, the horizontal axis represents frequency and the vertical axis represents amplitude.

- | | | |
|---|---------------------------------------|---|
| 9 | Change to spectrogram view on the PXA | a. Press View/Display, Power vs Time Spectrogram |
|---|---------------------------------------|---|

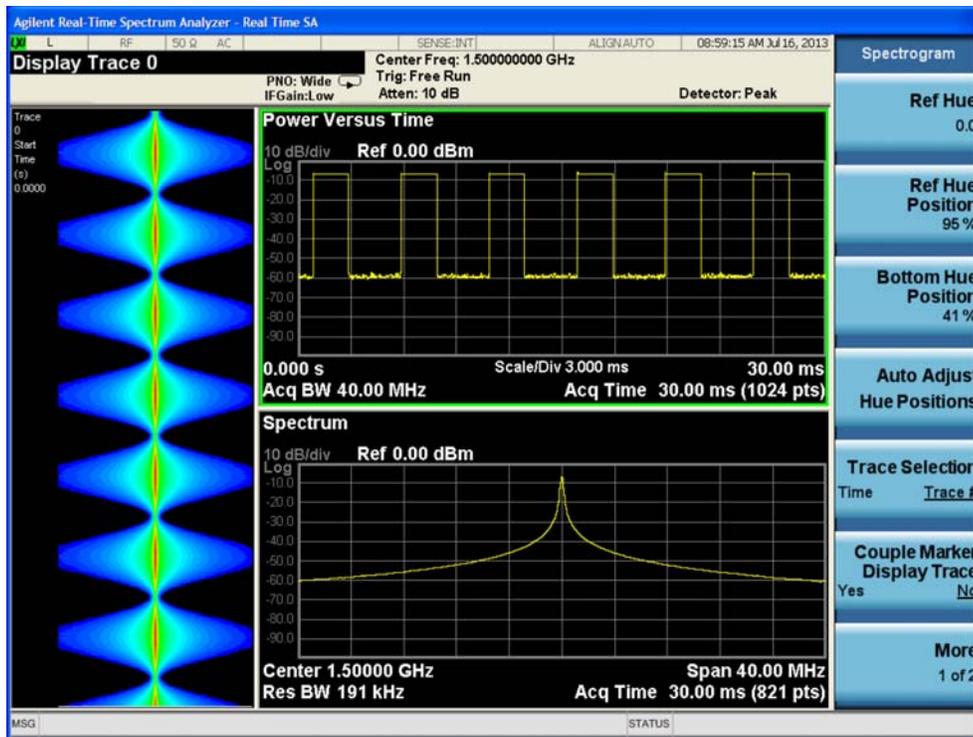


This view adds a Spectrogram trace to the left of the dual window. See "Spectrogram" on page 33 for more information.

Signal Detection and Analysis
Power vs. Time Measurement

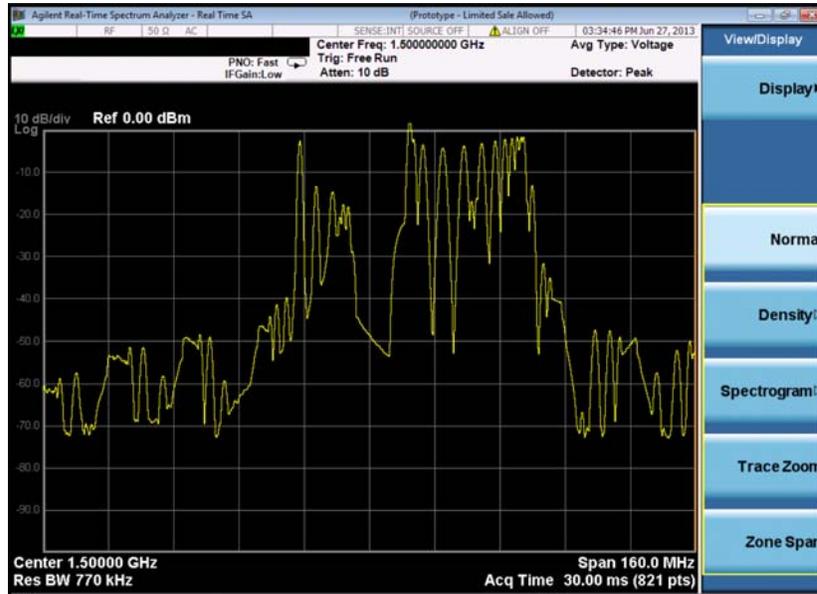
Step	Action	Notes	
10	Change the FM rate on the MXG	a. Press FM, More, Setup FM Source, FM Rate, 1, Hz.	
11	Change the span and spectrogram view on the PXA	a. Press Span, 40, MHz. b. Press View/Display, Power vs Time Spectrogram, Auto Adjust Hue Positions.	This sets the Ref Hue Position to the highest amplitude value found in the Spectrogram and sets the Bottom Hue Position to the lowest amplitude value found in the Spectrogram to enable you to focus on the signal of interest. See “Spectrogram” on page 33 for more information.

TIP



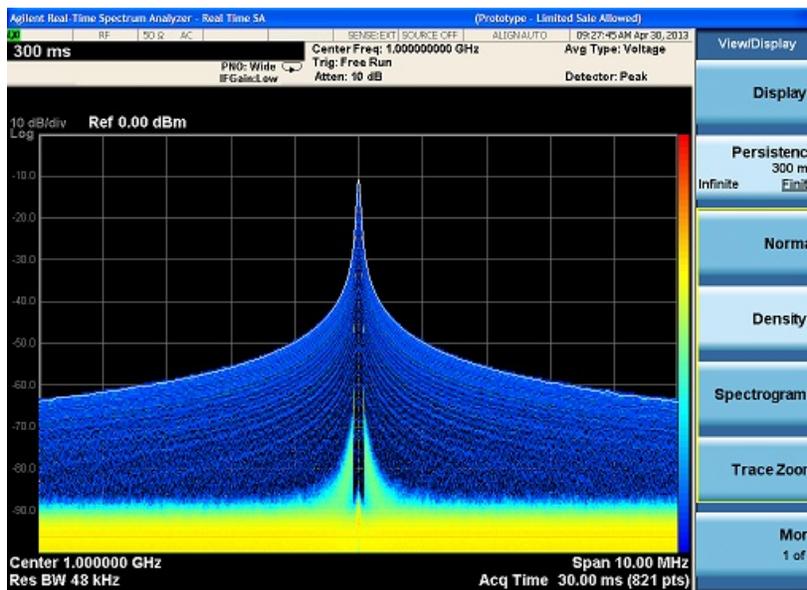
Display Views - Spectrum Measurement

Normal



The Normal view is a single window showing Real Time, Gap Free Frequency vs. Amplitude, with frequency on the X-axis and amplitude on the Y-axis.

