Agilent X-Series Signal Analyzer

This manual provides documentation for the following X-Series Analyzers:

PXA Signal Analyzer N9010A
MXA Signal Analyzer N9020A
EXA Signal Analyzer N9010A
CXA Signal Analyzer N9000A

N9063A & W9063A Analog Demod Measurement Application Measurement Guide

Agilent Technologies

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http://www.agilent.com/find/pxa
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Contents

1 Demodulating AM, FM, ΦM Signals

The Analog Demod measurement application provides the capability of demodulating Amplitude, Frequency, or Phase modulated signals (AM, FM, ΦM). These measurements provide functionality that can generally be categorized as follows:

- Demodulating a modulated carrier and playing the modulating signal over a speaker (sometimes referred to as *tune and listen*)
- Displaying demodulated signals in both time and frequency domains
- displaying modulation metrics

The following topics can be found in this section:

Setting Up and Making a Measurement

Making the Initial Signal Connection

CAUTION Before connecting a signal to the analyzer, make sure the analyzer can safely accept the signal level provided. The signal level limits are marked next to the RF Input connectors on the front panel.

See the Input Key menu for details on selecting input ports and the AMPTD Y Scale menu for details on setting internal attenuation to prevent overloading the analyzer.

Using Analyzer Mode and Measurement Presets

To set your current measurement mode to a known factory default state, press **Mode Preset**. This initializes the analyzer by returning the mode setup and all of the measurement setups in the mode to the factory default parameters.

To preset the parameters that are specific to an active, selected measurement, press **Meas Setup**, **Meas Preset**. This returns all the measurement setup parameters to the factory defaults, but only for the currently selected measurement.

The 3 Steps to Set Up and Make Measurements

All measurements can be set up using the following three steps. The sequence starts at the Mode level, is followed by the Measurement level, then finally, the result displays may be adjusted.

Table 1-1 The 3 Steps to Set Up and Make a Measurement

Step	Action	Notes
1. Select and Set Up the Mode	a. Press **Mode** b. Press **Analog Demod** c. Press **Mode Preset**. d. Press **Mode Setup**	All licensed, installed modes available are shown under the **Mode** key. Using **Mode Setup**, make any required adjustments to the mode settings. These settings will apply to all measurements in the mode.
2. Select and Set Up the Measurement	a. Press **Meas.** b. Select the specific measurement to be performed. c. Press **Meas Setup**	The measurement begins as soon as any required trigger conditions are met. The resulting data is shown on the display or is available for export. Use Meas Setup to make any required adjustment to the selected measurement settings. The settings only apply to this measurement.

Table 1-1 The 3 Steps to Set Up and Make a Measurement

Step	Action	Notes
3. Select and Set Up a View of the Results	Press **View/Display**. Select a display format for the current measurement data.	Depending on the mode and measurement selected, other graphical and tabular data presentations may be available. **X-Scale** and **Y-Scale** adjustments may also be made now.

NOTE A setting may be reset at any time, and will be in effect on the next measurement cycle or view.

Table 1-2 Main Keys and Functions for Making Measurements

Step	Primary Key	Setup Keys	Related Keys
1. Select and set up a mode.	**Mode**	**Mode Setup**, **FREQ Channel**	**System**
2. Select and set up a measurement.	**Meas**	**Meas Setup**	**Sweep/Control**, **Restart**, **Single**, **Cont**
3. Select and set up a view of the results.	**View/Display**	**SPAN X Scale**, **AMPTD Y Scale**	**Peak Search**, **Quick Save**, **Save**, **Recall**, **File**, **Print**

Demodulating an AM Signal Using the Agilent X-Series Signal Analyzer

This section demonstrates how to demodulate and listen to an AM signal. You can tune to an AM signal and view the results of the detector output displayed in the quad-view window or in single-window format.

Alternatively, the demodulated signal is also available as an audio output (to the speaker or headphone jack) and as video output (on the rear panel).

Step 1. Press **Mode**, **Analog Demod**.

Step 2. Press **Mode Preset**.

