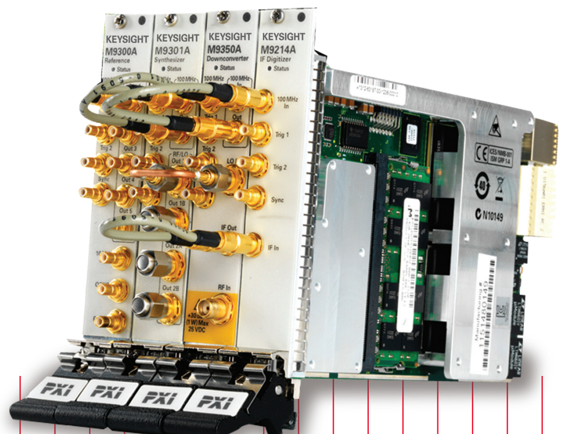
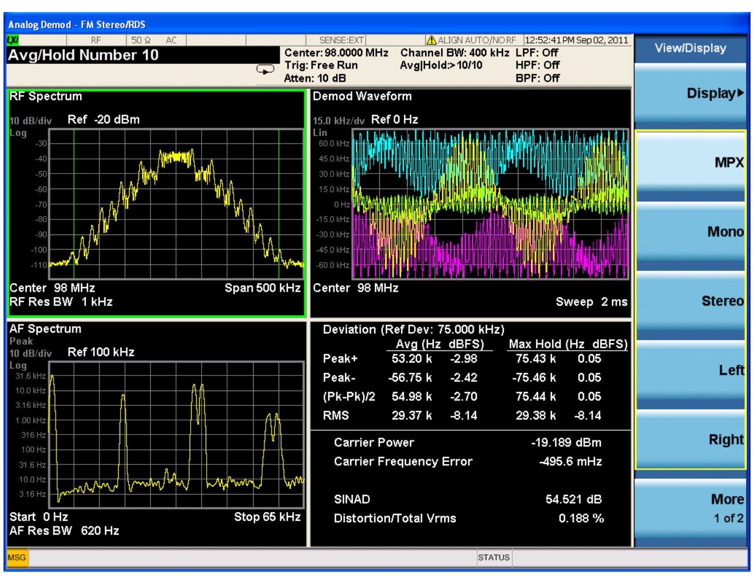
Keysight Technologies
M9063A Analog Demodulation X-Series Measurement Application for PXIe Vector Signal Analyzers

Technical Overview





- Demodulate AM, FM, PM, or FM stereo/RDS signals
- Quad view, simultaneously displays RF spectrum, demodulated waveform, AF spectrum, and demodulating metrics
- Results for MPX, mono, stereo, left and right channel of FM stereo signal, and RDS/RBDS decoding
- Selection of post-demod filters
- PC-based SCPI remote interface and manual user interface
- Built-in context sensitive help with SCPI command reference
- Transportable license supports up to four PXI VSA channels in one mainframe

KEYSIGHT TECHNOLOGIES

Analog demodulation measurement application

Expand the capabilities of your M9391A and M9393A PXIe vector signal analyzers (PXI VSAs) with Keysight Technologies, Inc. library of measurement applications - the same applications used to increase the capability and functionality of its X-Series signal analyzers. Eleven of the most popular applications are now available for use with Keysight's new M9393A PXIe performance VSA and the M9391A PXI VSA. When you combine the raw hardware speeds of the PXI VSAs and the X-Series measurement applications for modular instruments, you can test more products in less time, while ensuring measurement continuity from design to manufacturing.

The M9063A analog demodulation X-Series measurement application for modular instruments transforms PXI VSAs into easy-to-use transmitter testers for analog modulated signals, helping you design, evaluate, and manufacture your analog devices quickly and accurately. Even in the modern digital world, the analog demodulation measurement application helps you to troubleshoot distortions due to unintentional, analog modulation from digitally modulated transmitters --allowing you to stay on the leading edge of your design and manufacturing challenges.

Proven algorithms and a common user interface across the X-Series analyzers and modular PXI VSAs create a consistent measurement framework for signal analysis that ensures repeatable results and measurement integrity so you can leverage your test system software through all phases of product development. The analog demodulation measurement application is just one in a common library of several measurement applications. You can further extend your test assets by utilizing up to four PXI VSAs with one software license.

Keysight's X-Series applications for modular instruments also include a unique "Resource Manager" that provides direct access to PXI VSA hardware drivers for the fastest power and spectrum-based measurements, while simultaneously using the X-Series applications for fast modulation quality measurements and 89600 VSA for fast spectrum measurements.