Density



The Density view uses a bitmap to represent the signal density at each frequency and amplitude point determined by the current analyzer settings. The density is defined as the number of times a frequency and amplitude point is hit during a capture interval, which is the time a signal spends at each frequency and amplitude point in a given time period.

Signal Detection and Analysis

Display Views - Spectrum Measurement

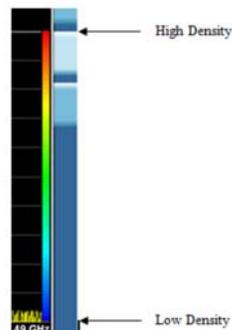
In this view, the X axis represents frequency, the Y axis represents amplitude and the Z axis represents number of hits. This view therefore displays three dimensional data on a two dimensional display, using color to represent the third dimension.

The view will also display a white trace over the bitmap. This trace shows the real time spectrum for the latest capture interval. The white trace is Trace 1 with detectors Peak, Negative Peak and Average derived from the density values and Sample being the last FFT that was used by the density bitmap.

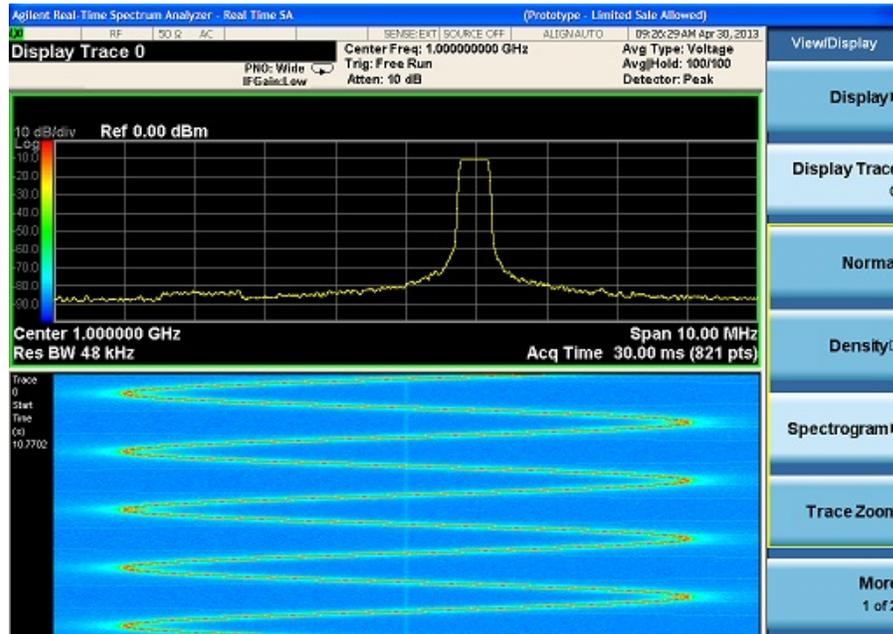
The bitmap is made up of cell values that are floating point numbers from 0 to 1, with 0 being no signal present and 1 indicating constant signal presence. For example, 0.5 indicates a signal was at the given frequency and amplitude point exactly half of the time.

The key to these colors is displayed as a color bar on the right side of the graphical display, as opposed to the left side of the display where Spectrogram shows the color bar. This is to avoid confusion that the color bar represents amplitude, as it does in the other views.

In Density view, high density is represented by the color at the top of the color bar and low density by the color at the bottom of the color bar.



Spectrogram



The Spectrogram View allows you to view a history of 10,000 traces, with up to 633 traces being displayed at any one time. In the Spectrogram View, each horizontal line in the spectrogram display represents one historical trace, which is the summary of an accumulation over an acquisition time interval. The data streams upwards from newest to oldest; the latest trace displays on the bottom and the oldest trace on the top.

Note that whenever you save state while in Spectrogram, and then recall the state, Spectrogram comes back with all the settings just as they were when you saved the state, but not including the Spectrogram data itself. If you want to save the Spectrogram data, you can Export it using Meas Results, and import it into a PC, although you cannot load it back into the analyzer.

In the Spectrogram View, the spectrogram window allows you to view a history of the last 10,000 traces. If the Spectrogram view is active at the same time as Normal View in a multi window layout, the two views will be coupled together. The Normal window shows the trace indicated by the Display Trace parameter in the View/Display menu. The Display Trace key determines which of the traces in the Spectrogram window is currently being viewed in the Normal window. A white line across the Spectrogram window shows the current position of the Display Trace. Display Trace can be selected as a Trace Number or Time. We will use Trace Number to describe the functionality in this section. On entry to the Spectrogram view, Display Trace has a value of 1, which means it is set to the latest trace to be acquired.

Every time an acquisition completes, the latest trace is displayed at the bottom of the Spectrogram and the historical traces are moved up one position. If active, the data displayed in the Normal window is the extracted trace from the Spectrogram data determined by the Display Trace value. Once the trace data has been written into the Spectrogram, it cannot be modified.

The Spectrogram can hold 10,000 traces. When the Spectrogram occupies a full vertical size Window, 633 traces can be displayed in the trace window at any one time. The Display Trace will be used to determine which traces are to be displayed. Navigating through the Spectrogram will be the same as navigating through any window, with the Display Trace being the equivalent of the cursor and the scroll bar used to indicate and control where in the 10,000 trace range is currently being displayed.

When you select a Display Trace that causes scrolling down through the Spectrogram traces, i.e. a Display Trace value less than the current Display Trace value, the lower value of the Spectrogram window will be the new Display Trace value. When you request a Display Trace that causes scrolling up, i.e. a Display Trace value greater than the current Display Trace value, the upper value of the Spectrogram window will be the new Display Trace value.

