# Keysight X-Series Signal Analyzer

This manual provides documentation for the following Analyzers:

N9040B UXA

N9030B PXA

N9020B MXA

N9010B EXA

N9000B CXA

> N9063C Analog Demod Measurement Application Measurement Guide



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Documentation is updated periodically. For the latest information about these products, including instrument software upgrades, application information, and product information, browse to one of the following URLs, according to the name of your product:

http://www.keysight.com/find/N9040B

http://www.keysight.com/find/N9030B

http://www.keysight.com/find/N9020B

http://www.keysight.com/find/N9010B

http://www.keysight.com/find/N9000B

To receive the latest updates by email, subscribe to Keysight Email Updates at the following URL:

http://www.keysight.com/find/MyKeysight

Information on preventing instrument damage can be found at:

www.keysight.com/find/PreventingInstrumentRepair

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Periodically, Keysight releases software updates to fix known defects and incorporate product enhancements. To search for software updates for your product, go to the Keysight Technical Support website at:

#### http://www.keysight.com/find/techsupport

# Table of Contents

### 1. Demodulating AM, FM, $\Phi$ M, FM Stereo/RDS Signals

Setting Up and Making a Measurement
Making the Initial Signal Connection
Using Analyzer Mode and Measurement Presets
Demodulating an AM Signal
Demodulating an FM Signal
Demodulating an FM Stereo/RDS Signal
Measuring L Only FM Stereo/RDS Signals
Measuring L=R FM Stereo/RDS Signals 19

### 2. Concepts

AM Concepts
FM Concepts
FM Stereo/RDS Concepts
FM Stereo
RDS/RBDS
Modulation Distortion Measurement Concepts
Purpose
Measurement Technique
Modulation SINAD Measurement Concepts
Purpose
Measurement Technique

Contents

Keysight X-Series Signal Analyzer N9063C Analog Demod Measurement Application

Measurement Guide

# 1 Demodulating AM, FM, $\Phi$ M, FM Stereo/RDS Signals

The Analog Demod measurement application provides the capability of demodulating AM (amplitude modulated), FM (frequency modulated),  $\Phi$ M (phase modulated), and FM Stereo/RDS (Radio Data System) signals. These measurements provide functionalities 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
- Displaying the RDS information in FM Stereo/RDS signals

The following topics can be found in this section:

"Setting Up and Making a Measurement" on page 8

"Demodulating an AM Signal" on page 9

"Demodulating an FM Signal" on page 11

"Demodulating an FM Stereo/RDS Signal" on page 13



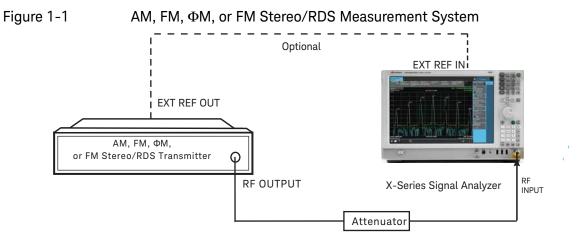
### Setting Up and Making a Measurement

### Making the Initial Signal Connection

Set the AM, FM,  $\Phi$ M, or FM Stereo/RDS transmitter under test to transmit the RF power. Connect the transmitting signal to the signal analyzer as shown below in Figure 1-1.

# 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 connector on the instrument front panel.

- 1. Connect the output AM, FM,  $\Phi$ M, or FM Stereo/RDS transmitter to the RF input port of the signal analyzer using appropriate cables, attenuators, and adapters.
- **2.** (Optional) If there is a frequency reference port on the transmitter, connect it to the EXT REF IN port on the signal analyzer for frequency synchronization.



After making the connection, see the **Input/Output** menu for details on selecting input ports and the **Amplitude** menu for details on setting the 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.

# Demodulating an AM Signal

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).

The signal under test is a 680 kHz signal with AM depth of 50% and AM rate of 1 kHz. Note that if you are using a broadcast AM signal in the United States, for example, the AM channels are broadcasting between 550 kHz and 1650 kHz.