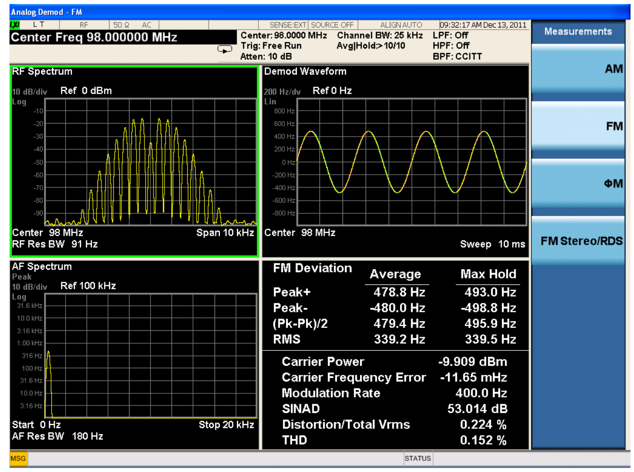


Figure 1. The quad view allows you to watch the RF spectrum, demod, waveform, AF spectrum, and demodulation metrics simultaneously.

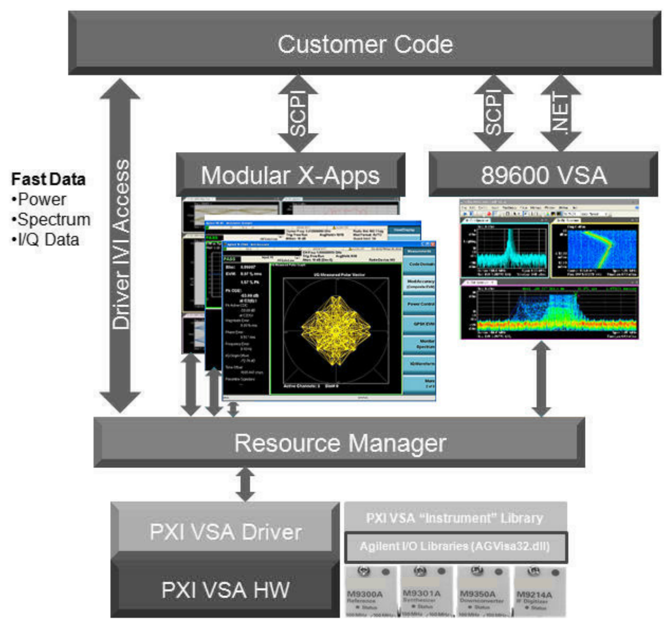


Figure 2. Resource Manager is included with all X-Series measurement applications for modular instruments.

Analog modulation and demodulation overview

Modulation is the process of translating some low-frequency or baseband signal (such as voice, music, or data) to a higher frequency (carrier signal). The primary reasons for modulation include allowing the simultaneous transmission of two or more baseband signals by translating them to different frequencies, and to take advantage of the greater efficiency and smaller size of higher-frequency antennae.

Analog modulation is the most fundamental modulation method. In analog modulation, the variations to the carrier are applied continuously in response to the analog information signal. By definition, the analog signal is continuous in time and amplitude, as opposed to a digital or discrete signal.

A high-frequency carrier signal commonly has sinusoidal form. There are two properties of a carrier signal that can be altered: 1) the amplitude (A) and 2) the angular position. Thus, there are amplitude modulation (AM) and angle modulation. Angle modulation can be further characterized as either frequency modulation (FM) or phase modulation (PM).

FM stereo is an enhancement to FM that uses stereo multiplexing. An FM stereo signal carries stereophonic programs in which signals are transmitted for L (left) and R (right) audio channels. Radio data system (RDS) consists of the text information such as traffic, weather, and radio station information carried in the FM signals. This information can be displayed on the screen of the end-user's device. RBDS is the United States version of RDS.

Table 1 summarizes these three formats of analog modulation.

Analog demodulation is a reverse process of the analog modulation. It offers quantitative assessments for analog modulation qualities. Analog demodulation is not only essential in testing FM or AM transmitters, but is also a powerful troubleshooting tool for analyzing unintentional signals from digitally modulated transmitters such as 2G/3G cellular phones, and wireless LAN and WiMAX™ devices.

The FM demodulation measurement is also an excellent alternative for high-volume manufacturing of low-price digital wireless devices, such as *Bluetooth*®, where test throughput and manufacturing costs are critical.

Table 1. Analog modulation formats

Modulation format	Modulation nature	Primary characteristics
Amplitude modulation (AM)	Amplitude of carrier signal varies in direct proportion to the instantaneous amplitude of the baseband signal	AM depth, AM rate, modulation distortion
Frequency modulation (FM)	Frequency of carrier signal varies in direct proportion to the instantaneous amplitude of the baseband signal	FM deviation, FM rate, modulation distortion
Phase modulation (PM)	Phase shift of carrier signal varies in direct proportion to the instantaneous amplitude of the baseband signal	Phase deviation, PM rate, modulation distortion
FM stereo/RDS	FM stereo is an enhancement to FM that uses stereo multiplexing consisting of a mono (L+R) signal, a stereo signal (L-R) and a pilot signal	FM deviation, FM rate, SINAD, distortion, THD, mono to stereo ratio, left to right ratio, 38 kHz pilot carrier freq error and phase error, RDS decoding