For example, if you have Display Trace set to 100, the lower value of the Spectrogram window will be 1 and the upper value 633. If you then set the Display Trace to 1000, this is scrolling up therefore the upper value of the Spectrogram window will be 1000 and the lower value 368. If you then set the Display Trace to 200 this is scrolling down, therefore the lower value of the Spectrogram window will be 200 and the upper value 32.

If the Spectrogram display window has not yet filled with 633 traces, the oldest trace is the highest numbered trace that has data in it. The value of Display Trace is annunciated in the upper left corner of the bottom window, along with the start time of that trace.

If you select a historical trace that has not yet been acquired, both the trace window and spectrogram window will remain blank until such time as the trace you requested is available. The Spectrogram window will then be populated one trace at a time as the subsequent traces are acquired, with the trace window showing the trace corresponding to the Display Trace value you requested. If you select a historical trace that is has been acquired, the Spectrogram window will be populated with the available historical traces and the trace window will show the trace corresponding to the Display Trace value you requested.

Any variable change that restarts an acquisition will clear out the spectrogram and start it over, unless you are in the idle state (single mode or waiting for a trigger), in which case it will be cleared out when you start an acquisition again. The Restart key will clear out all spectrogram traces and start over. The spectrogram display is also cleared on exit from the Spectrogram View, so every time you enter the Spectrogram View, the spectrogram window is empty.

You can Pause and Resume the spectrogram at any time. Pausing the spectrogram will cause the accumulation of traces to stop and allow adjustment of the Display Trace parameter to view any historical traces. On resume, the existing historical trace data will not be cleared, and subsequent captures will be added to the historical data. Although this will result in a gap in the spectrogram data, the data captured will still be done so in real time. The time stamp of each trace will identify that the spectrogram data is not gap free after a pause and resume.

The colors in the Spectrogram represent signal amplitude. The key to these colors is displayed next to the Y Axis in the upper window. By changing the Y Axis parameters you can change the scaling; that is, by changing the Ref Level or Scale/Div, the colors will get remapped to new Amplitude values. Note that this will, however, restart the Spectrogram.

Each horizontal line in the spectrogram represents a single trace, and the vertical axis represents time. For all values of Display Trace, the trace in the trace window will be updated on completion of an acquisition. To freeze the spectrogram, put Trace into View, or put the analyzer into Single mode (note that unless the Average/Hold Number=1, putting the analyzer into Single will not freeze the Spectrogram until the number of traces specified by the Average/Hold Number have been taken).

While in Spectrogram View, all functions and settings work as normal, except as noted below.

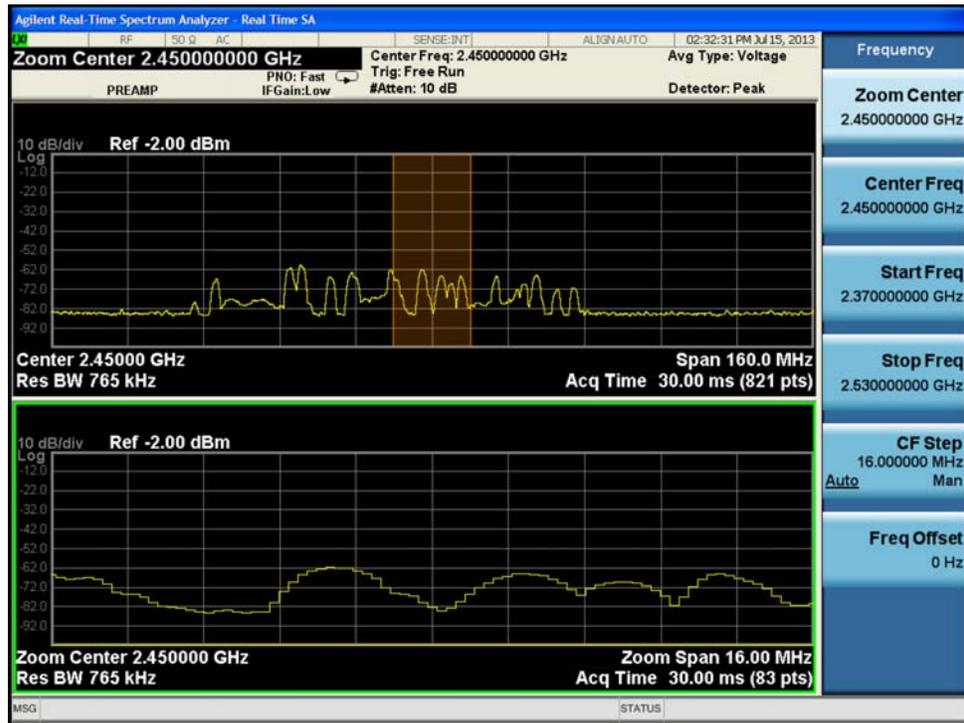
- The Single key causes a specified number of traces to be read into the spectrogram, after which the acquisition stops. The number of traces to be read into the spectrogram is controlled with the "Average/Hold Number" key in the Meas Setup menu. For example, if you set the "Average/Hold Number" to 5, then every time you press Single, it will take 5 acquisitions and put the 5 traces into the Spectrogram; then it will stop the acquisition. Note that you can set the "Average/Hold Number" to 1 to capture a single trace into the Spectrogram when the Single key is pressed.
- In the Spectrogram View, if the Trace is saved, exported or queried, the data that gets saved or returned is the data from the Display Trace in the spectrogram.
- Selecting or moving a marker that is turned on but not on the current Display Trace will NOT move the marker to the current Display Trace. A marker must remain on the trace that originally added it.
- Turning on a marker which is turned off will turn it on in the center of the current Display Trace.
- When a Peak Search is performed, if the selected marker is turned on but is not on the current Display Trace, it is first moved to the center of the current Display Trace before performing the search.

Representation of Time

In the Spectrogram view, zero time is the point where the first trace started, meaning that each subsequent trace point is at a positive time that represents when that point was gathered, relative to the start point. Each trace is time stamped as it starts, and this time is remembered for each trace. As successive traces appear their start times get successively larger, relative to the start time of the oldest trace. If a marker is placed on the live trace and its readout is set to Time, the time of this marker will increment by about the acquisition time for every new acquisition. If the measurement is paused, the Spectrogram will stop updating. When resume is selected the spectrogram will retain the existing traces and continue updating using

traces from the point at which Resume was selected. The time stamp of the individual Spectrogram traces will show the time from the beginning of the measurement the trace relates therefore showing there was a gap in the Spectrogram capture.