Step	Action	Notes		
1. Select Analog Demod mode.	<ul> <li>Press Mode/Meas, Analog</li> <li>Demod, OK.</li> </ul>	The default settings for Analog Demod Mode are the AM measurement and Quad View		
2. Preset the mode.	– Press Mode Preset.			
<b>3.</b> Set the center frequency of the AM signal.	<ul> <li>Press Center Freq and enter</li> <li>680, kHz.</li> </ul>			
4. Adjust the sweep time and	– Press Sweep.			
view the measurement results as in the figure below.	<ul> <li>Press Demod Wfm Sweep</li> <li>Time and enter 2 ms.</li> </ul>	This is the default setting.		



# Demodulating AM, FM, $\Phi \text{M},$ FM Stereo/RDS Signals Demodulating an AM Signal

Step	Action	Notes
5. Listen to the demodulated AM signal.	<ul> <li>Press Meas Setup,</li> <li>Ad vanced Tab</li> </ul>	
	<ul> <li>Toggle Demod to Speaker to</li> <li>On</li> </ul>	You may need to adjust the volume as necessary.

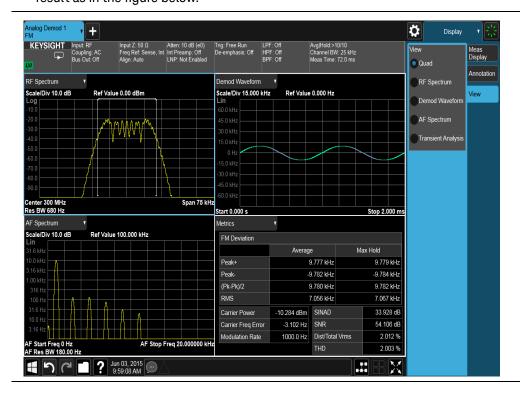
# Demodulating an FM Signal

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 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).

The signal under test is a signal at 300 MHz with FM deviation of 10 kHz and FM rate of 1 kHz. Note that if you are using a broadcast FM signal in the United States, for example, the FM channels are broadcasting between 87.7 MHz and 107.7 MHz.

Step	Action	Notes
1. Select Analog Demod mode.	<ul> <li>Press Mode/ Meas, Analog Demod.</li> </ul>	
2. Preset the mode.	– Press Mode Preset.	
3. Select FM measurement.	– Press Mode/ Meas, FM, OK.	The Quad view is the default setting.
<b>4.</b> Set the center frequency to the center of the FM signal.	<ul> <li>Tap Center Freq and enter 300, MHz.</li> </ul>	
<b>5.</b> Adjust the sweep time and view the measurement result as in the figure below.	<ul> <li>Press Sweep, Demod Wfm</li> <li>Sweep Time, 2, ms.</li> </ul>	This is the default setting.



Demodulating AM, FM,  $\Phi \text{M},$  FM Stereo/RDS Signals Demodulating an FM Signal

Step	Action	Notes
6. Listen to the demodulated FM signal.	<ul> <li>Press Meas Setup, Ad vanced Tab</li> </ul>	You may need to adjust the volume as necessary.
	<ul> <li>Toggle Demod to Speaker to</li> <li>On</li> </ul>	

Demodulating AM, FM,  $\Phi \text{M},$  FM Stereo/RDS Signals Demodulating an FM Stereo/RDS Signal

# Demodulating an FM Stereo/RDS Signal

This section demonstrates how to demodulate and listen to an FM Stereo signal and view key messages carried in RDS (Radio Data System). You can tune to an FM Stereo/RDS signal and view the measurement results of the multiplexed signal, the mono signal, the stereo signal, the left and right channel of the stereo signal, and the RDS messages in separate views.

Alternatively, the demodulated FM Stereo signal is also available as an audio output (to the speaker or headphone jack).