Choosing between X-Series applications and 89600 VSA software

X-Series measurement applications provide format-specific, one-button measurements for X-Series analyzers and modular PXI VSAs. With fast measurement speed, SCPI programmability, pass/fail testing and simplicity of operation, these applications are ideally suited for design verification and manufacturing. The 89600 VSA is the industry-leading measurement software for evaluating and troubleshooting signals for R&D and design validation. Supporting numerous measurement platforms and multiple measurement channels, the 89600 VSA provides flexibility and sophisticated measurements tools essential to find and fix signal problems. Recent enhancements for the modular PXI VSA platforms (89601B-SSA) provide fast spectrum measurements with benchtop analyzer SCPI programming compatibility.
www.keysight.com/find/89600

Analog demodulation measurements

With the analog demodulation measurement application, you can perform analog modulation analysis on various radio transmitting devices. The analysis includes:

- RF spectrum of the modulated signal
- Demod waveform (time-domain view of the baseband signal). FM stereo can view MPX, mono, stereo, left or right demod waveforms.
- AF spectrum (i.e., frequency-domain view of the baseband signal). FM stereo can view MPX, mono, stereo, left or right AF spectrum.
- Modulation metrics
  - AM depth
  - FM deviation
  - Phase deviation
  - Carrier power
  - Carrier frequency error (FM and PM only)
  - Modulation rate
  - Distortion/total Vrms
  - Signal to noise and distortion ratio (SINAD)
  - Total harmonic distortion (THD)
  - Left to right ratio
  - Mono to stereo ratio
  - 38 kHz pilot frequency error and phase error
  - RDS/RBDS decoding (including BLER, basic tuning and switching info, radio text, program item number and slow labeling codes, clock time, and date)

Measurement details

RF spectrum of the modulated signal

This is the most traditional spectrum analyzer measurement viewing the modulated carrier signal power in frequency domain. Prior to being modulated, the signal power of a sinusoidal carrier concentrates at the carrier frequency. By contrast, the modulated signal presents the power redistribution over frequencies. Its pattern depends upon the modulation format. (Refer to Figure 2.)

Demod waveform

This measurement retrieves the baseband signal from the modulated signal via the demodulation process, and displays the baseband signal in a pattern of modulation depth/deviation versus time. Since the modulation depth/deviation is directly proportional to the instantaneous amplitude of the baseband signal, the measurement result helps to intuitively evaluate the quality of the baseband signal. (Refer to Figure 3.)

AF spectrum

By applying the fast Fourier transform (FFT) to the baseband waveform, this measurement demonstrates the baseband signal behaviors in frequency domain graphically. The AF spectrum reveals the distortion of the baseband signal clearly just as the RF spectrum does for the RF signal. (Refer to Figure 4.)

Modulation metrics

AM depth

The AM depth measurement quantifies the amount of amplitude modulation to which the baseband signal modulates the carrier signal. The AM depth, also refers to AM modulation index (m), and
is defined as:

$$m \text{ (in \%)} = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}$$

where, Emax and Emin are amplitudes (in voltage) of the modulated signal at its peak and trout, respectively, in time-domain. The AM depth ranges from
0 to 100%.

FM deviation

The FM deviation reflects the amount of the frequency modulation to which the baseband signal modulates the carrier signal. The quantity being measured is the peak frequency deviation that is the maximum frequency excursion from the carrier frequency.

Phase deviation

The phase deviation, also referred to PM deviation, is a measure of the amount of the phase modulation. The quantity being measured is the peak phase deviation (in radians) that is the maximum phase excursion from the average carrier phase.

FM and PM are two forms of angle modulation. They are closely related, as phase is the time integral of the frequency, and frequency is the time derivative of phase.

Carrier power

This measures the power of the carrier signal without the modulation. Ideally, power for a sinusoidal carrier signal is concentrated around its carrier frequency.

Carrier frequency error

This measurement reports the difference between the nominal frequency and the actual frequency of the carrier. It is only available for the FM and PM.

Modulation rate

The modulation rate quantifies how fast the modulation is and equates to the frequency of the baseband signal that modulates the carrier.

Distortion/total Vrms

Modulation distortion is the undesired alterations added to the modulated signal by modulation processes. To assess the modulation quality of a transmitter, the modulation distortion needs to be quantified.

Modulation distortion is usually measured in a relative term against the total signal power:

$$\text{Modulation distortion (in \%)} = \frac{(P_{total} - P_{signal})^{1/2}}{(P_{total})^{1/2}} \times 100\%$$

where, P_{total} is the power of the total signal; P_{signal} is the power of the wanted modulating signal; and $P_{total} - P_{signal}$ is the total unwanted signal which can be further divided into the components of noise and harmonic distortion.