Step 3. Use an MXG RF source or an antenna for an AM signal to analyze. In this example an MXG is used transmitting at 680 kHz with AM depth of 50% and AM rate of 1 kHz.

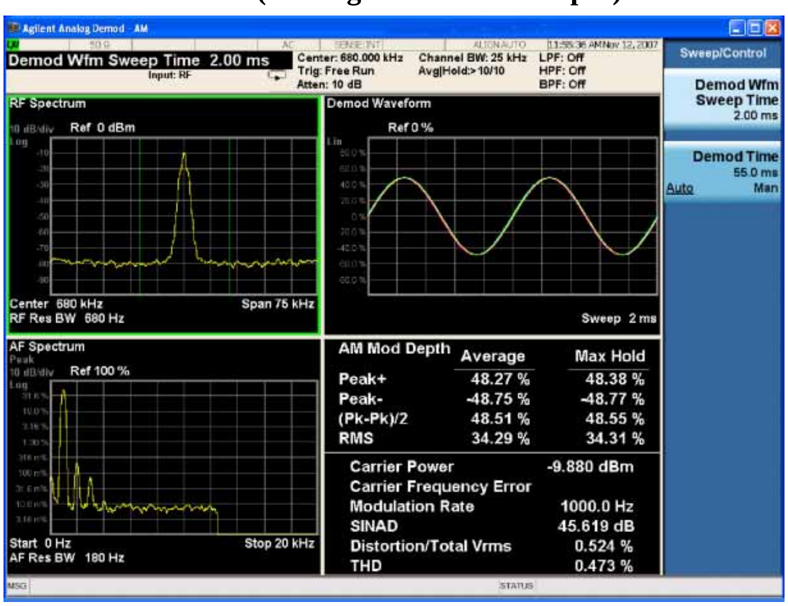
NOTE If you are using a broadcast AM signal in the United States, for example, the AM channels are broadcasting between 550 kHz to 1650 kHz.

Step 4. Press **Meas**, **AM**.

Step 5. Press **FREQ Channel**, **Center Freq**, **680**, **kHz** to set the center frequency to the center of the AM signal.

Step 6. Press **Sweep/Control**, **Demod Wfm Sweep Time**, **2**, **ms**.

Figure 1-1 **AM Demodulation (AM Signal with 50% Depth)**



Step 7. Press **Meas Setup**, **Demod to Speaker** to listen to the demodulated AM signal (adjust the volume as necessary).

Demodulating an FM Signal Using the X Series

This section demonstrates how to demodulate and listen to an FM signal. You can tune to an FM signal and view the results of the detector output displayed in the quad-view window or in single-window format.

Alternatively, the demodulated signal is also available as an audio output (to the speaker or headphone jack) and as video output (on the rear panel).

Step 1. Press **Mode**, **Analog Demod**.

Step 2. Press **Mode Preset**.

Step 3. Use an MXG RF source or an antenna for an FM signal to analyze. In this example an MXG is used transmitting at 300 MHz with FM deviation of 10 kHz and FM rate of 1 kHz.

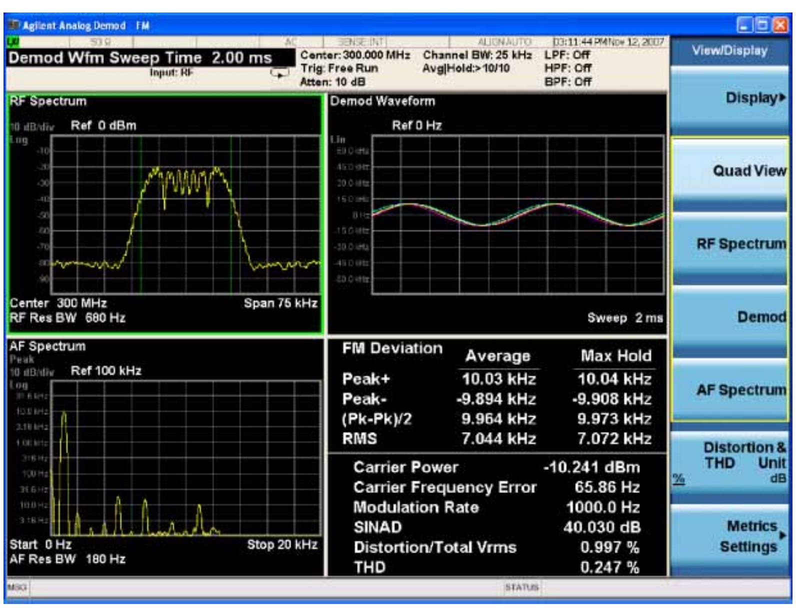
NOTE If you are using a broadcast FM signal in the United States, for example, the FM channels are broadcasting between 87.7 MHz to 107.7 MHz.