Measurement procedures for two typical FM Stereo/RDS signals are introduced here:

"Measuring L Only FM Stereo/RDS Signals" on page 13

"Measuring L=R FM Stereo/RDS Signals" on page 19

### Measuring L Only FM Stereo/RDS Signals

The parameters of the signal under test are:

FM reference deviation: 75 kHz

Pilot deviation: 10%

Pilot frequency: 19 kHz

Stereo frequency: 38 kHz

Left only tone: 1.0 kHz

RDS deviation: 6%

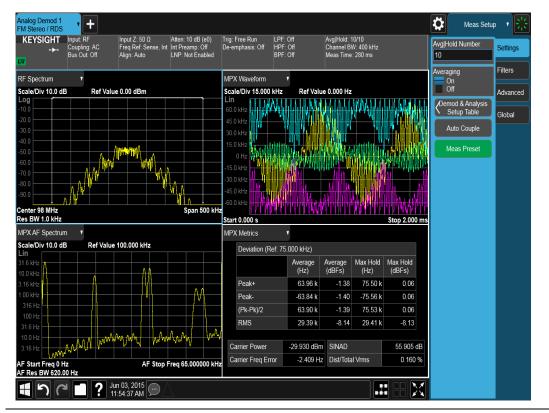
RDS frequency: 57 kHz

Step	Action	Notes
1. Select Analog Demod mode	<ul> <li>Press Mode/Meas, Analog</li> <li>Demod.</li> </ul>	
2. Preset the mode.	– Press Mode Preset.	
3. Select FM Stereo/RDS measurement.	<ul> <li>Press Mode/Meas, FM Stereo/RDS.</li> </ul>	
<b>4.</b> Set the center frequency to the center of the signal and set the AF stop frequency.	<ul> <li>Press FREQ Channel, Center Freq, 98, MHz.</li> <li>Press AF Stop Freq, 65, kHz.</li> </ul>	AF start frequency and AF stop frequency settings determine the span of the X axis in AF Spectrum window in MPX, Mono, Stereo, Left, and Right views.
5. Set the FM reference deviation.	<ul> <li>Press Meas Setup,</li> <li>Ad vanced, Ref Deviation,</li> <li>75, kHz.</li> </ul>	

Step	Notes	
<b>6.</b> View the measurement result of the multiplexed signal.	<ul> <li>Press Display, View, MPX.</li> </ul>	To display only the current trace in the Demod Waveform window, press <b>Meas</b> <b>Setup</b> and toggle <b>Averaging</b> to <b>Off</b> .

The figure below shows the measurement results of the multiplexed signal, including the mono part, stereo part, RDS/RBDS, and pilots. There are four windows:

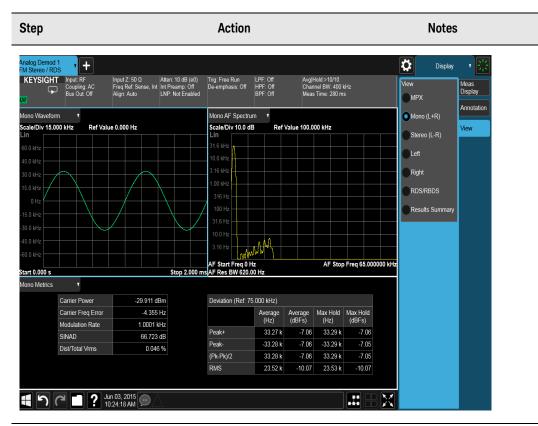
- RF Spectrum window (top left) displays the RF spectrum of the multiplexed signal.
- Demod Waveform window (top right) displays the baseband modulating signal in time domain. There
  are four traces in this window: maximum trace (in cyan), minimum trace (in magenta), average trace (in
  green), and current trace (in yellow).
- AF Spectrum window (bottom left) displays the modulating signal in frequency domain.
- Metric window (bottom right) displays the numeric measurement results.



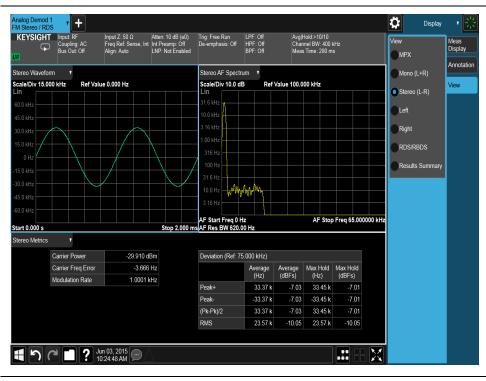
7. View the mono part of the multiplexed signal which corresponds to L+R.