SINAD

Another commonly used distortion measure is signal to noise and distortion ratio (SINAD). SINAD, in nature, is the reciprocal of the modulation distortion provided by the "distortion/total Vrms," but the SINAD is usually expressed in a logarithmic term as follows:

$$\text{SINAD (in dB)} = 20 \times \log \frac{(P_{total})^{1/2}}{(P_{total} - P_{signal})^{1/2}}$$

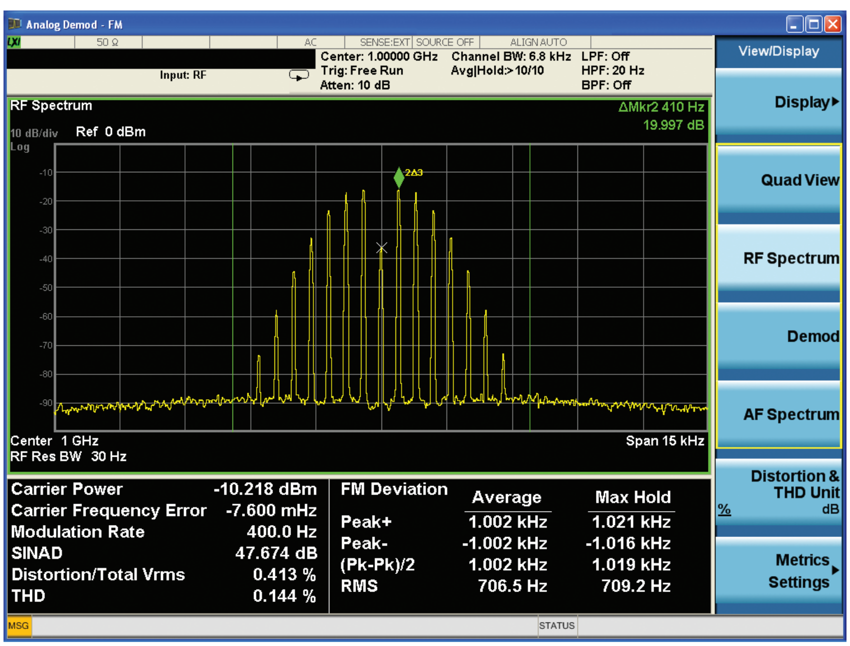


Figure 2. The RF spectrum view presents the modulated signal along with the results of demodulation.

THD

The total harmonic distortion (THD) measurement further isolates the total harmonic distortion component from the noise component in the total unwanted signal. It helps the user to troubleshoot the root causes of modulation distortion.

Other features

Observing carrier frequency settling time

The FM demod waveform provides an effective way to see the frequency settling of the carrier signal when it is turned on. The simultaneous detectors give you more insights into the carrier frequency settling behavior of your transmitter output, such as how quickly the carrier can be settled at its nominal frequency value.

Selection of detectors

Four types of detectors are provided: positive peak (Peak+), negative peak (Peak-), Peak/Peak average ((Pk-Pk)/2), and RMS. The Max Hold values for each detector are also displayed.

Comparing the result from the Peak+ detector and from the Peak- detector allows you to check modulation symmetry. For symmetric modulation, the Peak+, Peak-, and the (Pk-Pk)/2 detectors result in identical readings. For asymmetric modulation, the readings generated by the Peak+ and Peak- are different, and using the (Pk-Pk)/2 values is recommended.

The RMS detector results in the RMS (root-mean-square) value of modulation. It is a good choice when measuring noise or residual modulation, where the RMS value is generally more desirable than the peak value. The RMS detector is also a good choice for measuring non-sinusoidal signals.

Post-demod filters

The post-demod filters help you to optimize the measurement results by filtering out undesired signals such as harmonics, noise, and spurs from the demodulated signal. You may choose a high-pass filter (20, 50, or 300 Hz), and/or a low-pass filter (300 Hz, 3, 15, 30, 80, or 300 kHz) from the available post-demod filter bank to achieve the best demodulation results. For example, applying an appropriate low-pass filter helps minimize overshoot from square-wave modulation, such as frequency shift keying (FSK).

Additionally, a CCITT filter, which simulates the frequency response behavior of the human auditory system, is also available to help you evaluate the consequences of distortion of the demodulated signal from the human hearing perspectives.

To accommodate your pre-emphasized FM signals, the M9063A is also equipped with four separate de-emphasis filters (25, 50, 75, and 750 µs) for you to select.

Marker capabilities

The powerful marker capabilities offered by the M9063A further add great convenience to your analog demodulation measurements. You can set up to 12 markers and define them as “normal,” “delta,” or “fixed.”

Accelerating measurements further

The PXI VSAs offer great advantages in throughput with their industry-leading speed for measurements including the analog demodulation. If your task demands even higher throughput, the analog demodulation measurement application can accommodate your needs. It offers the flexibility to partially turn off the measured parameters that the flexibility for partially turning off the measured parameters, which are not required by your task, and can further accelerate your measurement to save every millisecond possible.