Step 4. Press **Meas**, **FM**.

Step 5. Press **FREQ Channel**, **Center Freq**, **300**, **MHz** to set the center frequency to the center of the FM signal

Step 6. Press **Sweep**, **Demod Wfm Sweep Time**, **2**, **ms**.

Step 7. **FM Demodulation (FM Signal with 10 kHz Deviation)**



Step 8. Listen to the demodulated FM signal (adjust the volume as necessary):

Press **Meas Setup**, **Demod to Speaker**.

Alternatively you can also use the headphone jack (located above the front-panel USB ports).

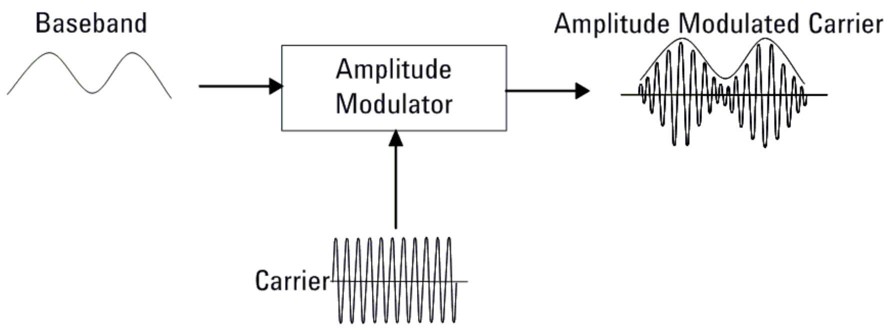
2 Concepts

The following topics can be found in this section:

AM and FM Demodulation Concepts

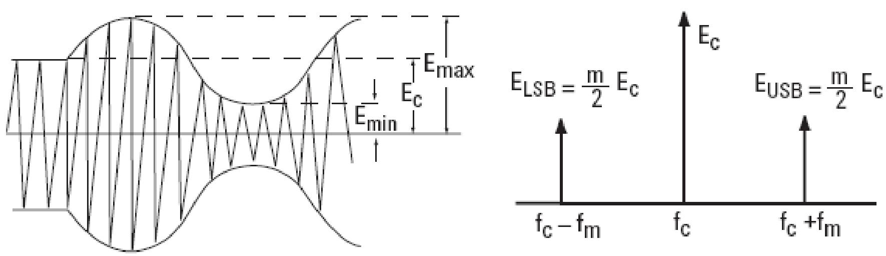
AM Concepts

Figure 2-1 **AM waveform**



In AM (Amplitude Modulation), the instantaneous amplitude of the modulated carrier signal changed in proportion to the instantaneous amplitude of the information signal.

Figure 2-2 **Calculation AM index in time and frequency domain**



The modulation index m represents the amount of the modulation or the degree to which the information signal modulates the carrier signal.The index for an AM signal can be calculated from the amplitudes of the carrier and either of the sidebands by the equation:

Equation 2-1

$$m = \frac{E_{max} - E_c}{E_c} = \frac{E_{max} - E_{min}}{E_{max} + E_{min}} = \frac{E_{USB} + E_{LSB}}{E_c} = \frac{2E_{SB}}{E_c}$$