Trace Zoom



In the Trace Zoom view, the screen is split into two windows. The top window is a normal spectrum analyzer window, and the bottom window ("Zoom Window") shows a "zoomed" representation of the traces in the top window. The data in both windows is identical, but the bottom window typically shows fewer data points, spread across the whole display, which allows you to see the data in those points more clearly.

The zoom region is indicated by a blue shading over the whole region. In the top window, this indicates which subset of the data is zoomed in the bottom window. The entire Zoom Window is shaded, to indicate that it represents the zoom region. You can set the span of the Zoom Window using the Zoom Span key (in the Span menu) and you can set the Center Frequency of the Zoom Window using the Zoom Center key (in the Frequency menu).

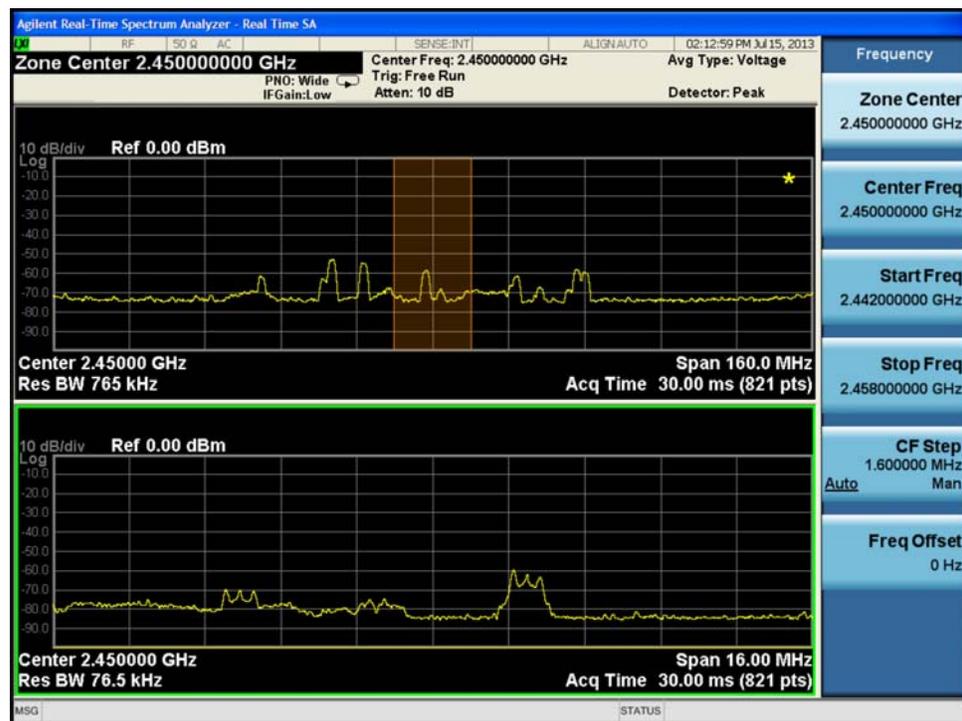
It is important to emphasize that the data and state in the two windows is IDENTICAL. The Zoom Window is simply a close-up view of a region of the top windows' traces. Therefore all traces and markers are the same in both windows; and any state changes you make affect both windows.

You set the number of sweep points shown in the Zoom Window separately from the top window. Changing the number of points in the bottom window WILL change the Zoom Span and does NOT change the number of points in the top window, because the more points you show in the bottom window, the greater is the percentage of the top window that you are showing in the bottom.

Two functions in Trace Zoom depend on which window is selected (the selected window has a thick green border around it). When the Zoom Window (bottom window) is selected, the Points key in the Sweep/Control menu changes to Zoom Points and adjusts the number of points in the bottom window. Also, for all Peak Search functions, if the bottom window is selected the search function will operate ONLY within that window. This allows you to perform a Peak Search over a specified, limited frequency range, while still viewing the larger frequency range in the top window.

NOTE If you have just switched to the Zoom Window via SCPI (using the :DISP:WIND function) you should wait at least one second before performing a Peak Search, to ensure that SCPI will direct the Peak Search command to the correct window.

Zone Span



In the Zone Span view, the screen is split into two windows. The top window is a normal spectrum analyzer window, and the bottom window ("Zone Window") shows a window whose span represents a region (zone) within the top window. The data in

the two windows represents two completely separate acquisitions. Each window acquires ONLY when the focus (thick green border) is on that window. It is important to understand that the data in the window without the focus remains unchanged until the focus is moved to that window.

In the top window, the zone region is indicated by a light orange shading and solid orange boundary lines. The Zone Window is not shaded orange; this emphasizes the fact that, unlike Trace Zoom, the data in the Zone Window does not match the top window but is from a separate acquisition. You can set the span of the Zone Window using the Zone Span key (in the Span menu) and you can set the Center Frequency of the Zoom Window using the Zone Center key (in the Frequency menu).

Note that in Zone Span, the Span of the top window cannot go below 100 Hz.

Saving Spectrogram Data

You can save the results of up to 10,000 successive, gap-free sweeps in Spectrogram mode. Each sweep contains 821 points of amplitude results representing all the data measured during the interval defined by the Acquisition setting. The spectrogram engine continues collecting new data while saving the data and if the save time is less than the collection time to fill all traces, then it is possible to continually save files with no loss of data.

For example, if you set an acquisition time to 100 ms, it takes about >16 minutes to fill the 10,000 traces. Saving all 10,000 traces to the internal drive on a PXA or MXA with Windows 7 takes about 12 seconds. While saving the file, the spectrogram continues running, with no loss of acquisitions every 100 ms.

To save a the Real-time Spectrum Analyzer Spectrogram results data in .csv format:

Step	Notes
1. Press Save, Data, Meas Results, Spectrogram	
2. Press Save As, Enter	The Save As dialog box enables you to name the files and select where you want to save the data.
3. Press Save	To save subsequent files, press Quick Save and the files will be saved with the same name but with sequential numbering.

In the saved data file, each individual line, beginning with Data1 represents one slice of the spectrogram. Data1 represents the most recent acquisition and the last Data(N), represents the oldest, or first trace record in the file.