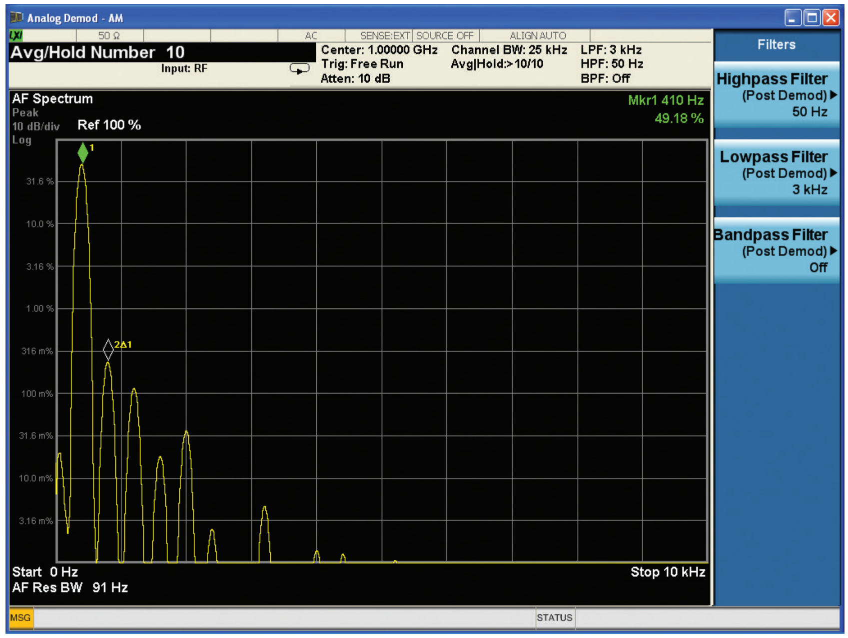


Figure 3. Apply the "post-demod” filters to optimize analysis results for the baseband (AF) spectrum.

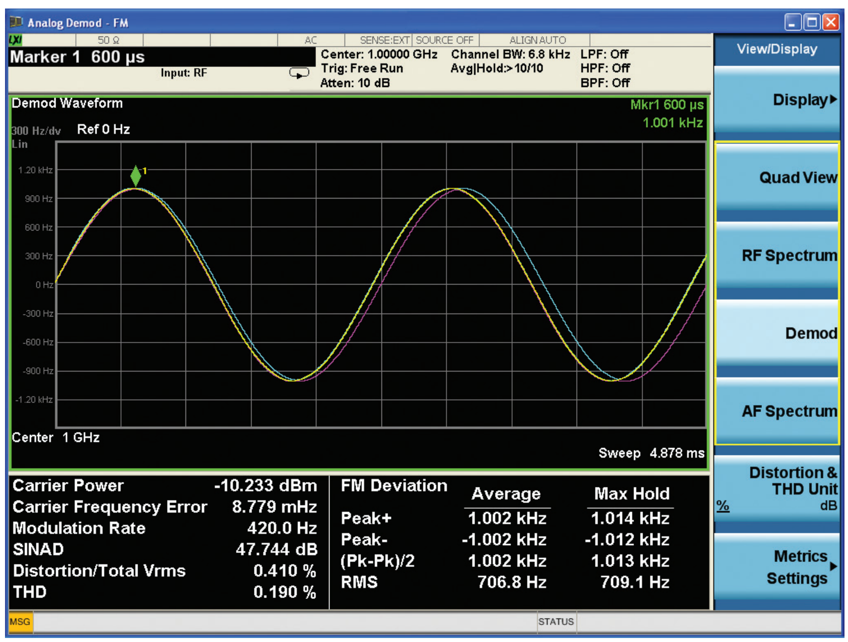


Figure 4. The demod waveform view displays the baseband signal in time domain.

FM stereo/RDS MPX view

FM MPX consists of FM signal multiplexing with the mono signal (L+R), stereo signal (L-R), pilot signal (at 19 kHz), and optional RDS signal (at 57 kHz). Figure 5 shows the FM stereo MPX view with four measurement windows. The top left window contains RF spectrum, the bottom left contains MPX AF spectrum, the top right contains MPX demodulated waveform, and the bottom right contains demodulation metrics with deviation, carrier power, carrier frequency error, SINAD and distortion results.