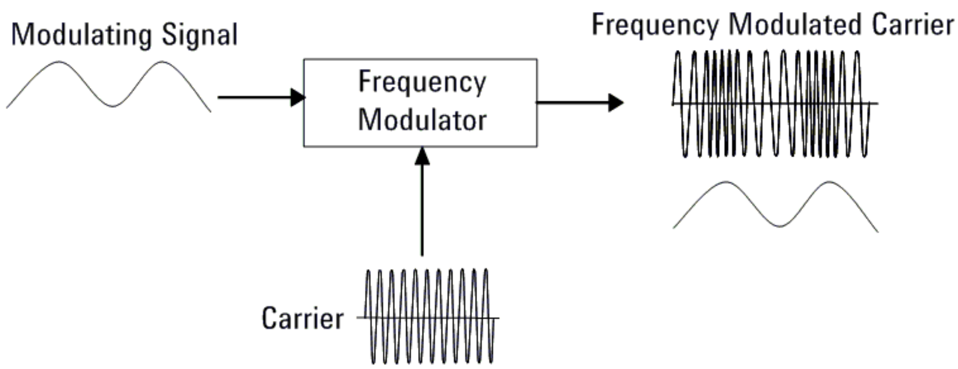
For 100% modulation, the modulation index is 1.0, and the amplitude of each sideband will be one-half of the carrier amplitude expressed in voltage. On a decibel power scale, each sideband will thus be 6 dB less than the carrier, or one-fourth the power of the carrier. Since the carrier power does not change with amplitude modulation, the total power in the 100% modulated wave is 50% higher than in the unmodulated carrier. The relationship between m and the logarithmic display can be expressed as:

Equation 2-2

$$(E_{SB}/E_c)dB + 6dB = 20\log m$$

FM Concepts

Figure 2-3 **FM waveform**



FM (Frequency Modulation) and PM (Phase modulation) belong to angle modulation. In FM, the instantaneous frequency deviation of the modulated carrier signal changed in proportion to the instantaneous amplitude of the modulating signal. And in PM, the instantaneous phase deviation of the modulated carrier with respect to the phase of the unmodulated carrier is directly proportional to the instantaneous amplitude of the modulating signal.

The modulation index for angle modulation, β, is expressed by this equation:

Equation 2-3

$$\beta = \Delta f_p/f_m = \Delta\phi_p$$

Where Δfp is the peak frequency deviation, fm is the frequency of the modulating signal, and $\Delta\phi$p is the peak phase deviation.

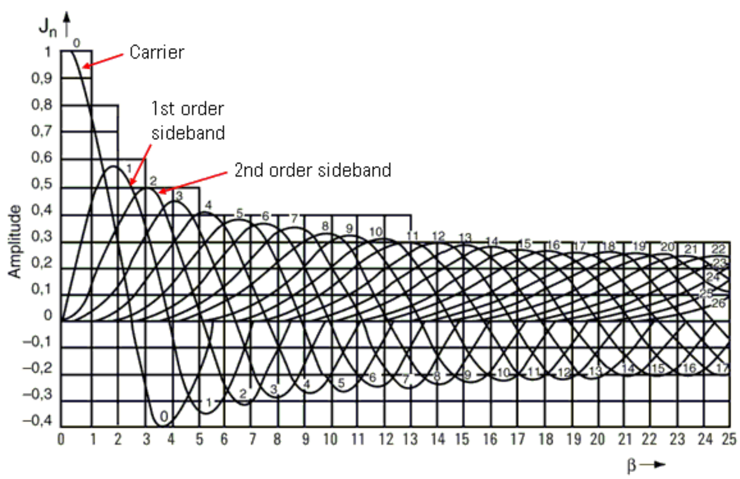
This expression tells us that the angle modulation index is really a function of phase deviation, even in the FM case. Also, the definitions for frequency and phase modulation do not include the modulating frequency. In each case, the modulated property of the carrier, frequency or phase, deviates in proportion to the instantaneous amplitude of the modulating signal, regardless of the rate at which the amplitude changes. However, the frequency of the modulating signal is important in FM and is included in the expression for the modulating index because it is the ratio of peak frequency deviation to modulation frequency that equates to peak phase.

Unlike the modulation index for AM, there is no specific limit to the value of β, since there is no theoretical limit to the phase deviation; thus there is no equivalent of 100% AM. However, in real world systems there are practical limits.