- Press Display, View, Mono.

# Demodulating AM, FM, $\Phi \text{M},$ FM Stereo/RDS Signals Demodulating an FM Stereo/RDS Signal



- 8. View the stereo part of the multiplexed signal which corresponds to L-R.
- Press Display, View, Stereo.



Step	Action	Notes
<b>9.</b> (Optional) Set the baseband filters to improve the measurement results.	<ul> <li>Press Meas Setup, Filters.</li> </ul>	The highpass filter, lowpass filter, and bandpass filter can be combined as you like.
<b>10.</b> If pre-emphasis is used in the signal under test, set to use de-emphasis in the signal analyzer.	<ul> <li>Press Meas Setup, Filters, De-Emphasis and choose the appropriate de-emphasis filter.</li> </ul>	
11. View measurement results	– Press Display, View, Left.	

of the left channel.

Analog Demod 1 FM Stereo / RDS 0 + Display Input: RF Coupling: AC Bus Out: Off Input Z: 50 Ω Freq Ref: Sens Align: Auto Atten: 10 dB (e0) Int Preamp: Off LNP: Not Enabled Trig: Free Run De-emphasis: 50 Avg|Hold:>10/10 Channel BW: 400 kHz Meas Time: 280 ms KEYSIGHT LPF: Off HPF: Off BPF: Off Meas Display View Ģ MPX Annotation Left Waveform Left AF Spectrum Mono (L+R) Scale/Div 15.000 kHz Ref Value 0.000 Hz Scale/Div 10.0 dB Ref Value 100.000 kHz /iew Stereo (L-R) Left Right RDS/RBDS Results Summary AF Start Freq 0 Hz Stop 2.000 ms AF Res BW 620.00 Hz AF Stop Freq 65.000000 kH Start 0.000 s Left Metrics Carrier Power -29.902 dBm Deviation (Ref: 75.000 kHz) -5.061 Hz Max Hold Max Hold (Hz) (dBFs) Carrier Freq Error Average (Hz) Average (dBFs) Modulation Rate 1.0001 kHz Peak+ -7.46 -7.46 SINAD 66.960 dB -31.78 k -7.46 -31.79 k -7.46 Peak-Dist/Total Vrms 0.045 % (Pk-Pk)/2 31.79 k THD 0.014 % RMS 22.47 k -10.47 22.47 k -10.47 ー C I ? Jun 03, 2015 💬  $\mathbb{X}$ 

**12.** View measurement results – Press **Display**, **View**, **Right**. of the right channel.

The audio in the test signal is an L-only tone, so in the results of the right channel, the demod waveform is almost zero.

# Demodulating AM, FM, $\Phi \text{M},$ FM Stereo/RDS Signals Demodulating an FM Stereo/RDS Signal

tep		Action					Note	S
Coupling: AC	nput Z: 50 Ω Atten: 10 dB (eC Freq Ref. Sense, Int Int Preamp: Off Align: Auto LNP: Not Enabl	De-emphasis: 50µs	LPF: Off HPF: Off BPF: Off	Avg ł Chan Meas	Hold:>10/10 mel BW: 400 l s Time: 280 m	xHz s		Neas Display
Right Waveform		Right AF Spectru	n v					nnotation
Scale/Div 15.000 kHz Ref Value	0.000 H-	Scale/Div 10.0 dl		Value 100.0	00 1-11-		Mono (L+R)	
_in	0.000 H2	Lin	Ref	value 100.0	oo knz		Stereo (L-R)	fiew
60.0 kHz		31.6 kHz						
45.0 kHz		10.0 kHz					Left	
30.0 kHz		3.16 kHz					Right	
		1.00 kHz						
		316 Hz					RDS/RBDS	
0 Hz		100 Hz					Results Summary	
		31.6 Hz					Results Summary	
		10.0 Hz						
		— H.						
		3.16 Hz	handan					
		AF Start Freq 0 H	z		AF Stop	Freq 65.000000 k	Hz	
tart 0.000 s	Stop 2.00	0 ms AF Res BW 620.0	0 Hz					
ight Metrics 🔹								
Carrier Power	-29.901 dBm	Deviation (Ref: 75	.000 kHz)					
Carrier Freq Error	-5.333 Hz		Average		Max Hold			
Modulation Rate	1.0001 kHz		(Hz)	(dBFs)	(Hz)	(dBFs)		
SINAD	10.234 dB	Peak+	49.80	-63.56	58.33	-62.18		
Dist/Total Vrms	31.046 %	Peak-	-46.43	-64.17	-56.26	-62.50		
THD	10.251 %	(Pk-Pk)/2	48.11	-63.86	57.29	-62.34		
		RMS	24.85	-69.59	25.90	-69.24		
	03, 2015 27:38 AM						1	
	27:38 AM 💭 🔼							

