Keysight Technologies

AM/FM Signals Measurement and Operation Using the N9340B Option AMA

Technical Overview

KEYSIGHT TECHNOLOGIES

Introduction

Amplitude modulation (AM) of a sine or cosine carrier results in a variation of the carrier amplitude that is proportional to the amplitude of the modulating signal that contains information. Frequency modulation (FM) is a scheme of angular modulation in which the modulating signal is used to vary the frequency of a carrier wave. The instantaneous frequency of the modulated carrier is directly proportional to the instantaneous amplitude of the modulating signal.Option AMA for the N9340 series Handheld Spectrum Analyzer provides modulation analysis and measurements for AM and FM signals. These measurements include carrier power, modulation rate, modulation index, SINAD, and more. In addition, the baseband modulating signal is displayed after demodulation of the AM/FM carrier. Descriptions of these measurements are given on the following pages.

Measurement

Carrier Power

Carrier power is one of the most common measurements of communication signal quality. In the modulation analysis section, the analyzer computes the mean carrier amplitude for the carrier frequencies that are proportional to the carrier power.

Modulation Rate

The modulation rate indicates the frequency of the baseband modulating signal. After demodulating the modulated signal, the modulation rate is calculated, which accurately represents the audio or baseband signal frequency.

Modulation Index

For the different modulation types, the definition of modulation index varies as indicated below.

AM Depth

AM is a linear process. The baseband modulating signal varies the amplitude of the resulting modulated carrier, which essentially, adds and subtracts power to the carrier. The AM depth is the amount of carrier amplitude modulation. It ranges from 0.1% to 100%, and in the N9340 option AMA the measurement range is from 5% to 95%. The following modulation index (m) equations define the AM depth:

In time domain:
m = (Emax-Emin)/ (Emax+Emin)
In frequency domain:
m = 2Esb/Ec

Where, Emax and Emin are the maximum and minimum amplitudes (in voltage), respectively, of the modulated signal in the time domain; Esb and Ec are the amplitude (in voltage) of the sideband and carrier, respectively. In option AMA, the measurement is implemented in the time domain.

FM Deviation

FM deviation quantifies the amount of the frequency modulation. The quantity being measured is the peak frequency deviation which is the maximum frequency excursion from the average carrier frequency. In a signal generator calibration, a measuring instrument must accurately quantify the peak frequency deviation of the modulated signals to validate the specified signal generator values.

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

$$\beta = f_p/f_m$$

Whereis the peak frequency deviation, is the modulation rate. Option AMA, provides the measurement results for frequency deviation and modulation rate which can be used to compute the FM modulation index.

SINAD (Signal to Noise and Distortion)

The modulation distortion for the AM (FM) is the undesired alterations to the modulated signal added by the modulation processes, and is defined as the total harmonic distortion plus noise. Modulation SINAD is measured by determining the ratio of fundamental power to harmonic and noise power contained in the modulated signal, which is defined as:

$$dB\_SINAD = 20\log\left(\sqrt{\frac{P_{total}}{P_{total} - P_{signal}}}\right)$$

is total power of signal and distortion plus noise. is the signal power. In option AMA, the received signal is first demodulated, filtered, and the DC component removed. Then the filtered signal is transformed into the frequency domain by performing an FFT. Next the total power in the filter bandwidth is measured as and the peak power of the modulated signal is computed as. Finally, the SINAD is computed and displayed.

FM Deviation

Carrier frequency offset indicates that the difference between actual carrier frequency and the desired carrier frequency. This offset may be produced by the DUT, the asynchronous instrument working as a respective reference, and man-made factors. In option AMA, the analyzer can measure this error in a limited bandwidth that is used to demodulate the signal. If the offset exceeds the bandwidth limit, this measurement result is unreliable.

Operation

The N9340 series Handheld Spectrum Analyzer Option AMA provides a convenient and fast operational mode for the user. This option is engaged by pressing the MODE>Demodulation Analysis>Enter>AM or FM. The initial display and user interface is AM as shown in the figure below:

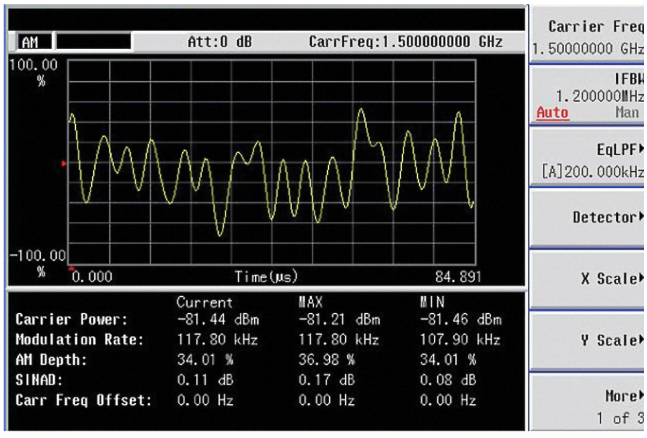

Figure 1. The display interface of AM

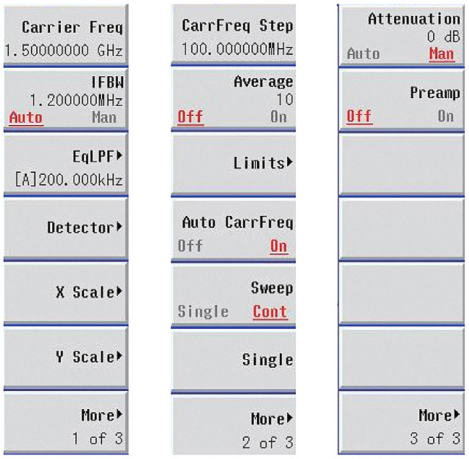

Figure 2. The operational menu of option AMA

Measure Setup

There are three menu pages for option AMA. The user may utilize this menu to change the measurement parameters to better ensure accuracy and improve measurement speed. The following explanations provide details for the Measurement Setup Menu.

Carrier Freq

Carrier Freq indicates the system demodulated carrier frequency i.e., the tune frequency of the system. The carrier frequency error must be less than 1.2 MHz - modulation signal BW/2. Carrier frequency errors which exceed this limit will result in measurement inaccuracy. The initial carrier frequency is 1.5 GHz.

Tip: If the carrier frequency is known, then the frequency value may be input directly, otherwise the carrier frequency should be measured in the Spectrum Analyzer mode of N9340 using the marker function, or for even more precision, the marker counter function.

IFBW

IFBW denotes the Intermediate Frequency Bandwidth, which indicates the system bandwidth used to demodulate the signal. If this bandwidth is less than the signal bandwidth, the system cannot demodulate the AM/FM signal precisely. However, due to the influence of wideband and system noise, a wider system bandwidth would allow more noise which may add uncertainty to the measurement results. In addition, IFBW is related to the DDC output data rate which will impact the measurement time. That means the wider the IFBW, the faster measurement. The default setting is Auto.

Tip: Most of the time, it is recommend that the user employ the Auto function of IFBW which optimizes the tradeoff between the measurement speed and accuracy. But if the measurement accuracy is less important, the user can manually set the IFBW wider than the Auto IFBW value and obtain a faster measurement speed.

EqLPF

EqLPF means Equivalent Low Pass Filter, this setting is relevant to the IFBW, and the filter bandwidth is proportional to the IFBW value. For more accurate measurements, this function can filter a portion of the noise in the IF bandwidth. If the user is concerned about audio harmonic distortion, turning off the EqLPF or by setting the EqLPF according to the desired audio frequency range can ensure audio frequency measurement accuracy., The EqLPF has seven selections, including Off, 1/6, 1/20, 1/60, 1/200, 1/600, 1/2000 IFBW. The default setting is Auto.

Tip: The Auto setting in EqLPF filters most of the noise in the IF bandwidth higher than the signal frequency to ensure the accuracy of the modulation rate and modulation index. A lower EqLPF setting may lead to a much larger measurement time than normal.

Detector

The detector menu enables the manual selection of detection types for a particular measurement. There are four types of detectors: Peak+, Peak- , Peak+-/2, RMS. These detectors are all selected based on the type of modulated signal.

The peak detector is used for the AM depth and FM deviation measurements. Using the RMS detector may introduce errors. When the modulating signal (or baseband signal) is asymmetric, using the Peak+ or Peakdetectors will generate different measurement results, therefore the ±Peak/2 detector is recommended. In the detector menu, Peak Hold is also provided. If Peak Hold is On, the measurement result is the maximum (when Detector is Peak+) or minimum (when Detector is Peak-) value of these peaks over the entire measurement time. If Peak Hold is Off, the measurement result (Peak+ or Peakmode) is the average of these peaks over the entire measurement time. The default setting is Peak+-/2 detectorwith Peak Hold set to Off.

X Scale

X Scale provides control of the graticle's horizontal settings. Scale/Div is for setting the horizontal value per division. Ref Value allows you to set the starting value in terms of time at the reference position. Ref position allows you to set the display's reference position to Left, Ctr (center), or Right. If the Autoscale key is pressed, the Scale/Div is automatically determined by the measurement results. The default Ref Value is zero and the Reference Position is left.

Y Scale

X Scale provides control of the graticule's vertical settings. Scale/Div is for setting the vertical value per division. Ref Value allows you to set the starting value in term of amplitude at the reference position. Ref position allows you to set the display's Reference Position to Top, Ctr (center), or Bottom. If the Autoscale key is pressed, the Scale/Div is automatically determined by the measurement results. The default Ref Value is zero and the Reference Position is Ctr. The Ext Gain state allows the user to add any external gain to the carrier power test results.

CarrFreq Step

CarrFreq Step allows the user to modify the carrier frequency step size utilized by the up/down keys or knob. The initial value is 100 MHz.

Average

Provides display averaging of the measurement results. Because measurements of noise like or random signal characteristics may produce unsteady or highly variable results, the display averaging function can smooth the result and provide the mean value. When the Average function is off, the column title "Average" in the Numerical Results view will change to "Current". If the Average function is on, users can set the average count number used for the degree of measurement result averaging. The Average function is automatically set to off when single sweep is selected.