The second column in the trace data is a time stamp and each individual row represents all the data captured during that particular time interval. All 821 frequency points are listed (the data goes all the way to column "AEQ" in the Excel spreadsheet). Refer to the following example graphic.

Saving Density Data

The Density result file has the same data as the other Meas Results files with the additional data: #FFT's, Sample Rate and Acquisition Time.

The format of the data listed under DATA, is a series of frequency and amplitude points with the value at each point representing the density percentage, in the range 0-1. Therefore, a frequency and amplitude point that is hit 50% of the time during an acquisition will be represented by 0.5. The location of the frequency and amplitude point within the bitmap will correspond to the row and column point in the .csv file.

To save a the Real-time Spectrum Analyzer Density results data in .csv format:

Step	Notes
1. Press Save, Data, Meas Results, Density	
2. Press Save As, Enter	The Save As dialog box enables you to name the files and select where you want to save the data.
3. Press Save	To save subsequent files, press Quick Save and the files will be saved with the same name but with sequential numbering.

In the saved data file, the header data is listed first. The format of the data will be a series of frequency and amplitude points with the value at each point representing the density percentage, in the range 0-1. Therefore, a frequency/amplitude point that is hit 50% of the time during an acquisition will be represented by 0.5. The location of the frequency/amplitude point within the bitmap will correspond to the row/column point in the .csv file. Refer to the following example graphic.

Signal Detection and Analysis
 Saving Density Data

	A	B	C	D	E	
1	Trace					
2	Real Time SA					
3	A.13.00_R1005	N9030A				
4	503 508 513 526 ALV B1)	1				
5	Scale Per Div	10				
6	Segment	0				
7	Result Type	Density				
8	Measurement Type	Spectrum				
9	Number of Points	821				
10	Pvt Number of Points	1024				
11	Acquisition Time	0.030000775				
12	Start Frequency	2370000000				
13	Stop Frequency	2530000000				
14	Average Count	0				
15	Average Type	Voltage				
16	RBW	765417.2251				
17	RBW Filter	Gaussian				
18	RBW Filter BW	3dB				
19	Trigger Source	Free				
20	Trigger Level	1.2				
21	Trigger Slope	Positive				
22	Trigger Delay	0				
23	PreAmp State	Off				
24	PreAmp Band	Low				
25	Phase Noise Optimizat	Fast				
26	If Gain	Low				
27	RF Coupling	AC				
28	Ext Ref	10000000				
29	Input	RF				
30	RF Calibrator	Off				
...						
44	Trace Math Offset	0				
45	DATA					
46	Freq/Ampl	2370000000 Hz	2370195121.95122 Hz	2370390243.90244 Hz	2370585365.85366 Hz	2370780
47	-110 dBm	0.000538963	0.000808444	0.000943184	0.001212666	
48	-109.5556 dBm	0.000853357	0.000449135	0.000808444	0.000943184	
49	-109.1111 dBm	0.001077925	0.001122838	0.001302493	0.001077925	
50	-108.6667 dBm	0.001077925	0.000898271	0.001077925	0.001033011	
51	-108.2222 dBm	0.00139232	0.001302493	0.000898271	0.001661801	
52	-107.7778 dBm	0.001212666	0.001616888	0.001706715	0.001482147	
53	-107.3333 dBm	0.001302493	0.00152706	0.001482147	0.001437233	
54	-106.8889 dBm	0.001437233	0.001661801	0.002245677	0.001796542	
55	-106.4444 dBm	0.001751094	0.001500938	0.001751094	0.001626016	
56	-106 dBm	0.002084636	0.002251407	0.002042944	0.002459871	
57	-105.5556 dBm	0.002501563	0.0022931	0.002918491	0.002793413	
58	-105.1111 dBm	0.001751094	0.001876173	0.002168022	0.002459871	
59	-104.6667 dBm	0.001959558	0.002584949	0.002126329	0.002543256	
60	-104.2222 dBm	0.002835105	0.003293725	0.003627267	0.003877423	
61	-103.7778 dBm	0.002793413	0.002835105	0.002710027	0.003752345	

4 Frequency Mask Triggers (FMT)

FMT Technology When looking for a specific signal, a powerful approach is to compare the fast stream of spectrum data to a user-defined spectrum mask and then generate a trigger when the mask is exceeded.

[“FMT Set Up” on page 46](#)

[“FMT Setup Details” on page 50](#)

[“Trigger Setup Details” on page 54](#)

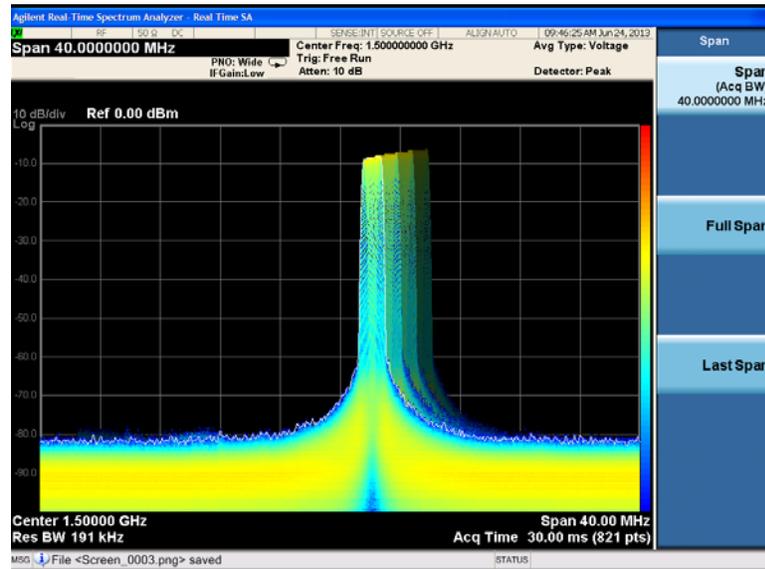
FMT Set Up

The masks can be a combination of upper and lower limits, and can be entered numerically or graphically. One convenient approach is to let the analyzer use the measured signal environment to automatically generate a mask and then modify the mask as needed.

The following procedure uses an Keysight MXG and PXA to demonstrate how to create and use a frequency mask feature.