**13.** View the RDS/RBDS results.

 Press Display, View, RDS/RBDS.

The figure below displays the BLER result and the information bits in the upper part and key RDS messages like basic tuning and switch information, radio text, and so on in the lower part. For more information, refer to "Basic Structure of RDS" on page 31 and "BLER" on page 31.

Keysight ,	Coupling: AC Fr	put Z: 50 Ω eq Ref: Sense, In ign: Auto	Atten: 10 dB (e0) t Int Preamp: Off LNP: Not Enabled	De-emphasis: 50µs	LPF: Off HPF: Off BPF: Off	Avg Hold:>10/10 Channel BW: 400 kl Meas Time: 280 ms	łz	View MPX	Meas Display Annotatio
RDS/RBDS	۳							Mono (L+R)	, annotatio
	BLER	0.00E+000 ( 0	) / 192 )					Stereo (L-R)	View
	Information Bits			0000 01010010011000 0001 10101011001111				Left	
	Basic Tuning and	Switching Info		Program Item	Number and Slov	w Labelling Code:			
	Traffic Announceme	ent (TA)	Off	Link Actuator		Off		Right	
	Music/Speech (M/S		Music	Extended Coun	try Code (ECC)	0xE1 (225)		RDS/RBDS	
	Program Service N	ame (PS)	RDS Test	Program Item N	lumber Code	0:0:0 (0)		č	
	Alternative Frequer	ncy State	On	Language Code	9			Results Summary	
	Alternative Frequer	ю	91.5MHz						
	Dynamic PTY		Off		Clock Time and Date				
	Compressed		Off	Modified Julian	Day (Y.M.D)	2008.8.8			
	Artificial		Off	UTC Hour		0			
	Stereo		On	UTC Minute		0			
				Local Time Offs	set (Half Hour)	-0			
	Radio Text		0 F 7 4						
	Text		Radio Text						

Step			Action				Notes		
	v a summary ric measure ts.		– Press D Result			',			
NC	CIE Cr th	osstalk is disp e audio signal	layed as "Mon	o to Stei . only or	reo". No	rmally,	ayed as "Left to Right" and the mono to stereo the left to right separation test is taken when to stereo crosstalk test is taken when the audic		
nalog Demod 1 M Stereo / RDS KEYSIGHT	Input: RF Input Z: 5 Coupling: AC Freq Ref: Bus Out: Off Align: Auf	Sense, Int Int Preamp: Off	Trig: Free Run De-emphasis: 50µs BPF: Off	Chan	lold:>10/10 nel BW: 400 kHz Time: 280 ms		Display View Meas Mex Display		
Result Metrics	•						Mono (L+R) Stereo (L-R)		
		Deviation (Ref: 75.000 kHz		Mod Rate	SINAD	THD	Left		
MPX	Peak+ 63.18 kHz -1.49 dBFS	(Pk-Pk)/2 63.54 kHz -1.44 dBFs	RMS 29.40 kHz -8.14 dBFS		56.249 dB		Right		
Mono	33.28 kHz -7.06 dBFS				66.410 dB		RDS/RBDS		
Stereo	33.38 kHz -7.03 dBFS	33.38 kHz -7.03 dBFs	23.57 kHz -10.05 dBFS	1.0001 kHz					
Left	31.77 kHz -7.46 dBFS	31.78 kHz -7.46 dBFs	22.46 kHz -10.47 dBFS	1.0001 kHz	66.941 dB	0.015 %	Results Summary		
Right	50.03 Hz -63.52 dBFS	48.43 Hz -63.80 dBFS	24.94 Hz -69.56 dBFS	1.0001 kHz	10.010 dB	10.264 %			
Pilot	7.513 kHz -19.98 dBFS								
RDS	4.439 kHz -24.56 dBFS	4.445 kHz -24.54 dBF	3.130 kHz -27.59 dBFS						
	Left To Right	59.092 dB	Mono To Stereo		-0.018 dB				
	RF Carrier Power	-29.900 dBm	RF Carrier Freq Error		-3.894 Hz				
	38 kHz Carrier Freq Error	0.00 Hz	38 kHz Carrier Phase Er	ror	0.00 deg				
	lun 03 201						2		
ר <b>ב</b>	Jun 03, 201: 10:28:49 AN								
	en to the der ereo signal.	nodulated		<ul> <li>Press Meas Setup,</li> <li>Ad vanced Tab</li> </ul>			You may need to adjust the volume as necessary.		
			– Toggle to <b>On</b>	Demo	d to S	peak	er		