Limits

Enables setting a limit metric to warn the user if the measured result exceeds the specified value. There are four limits in this menu: CarrPower up, AM depth (FreqDev) up, AM depth (FreqDev) low, and Carrfreoff up.

Auto Carr Freq

The Auto Carr Freq function allows carrier frequency deviation in the limit band. If the deviation exceeds the band, this function can not be used. The initial state is On.

Sweep

Sweep has two submenus: Single and Continuous. Single enables the initiation of one measurement sweep at a time. Continuous sets the analyzer for repetitive measurement sweeps, but does not restart the current sweep.

Single

This is the trigger for single measurements.

Attenuation

This function adjusts the level of the input signal to match the amplitude range required for normal measurements. It has two operating modes: Auto and Man. The Auto mode indicates when the analyzer can automatically adjust the attenuation to the appropriate range based on the input signal power, which then will satisfy normal measurements. The Man mode allows the user to set the attenuation. The default state is Man.

Preamp

The preamp feature amplifies low power signals, which extends the measurement range of the analyzer and its options. However, this function isn't recommended for option AMA, because the preamp would add additional noise that could impact the measurement accuracy. It is suggested that the input signal power be kept within the option AMA amplitude specifications. The initial state of the preamp is Off.

Operational Example

Assume there is an AM signal with unknown modulation characteristics. The example below gives a quick measurement demo using the N9340B analyzer with the AMA option.

Step 1: Using the Spectrum Analyzer mode in N9340B to estimate the carrier frequency, as shown in figure 3:

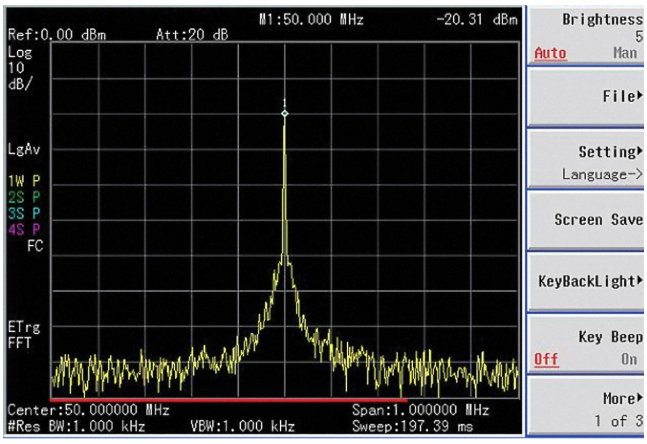

Figure 3. Use the spectrum analyzer to obtain the carrier frequency

From figure 3, we know the carrier frequency is about 50 MHz.

Step 2: Enable the AMA option and set the carrier frequency to 50 MHz; leaving the other parameter settings at their default values. Then observe in Figure 4 how quickly the measurement results are provided.

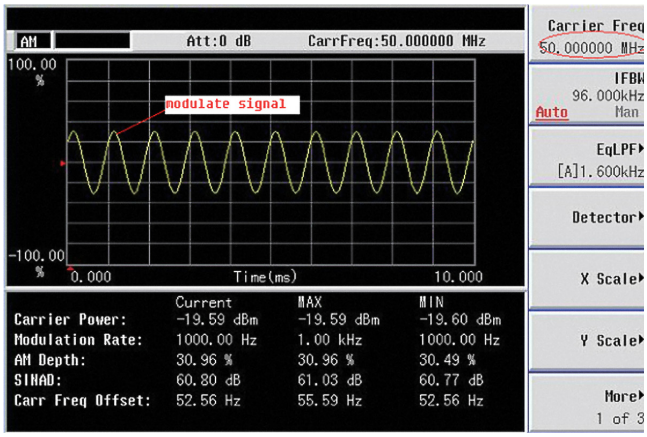

Figure 4. The AM signal measure results

From Figure 4, we can see the modulation metrics for this signal. The current measurement results show a carrier power of -19.59 dBm, a modulation rate of 1 kHz, AM depth of 30.96%, a SINAD (in a 96 kHz IF bandwidth with a 1.6 kHz low pass filter) of 60.8 dB, and a carrier frequency offset of 52.56 Hz. Possibly, the carrier frequency offset is produced by the internal reference being asynchronous with an external reference.

This example is a simple, but demonstrates the convenient operation of the option AMA. If users have special requirements for these measurements, the measurement parameters can easily be modified according to the instructions above.

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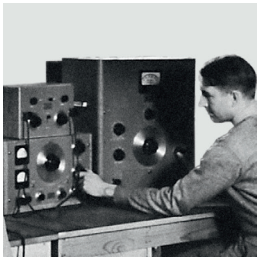

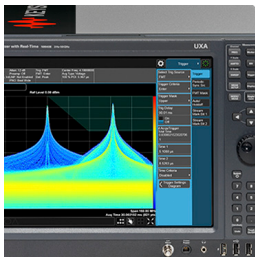

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Published in USA, December 2, 2017
5989-9332EN
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