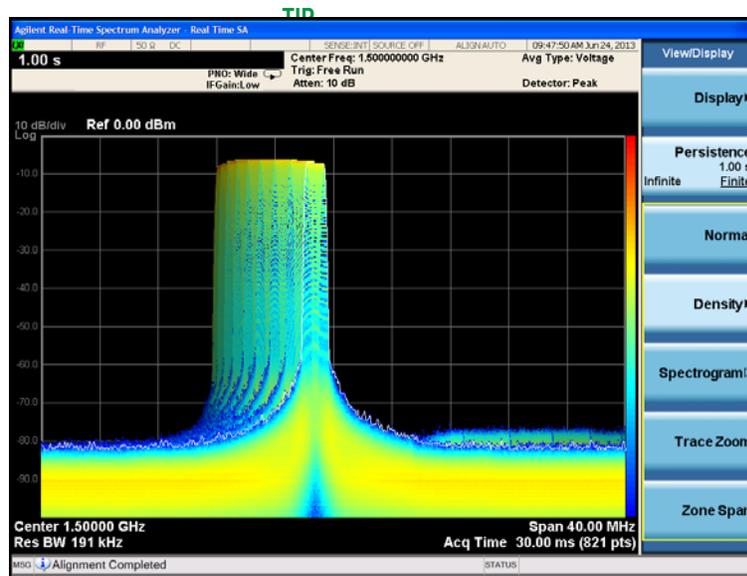
Step	Action	Notes
1 Set up the MXG	<ol style="list-style-type: none">Press Preset, FREQ, 1.5, GHz, AMPD, -10, dBm, RF On Off to On.Press FM, FM Source, Func Gen 1, FM Dev, 8, MHz, More, Setup FM Source, FM Rate, 0.3, Hz, Return, Return, FM Off On to On.Press AM, AM Source, Func Gen 2, AM Depth, 90, %, More, Setup AM Source, AM Rate, 0.4, Hz, Return, Return, AM Off On to On.	
2 Configure the instruments		
3 Set up the PXA	<ol style="list-style-type: none">Press Mode, Real-Time Spectrum Analyzer.Press FREQ, 1.5, GHz, SPAN, 40, MHz.	

Step	Action	Notes
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The signal can vary relatively slowly in both frequency and amplitude.

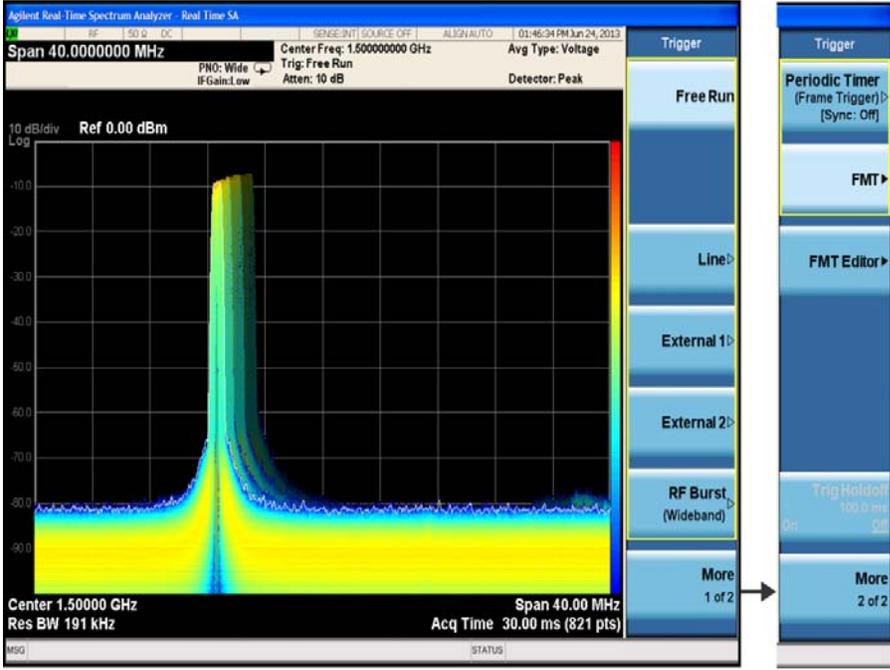
- | | | |
|---|---------------------|---|
| 4 | Set the Persistence | <ul style="list-style-type: none"> a. Press View/Display. b. Press Persistence, 1, s. |
|---|---------------------|---|



- | | | |
|---|--|---------------------------------|
| 5 | Access a frequency mask trigger using front-panel keys | a. Press Trigger, More . |
|---|--|---------------------------------|

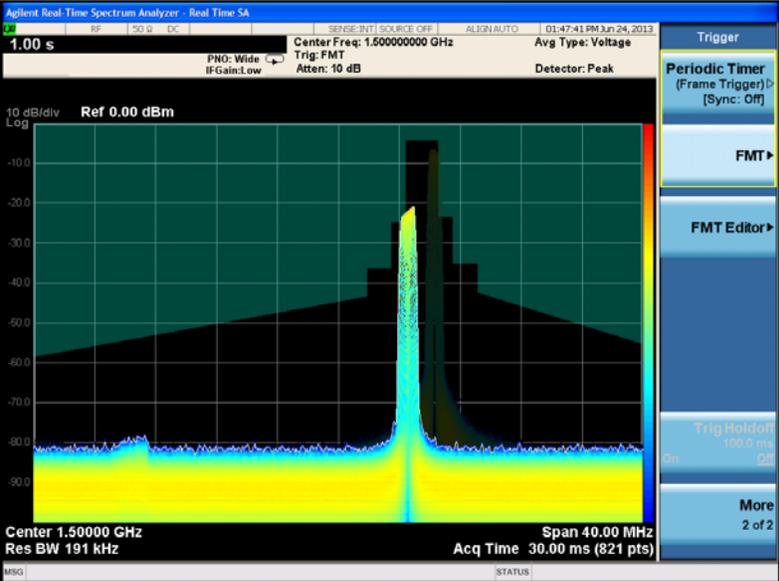
The FMT key appears. Refer to the following graphic.

Frequency Mask Triggers (FMT) FMT Set Up

Step	Action	Notes
		

- 6 Select FMT
- a. Press **FMT, FMT** (pressing FMT once activates the mask function and pressing it again displays the Trigger Setup menu).
- An FMT mask appears surrounding the signal. Refer to the following graphic that shows the display and a list of menu keys.