Demodulating AM, FM,  $\Phi \text{M},$  FM Stereo/RDS Signals Demodulating an FM Stereo/RDS Signal

### Measuring L=R FM Stereo/RDS Signals

The parameters of the signal under test are as below.

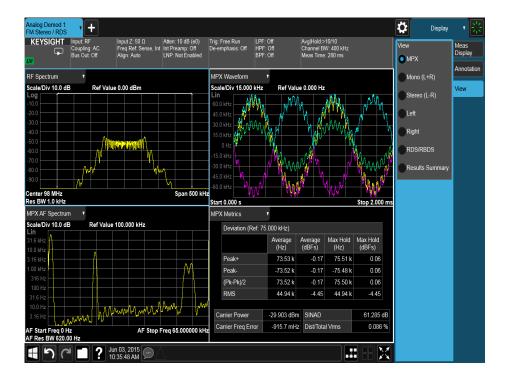
FM reference deviation: 75 kHz Pilot deviation: 10% Pilot frequency: 19 kHz Stereo frequency: 38 kHz Left = Right tone: 1.0 kHz RDS deviation: 6% RDS frequency: 57 kHz

Step	Action	Notes
1. Select Analog Demod mode.	<ul> <li>Press Mode, Analog</li> <li>Demod.</li> </ul>	
2. Preset the mode.	– Press Mode Preset.	
3. Select FM Stereo/RDS measurement.	<ul> <li>Press Mode/Meas, FM Stereo/RDS.</li> </ul>	
<b>4.</b> Set the center frequency to the center of the signal and set the AF stop frequency.	<ul> <li>Press FREQ, Center Freq, 98, MHz.</li> <li>Press AF Stop Freq, 65, kHz.</li> </ul>	AF start frequency and AF stop frequency settings determine the span of the X axis in AF Spectrum window in MPX, Mono, Stereo, Left, and Right views.
5. Set the FM reference deviation.	<ul> <li>Press Meas Setup,</li> <li>Ad vanced, Ref Deviation,</li> <li>75, kHz.</li> </ul>	
<b>6.</b> View the measurement result of the multiplexed signal.	<ul> <li>Press Display, View, MPX.</li> </ul>	To display only the current trace in the Demod Waveform window, press <b>Meas</b> <b>Setup</b> and toggle <b>Averaging</b> to <b>Off</b> .