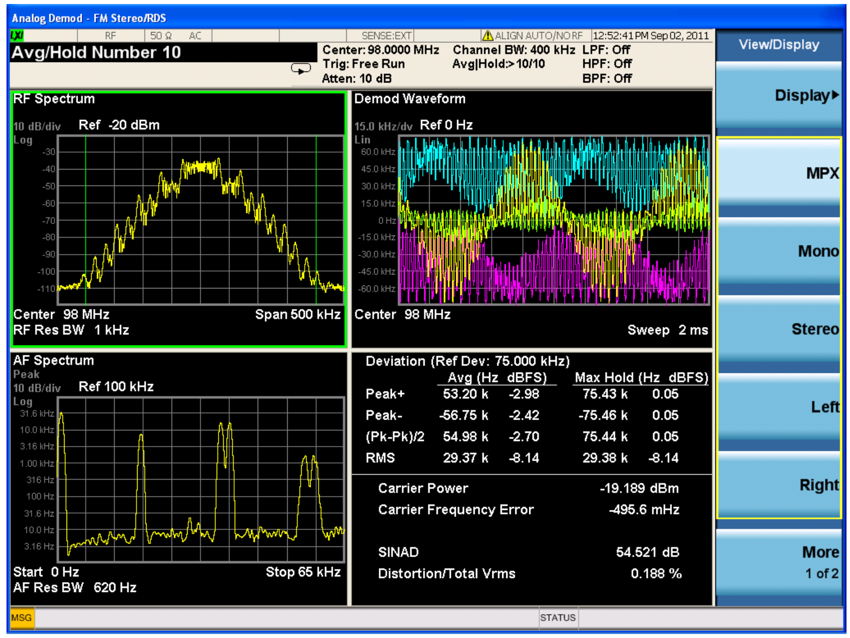


Figure 5. FM stereo MPX view/display with RF spectrum, AF spectrum, demod waveform and demodulation metrics results.

FM stereo mono/stereo/left/right view

For FM stereo, mono signal (L+R) occupies the lower part of the baseband spectrum (50 Hz to 15 kHz) in order to maintain backward compatibility with the previous monophonic FM systems. The stereo signal (L-R) is amplitude modulated onto a suppressed subcarrier at 38 kHz. A pilot signal is transmitted at 19 kHz and is used by the receiver to identify a stereo transmission and reconstruct L and R audio signals from the multiplexed signal. In the receiver, mono and stereo signals will be demodulated first and then the mono signal (L+R) is added to the stereo signal (L-R) to get the L signal, and the stereo signal (L-R) is subtracted to get the R signal. The mono/stereo/left/right views will display the demodulated waveform, AF spectrum and deviation, SINAD, distortion and THD results for the selected channel. Figure 6 is an example of FM stereo left channel demodulation results.

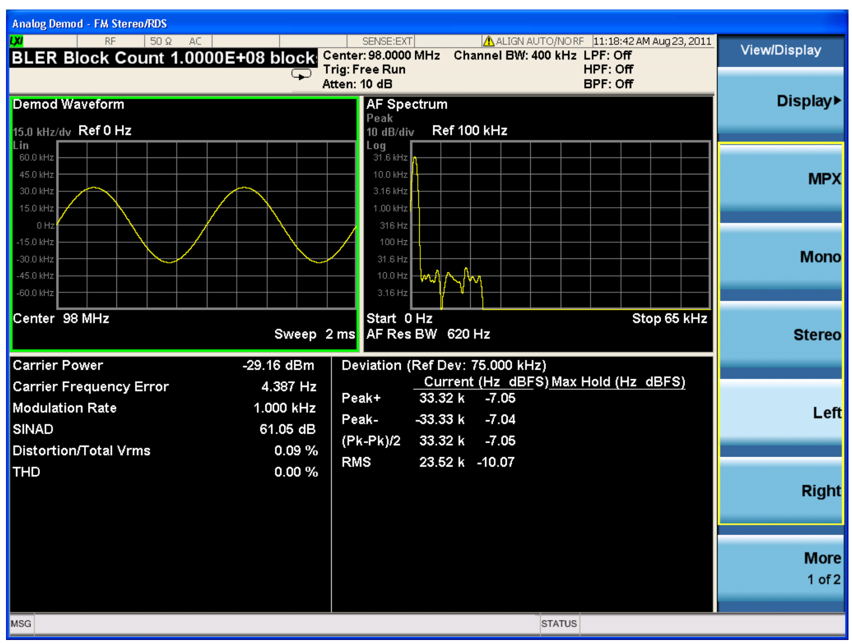


Figure 6. FM stereo mono/stereo/left/right view/display with demod waveform, AF spectrum and demodulation metrics results.

RDS/RBDS decoding results view

The main objectives of FM RDS/RBDS are:

- To enhance functionality for FM receivers
- To make the receivers more user-friendly by using features such as PI (program identification), PS (program service) name display, and, if applicable, automatic tuning for portable and car radios.

RDS/RBDS uses the 57 kHz subcarrier to carry the data at 1.1875 kbps bitrate. The 57 kHz subcarrier is chosen to be the third harmonic of the pilot tone. The deviation range of the FM carrier due to the unmodulated RDS/RBDS subcarrier is 1.0 kHz ± 7.5 kHz. Figure 7 is an example of the RDS/RBDS decoding view showing the results of the BLER, basic tuning and switching info, radio text, program item number and slow labeling codes, clock-time, and date information.