Refer to "Trigger Setup Details" on page 54.

			
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Step	Action	Notes
7	Access a frequency mask trigger using the FMT Editor	a. Press FMT Editor

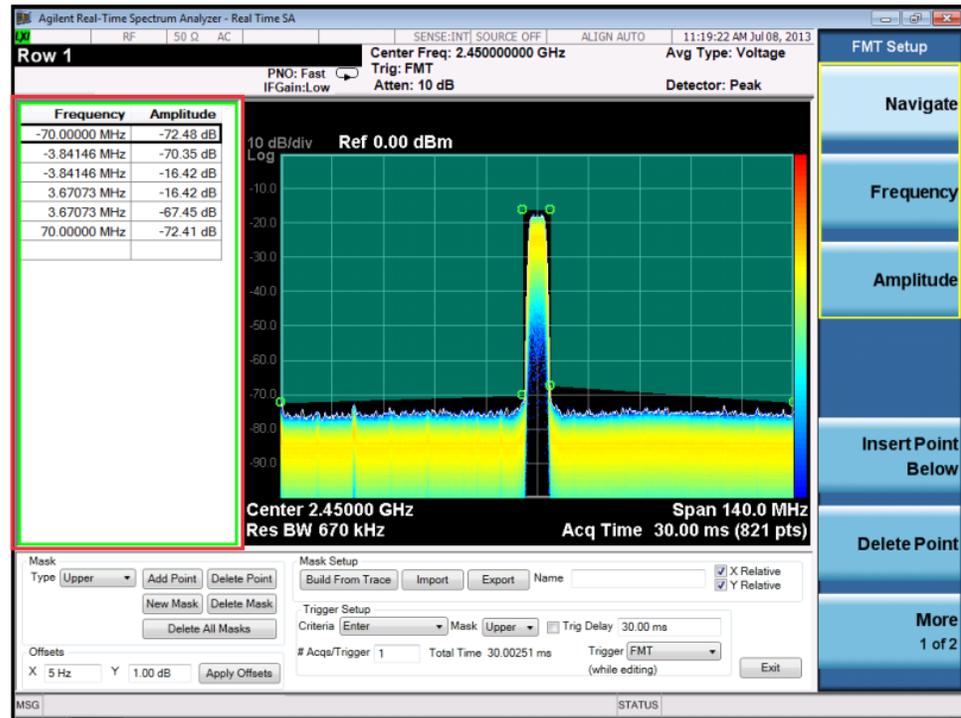
Note that the signal is shown with a white trace and the mask is built around the signal. Refer to the following graphic.

When you bring up the FMT Editor, the Navigate key is active enabling you to configure the FMT setting using a mouse or the menu keys. You may also change the mask by dragging the points (circles representing frequency and amplitude) on the display. See “FMT Setup Details” on page 50.

The screenshot displays the Agilent Real-Time Spectrum Analyzer's FMT Editor. The main window shows a spectrum plot with a white signal trace and a blue mask. The plot is centered at 1.50000 GHz with a span of 40.00 MHz. The amplitude scale is in dB/dBm, ranging from -90.0 to 10.0. The interface includes a table of frequency and amplitude data, a 'Mask' section with 'Upper' type, and a 'Trigger Setup' section. A 'More' button is visible in the bottom right of the interface.

Frequency	Amplitude
-20.00000 MHz	-58.56 dB
1.87805 MHz	-43.41 dB
1.87805 MHz	-36.25 dB
3.48780 MHz	-36.25 dB
3.48780 MHz	-24.80 dB
4.41463 MHz	-24.80 dB
4.41463 MHz	-4.32 dB
6.56098 MHz	-4.32 dB
6.56098 MHz	-23.53 dB
7.48780 MHz	-23.53 dB
7.48780 MHz	-35.23 dB
9.14634 MHz	-35.23 dB
9.14634 MHz	-42.41 dB
20.00000 MHz	-55.30 dB

FMT Setup Details



Navigate

When you enter the FMT Editor, this is the active function that enables you to move through the table to edit the desired point. You can use the instrument arrow keys or a mouse connected to a USBPort to edit the table of values (highlighted in red).

Frequency

Selects the frequency value of the current row for editing. You may use the arrow keys to navigate and edit other rows in the table.

Amplitude

Selects the amplitude value of the current row for editing. You may use the arrow keys to navigate and edit other rows in the table.

Insert Point Below

This inserts a point (frequency and amplitude values that form the mask anchor points) below the current point. The new point is a copy of the current point and becomes the current point. The new point is not yet entered into the underlying table, and the data in the row is displayed in light gray. When you select the terminating unit, the new point is entered in the table.

Delete Point

This will immediately delete the currently selected point, whether or not that point is being edited, and select Navigate as the active function. The point following the currently selected point (or the point preceding if there are no points following) will be selected.

New Mask

Clears any existing mask and creates a new mask of 4 points. Two points will be at $20\% \pm$ the Center frequency and at the Reference Level. The other two points will be at $10\% \pm$ Center Frequency and 20% below the Reference Level.

When selected the following warning message will appear:

"This will delete all the points in the current mask,
Are you sure you want to do this?

Press Enter to proceed or ESC to Cancel"

Mask Type

This key/selection enables you to select either an upper or lower mask type.

Trigger Setup

["Trigger Setup Details" on page 54.](#)

Mask Setup

Opens a menu that enables you to select the Mask parameters.

Build Mask from Trace

This enables you to generate a mask from the trace displayed in the FMT setup view. The points generated will provide a rough outline of the current trace, with a maximum of 20 points.

The mask points generated by Build Mask from Trace can use X and Y offset to adjust the mask position.

Import Mask from File

This enables you to import a mask from a file. This key is a shortcut to selecting the **Recall, Import Data, FMT** key path. Selecting this key will select FMT as the import and bring up the **Open** dialog box.

All the FMT setup parameters will be updated with the values from the imported file.

**Export Mask
to File**

Enables you to export a mask to a file. This key is a shortcut to selecting the **Save, Export Data, FMT** key path. Selecting this key will select FMT as the the export type and bring up the **Save As** dialog box.