Unlike AM, which is a linear process, angle modulation is nonlinear. This means that a single sine wave modulating signal, instead of producing only two sidebands, yields an infinite number of sidebands spaced by the modulating frequency.

The Bessel function graph shows the amplitudes of the carrier and the sidebands as a function of modulation index, β. The spectral components, including the carrier, change their amplitudes as the modulation index varies.

Figure 2-4 **Carrier and sideband amplitude for angle-modulated signals**



In theory, for distortion-free detection of the modulating signal, all the sidebands must be transmitted. However, in practice, the sideband amplitudes become negligibly small beyond a certain frequency offset from the carrier, so the spectrum of a real-world FM signal is not infinite.

Demodulating an AM Signal Using the Analyzer as a Fixed Tuned Receiver (Time-Domain)

The X-Series signal analyzer can be used to recover amplitude modulation on a carrier signal.

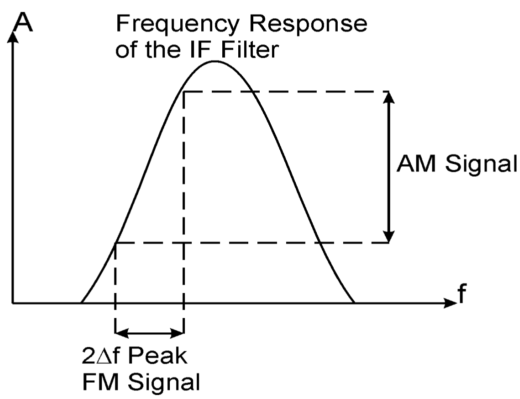
The following functions establish a clear display of the waveform:

- 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.
- 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, aa analyzer can be used as a manually tuned receiver. However, in contrast to AM, the signal is not tuned into the passband center, but to one slope of the filter curve as shown in Figure 2-5.

Figure 2-5 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). 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.

Modulation Distortion Measurement Concepts

Purpose

This measurement is used to measure the amount of modulation distortion contained in the Modulated signal by determining the ratio of harmonic and noise power to fundamental power. This measurement verifies the modulation quality of the signal from the DUT.

Measurement Technique

Modulation Distortion is defined as:

Equation 2-4

$$\%_{ModulationDistortion} = \sqrt{\frac{P_{total} - P_{signal}}{P_{total}}} \times 100\%$$

where: P_{total} = the power of the total signal,

P_{signal} = the power of the wanted modulating signal, and

P_{total} - P_{signal} = total unwanted signal which includes harmonic distortion and noise.

First, the received signal is demodulated and filtered to remove DC. Then the filtered signal is transformed by an FFT into frequency domain. Next, total power in the total filter band is measured as P_{total}, the peak power of the modulated signal is computed as P_{signal}, the square root of the ratio of P_{total} - P_{signal} to P_{total} is calculated. The result is the signal's modulation distortion. It can be expressed as dB or %.

Modulation SINAD Measurement Concepts

Purpose

Modulation SINAD (SIgnal to Noise And Distortion) measures the amount of Modulation SINAD contained in the modulated signal by determining the ratio of fundamental power to harmonic and noise power. Modulation SINAD is the reciprocal of the modulation distortion provided by the Modulation Distortion measurement. This is another way to quantify the quality of the modulation process.

Measurement Technique

Modulation SINAD is defined as:

Equation 2-5

$$dB_{ModulationSINAD} = 20 \times \log \sqrt{\frac{P_{total}}{P_{total} - P_{signal}}}$$

where: P_{total} = the power of the total signal,

P_{signal} = the power of the wanted modulating signal, and

P_{total} - P_{signal} = the total unwanted signals which include harmonic distortion and noise.

First, the received signal is demodulated and filtered to remove DC, then the filtered signal is transformed by an FFT into frequency domain. Next, total power in the total filter band is measured as P_{total}, the peak power of the modulated signal is computed as P_{signal}, the square root of the ratio of P_{total} to P_{total} - P_{signal} is calculated. The result is the signal's Modulation SINAD. It can be expressed as dB or %.