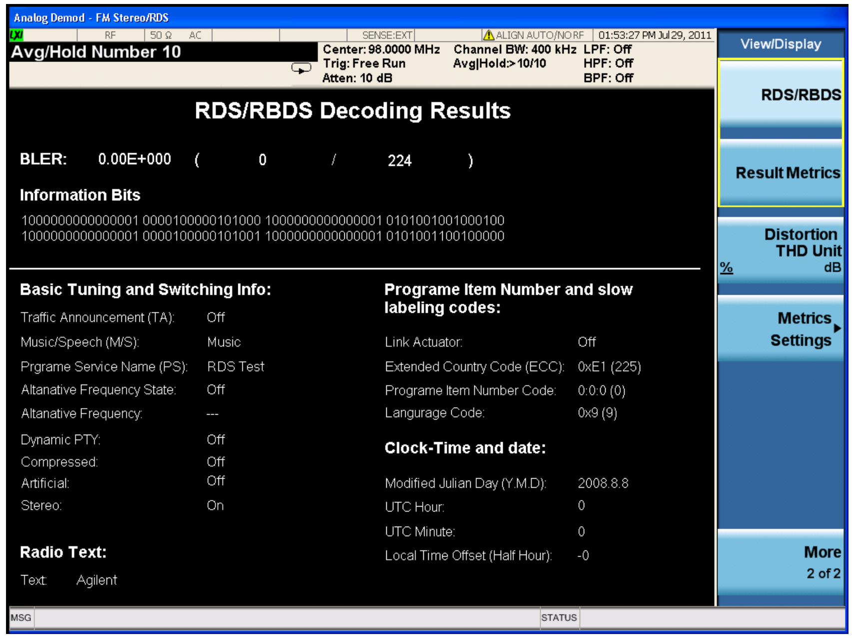


Figure 7. FM stereo RDS/RBDS decoding results view/display with BLER and decoded RDS information.

FM stereo numeric result summary view

Figure 8 shows the numeric result summary view with detailed MPX, mono, stereo, left, right, pilot, and RDS deviation, mod rate, SINAD and THD results in the top section. Furthermore, the left to right ratio, mono to stereo ratio, RF carrier power, RF carrier frequency error, 38 kHz carrier frequency error, and 38 kHz carrier phase error will be shown on the bottom section.

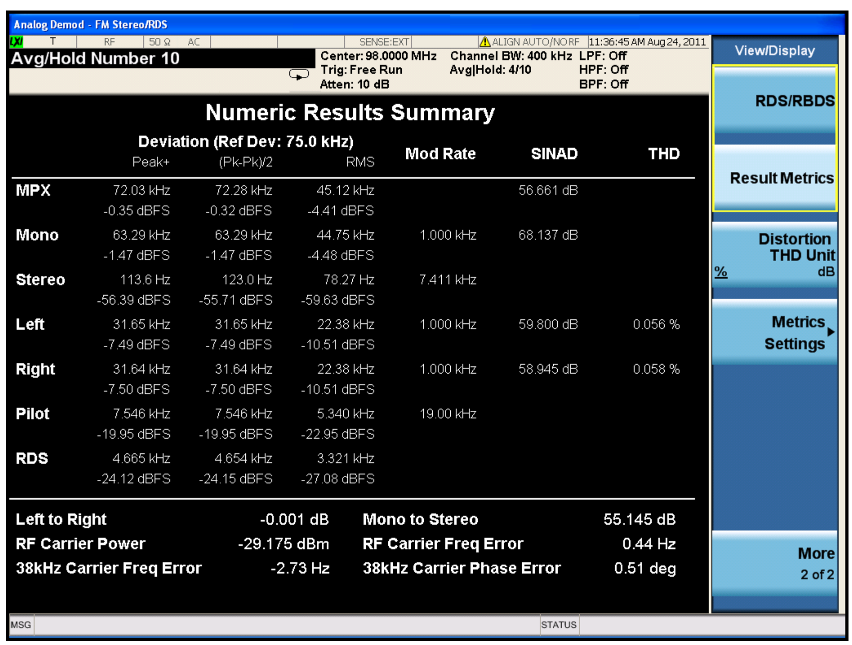


Figure 8. FM stereo numeric result metrics view/display with deviation, mod rate, SINAD, THD, left to right ratio, mono to stereo ratio and 38 kHz carrier frequency error, and phase error.

Measurement details

All of these measurements are available with the press of a button (Table 2). The measurements are fully remote controllable via the IEC/IEEE bus or LAN, using SCPI commands.

Table 2. One-button measurements provided by the M9063A measurement application.