The default path is My Documents\ "Mode"\data\FMT

Offsets

Opens a menu that enables you to configure offset parameters.

—**X Offset** - Offsets all the frequency points in the mask by the specified frequency.

—**Y Offsets** - Offsets all the amplitude points in the mask by the specified amplitude.

—**Apply Offsets to Mask** - Apply X and Y offsets to the selected mask.

Fixed/Relative

Opens a menu that will allow you to specify that the selected mask is relative to either the center frequency or the reference level.

—**X Relative to CF** - Chooses whether the mask frequency points are coupled to the instrument center frequency, or whether the frequency points are expressed as an offset from the instrument center frequency.

For example, assume the analyzer center frequency is at 1 GHz. If Relative to CF is "Off", entering a mask point with a frequency coordinate of 300 MHz displays the mask point at 300 MHz, and the mask point will not change frequency if the center frequency changes. If Relative to CF is "On", entering mask point with a frequency coordinate of 300 MHz displays the mask point at CF + 300 MHz, or 1.3 GHz. Furthermore, if the center frequency changes to 2 GHz, the mask point will be displayed at CF + 300 MHz, or 2.3 GHz.

It is possible to change this setting after a mask point has been entered. When changing from On to Off or vice-versa, the frequency values in the mask table change so that the mask points remains in the same position for the current frequency settings of the analyzer.

—**Y Relative to RL** - Chooses whether the mask amplitude points are coupled to the instrument reference level, and whether the amplitude points are expressed as an offset from the instrument reference level.

For example, assume you have a mask, and the reference level at -10 dBm. If Relative to RL is "Off", entering a mask point with an amplitude coordinate of -20 dBm displays the mask point at -20 dBm, and the mask point will not change amplitude if the reference level amplitude changes. If Relative to RL is "On", entering a mask point with an amplitude

coordinate of -20 dB displays the mask point at RL - 20 dB, or -30 dBm. Furthermore, if the reference level amplitude changes to -30 dBm, the mask point will be displayed at RL - 20 dB, or -50 dBm.

It is possible to change this setting after a mask point has been entered. When changing from On to Off or vice-versa, the amplitude values in the mask table change so that the mask points remains in the same position for the current reference level settings of the analyzer.

- Mask Name** Provides a description of up to 60 characters by which you can easily identify the limit. This will be stored in the exported file and can be displayed in the active function area to be displayed in a screen capture.
- Mask Color** Opens a menu tha enables you to select the Mask color parameters.
- Mask Hue - This parameter allows you to adjust the Hue of the Mask.
 - Mask Opacity - This parameter allows you to adjust the Opacity of the mask.
 - Mask Opacity Preview** - Displays the Mask Opacity that will be used .

Delete Mask

This key/selection deletes the currently selected mask.

When selected the following warning message appears:

```
"This will delete all the points in the current mask,  
Are you sure you want to do this?"
```

```
Press Enter to proceed or ESC to Cancel"
```

Delete All Masks

This key/selection deletes both the upper and lower masks.

When selected the following warning message appears:

```
"This will delete all the points in both the masks  
Are you sure you want to do this?"
```

```
Press Enter to proceed or ESC to Cancel"
```

Trigger Setup Details

Trigger Criteria

This parameter is used to define the event that will cause a trigger to occur. The events are ways that the signal interacts with the frequency mask. The data captured by RTSA is generated using multiple FFTs. The Trigger Criteria selection determines which FFTs are used in the data generation.

Enter	A trigger will occur when a signal enters the frequency mask area. The trigger event will not happen again until the signal leaves the mask and re-enters.
Leave	A trigger will occur when a signal leaves the frequency mask. This requires a signal to be present in the mask area.
Inside	A trigger event will occur when a signal is in the mask area and will continue to trigger until the signal is no longer in the mask area.
Outside	A trigger event will occur when the signal is not in the mask area and will continue to trigger until the signal is in the mask area.
Enter - Leave	A trigger will occur when a signal enters the frequency mask area then leaves it.
Leave - Enter	A trigger will occur when a signal re-enters the frequency mask area after leaving it.

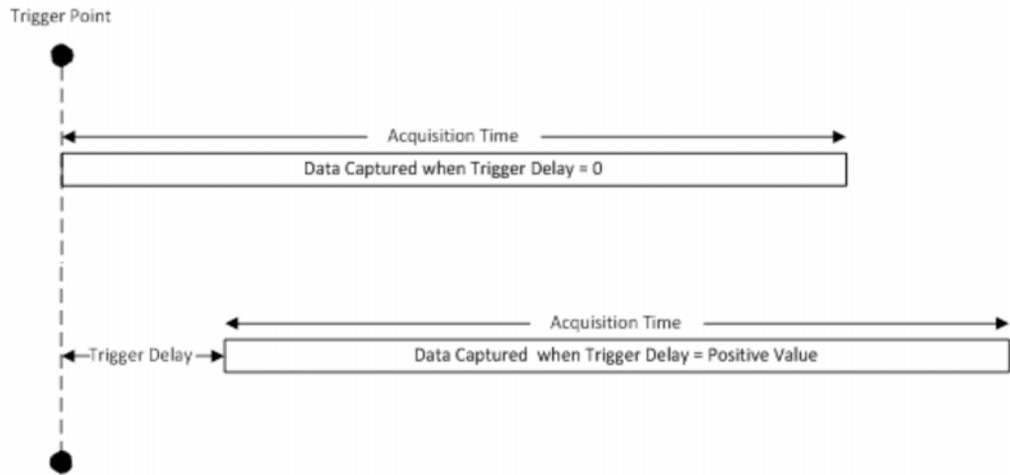
Trigger Mask

This parameter is used to select which Mask to be used for triggering; Upper, Lower, or Both.

Trig Delay

Controls a time delay during which the analyzer will wait to begin a sweep after meeting the trigger criteria. See [“Trig Delay Diagram” on page 55](#).

Trig Delay Diagram



#of Acquisitions /Trigger

This specifies how many acquisitions worth of data to return for each satisfied trigger. This is most useful with Spectrogram when you have short Acquisition Times, yet you want more than 1 Spectrogram scan for every triggered result. If the number of acquisitions per trigger is 20 and the Acquisition Time is 30 msec, then you will get 600 msec ($20 * 30$ msec) worth of data after the trigger condition has been met.