Technology	**AM**	**PM**	**FM**	**FM stereo/RDS**
Measurement application	M9063A-2TP	M9063A-2TP	M9063A-2TP	M9063A-3TP
PXIe vector signal analyzer	M9391A, M9393A			
Measurement				
RF spectrum	▪	▪	▪	▪
RF carrier power (dBm)	▪	▪	▪	▪
RF carrier freq error (Hz)			▪	▪
AF spectrum	▪	▪	▪	MPX, mono, stereo, left, right
Demodulated waveform	▪	▪	▪	MPX, mono, stereo, left, right
Demodulation	AM depth (%)	PM deviation (dB)	FM deviation (dB)	FM deviation (dB)
Peak+	▪	▪	▪	▪
Peak–	▪	▪	▪	▪
(Pk-Pk)/2	▪	▪	▪	▪
RMS	▪	▪	▪	▪
Modulation rate (Hz)	▪	▪	▪	▪
SINAD (dB)	▪	▪	▪	▪
THD (dB or %)	▪	▪	▪	▪
Distortion/total power (dB or %)	▪	▪	▪	▪
Left to right ratio (dB)				▪
Mono to stereo ratio (dB)				▪
38 kHz carrier power (dB)				▪
38 kHz freq error (Hz)				▪
RDS/RBDS decoding				▪
BLER				▪
Basic tuning and switching Info				▪
Radio text				▪
Program item number and slow labeling code				▪
Clock time and date				▪

Ordering information

Software licensing and configuration

Transportable, perpetual license: This allows you to run the application using an embedded PXI PC controller or external PC, plus it may be transferred from one controller or PC to another. One software license supports up to four modular PXI VSA channels in one PXI mainframe.

Try before you buy!

Free 30-day trials of X-Series measurement applications provide unrestricted use of each application's features and functionality on your modular PXI VSA. See **www.keysight.com/find/M90XA** for more information.

You can upgrade!

Options can be added after your initial purchase.

All of our X-Series application options are license-key upgradeable.

The table below contains information on our transportable, perpetual licenses. For more information, please visit the product web pages.

M9063A analog demodulation X-Series measurement application

Description	Model-Option	Additional information
Analog demodulation	M9063A-2TP	
FM stereo/RDS	M9063A-3TP	

Measurement consistency you can trust

Did you know that X-Series measurement applications for modular instruments use the same measurement algorithms and programming commands as the bench top applications? This means you will get consistent measurement results if you use Keysight bench top and modular equipment across the product development cycle. Learn how this consistency and programming compatibility will increase the efficiency of your product development cycle.

www.keysight.com/find/measurementconsistency

Recommended hardware configuration

M9391A PXIe vector signal analyzer configuration

Model-Option	Description	Notes
M9391A-F03, -F06	3 GHz or 6 GHz frequency range	One required
M9391A-B04, -B10, or -B16	40 MHz, 100 MHz or 160 MHz analysis bandwidth	One required. -B16 recommended for fastest spectrum measurements with 89600 VSA software Option SSA.
M9391A-300	PXIe frequency reference	Recommended.
M9391A-UNZ	Fast tuning	Recommended. Highly recommended for fastest spectrum measurements with 89600 VSA software Option SSA.
M9391A-M01, -M05, or -M10	Memory options (512 MB, 2 GB, or 4 GB)	Recommend 1 Gsa/4 GB memory

M9393A PXIe performance vector signal analyzer configuration

Model-Option	Description	Notes
M9393A-F08, -F14, -F18, or -F27	8 GHz, 14 GHz, 18 GHz, or 27 GHz frequency range	One required
M9393A-B04, -B10, or -B16	40 MHz, 100 MHz or 160 MHz analysis bandwidth	One required. -B16 recommended for fastest spectrum measurements with 89600 VSA software Option SSA.
M9393A-300	PXIe frequency reference	Recommended.
M9393A-UNZ	Fast tuning	Recommended. Highly recommended for fastest spectrum measurements with 89600 VSA software Option SSA.
M9393A-M01, -M05, or -M10	Memory options (512 MB, 2 GB, or 4 GB)	Recommend 1 Gsa/4 GB memory

Related literature

- *N9063A & W9063A Analog Demodulation*, Self-Guided Demonstration, literature number 5990-5921EN
- *Spectrum Analysis Amplitude and Frequency Modulation*, Application Note 150-1, literature number 5954-9130EN
- *N9063A & W9063A Analog Demod*, Measurement Guide, part number: N9063-90006
- *M9391A PXIe Vector Signal Analyzer Datashee*t, literature number 5991-2603EN
- *M9391A & M9381A PXIe Vector Signal Analyzer & Generator* Configuration Guide, literature number 5991-0897EN
- *X-Series Measurement Applications for Modular Instruments* Brochure, literature number 5991-2604EN

Web

- Product page: **www.keysight.com/find/M9063A**
- X-Series measurement applications: **www.keysight.com/find/M90XA**
- X-Series signal analyzers: **www.keysight.com/find/X-Series**
- M9391A PXIe vector signal analyzer **www.keysight.com/find/M9391A**
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