Step Action Notes
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The figure below shows measurement results of the multiplexed signal, including the mono part, the stereo part, RDS/RBDS, and pilots. There are four windows:

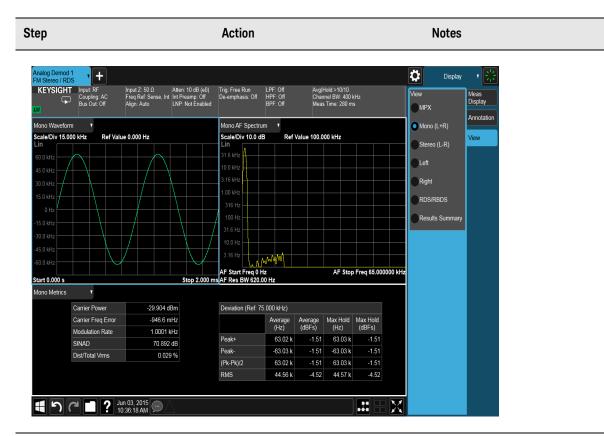
- RF Spectrum window (top left) displays the RF spectrum of the multiplexed signal.
- Demod Waveform window (top right) displays the baseband modulating signal in time domain. There are four traces in this window: maximum trace (in cyan), minimum trace (in magenta), average trace (in green), and current trace (in yellow).
- AF Spectrum window (bottom left) displays the modulating signal in the frequency domain.
- Metric window (bottom right) displays the numeric measurement results.



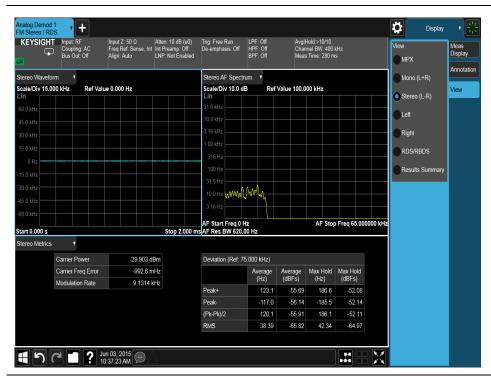
7. View the mono part of the multiplexed signal which corresponds to L+R.

- Press **Display**, View, Mono.

# Demodulating AM, FM, $\Phi \text{M},$ FM Stereo/RDS Signals Demodulating an FM Stereo/RDS Signal



- 8. View the stereo part of the multiplexed signal which corresponds to L- R.
- Press View/Display, Stereo.



Step	Action	Notes
<b>9.</b> (Optional) Set the baseband filters to improve the measurement results.	<ul> <li>Press Meas Setup, Filters.</li> </ul>	The highpass filter, lowpass filter, and bandpass filter can be combined as you like.
<b>10.</b> If pre-emphasis is used in the signal under test, set to use de-emphasis in the signal analyzer.	<ul> <li>Press Meas Setup, Filters, De-Emphasis and choose the appropriate de-emphasis filter.</li> </ul>	
11. View the measurement results of the left channel.	- Press <b>Display</b> , <b>View, Left</b> .	In this test case, the left channel equals to the right channel.

KEYSIGH ⊊		Freq Ref: Sense, Int	Atten: 10 dB (e0) Int Preamp: Off LNP: Not Enabled	Trig: Free Run De-emphasis: 75µs	LPF: Off HPF: Off BPF: Off	Cha	Hold: 5/10 nnel BW: 400   s Time: 280 m			View MPX	Meas Display
.eft Waveform	1 <b>V</b>			Left AF Spectrum	۲					Mono (L+R)	Annotatio
Scale/Div 15.0	000 kHz Ref Val	Scale/Div 10.0 df	Scale/Div 10.0 dB Ref Value 100.000 kHz						View		
				31.6 kHz						Stereo (L-R)	
60.0 kHz				10.0 kHz						●Left	
45.0 kHz				3.16 kHz						Right	
30.0 kHz	$\frown$			1.00 kHz						· ·	
15.0 kHz				316 Hz						RDS/RBDS	
0 Hz				100 Hz						Results Summary	
				31.6 Hz						· ·	
				10.0 Hz							
				3.16 Hz							
60.0 kHz				AF Start Freq 0 H	A.A.		AE Stor	Freq 65.000	000 644		
tart 0.000 s			Stop 2.000 m	sAF Res BW 620.0			AI Olo	110000	0000 Kinz		
.eft Metrics	*										
	Carrier Power	-29.903 di	Зm	Deviation (Ref: 75	.000 kHz)						
	Carrier Freq Error Modulation Rate	-861.6 m 1.0001 k			Average (Hz)	Average (dBFs)	Max Hold (Hz)	Max Hold (dBFs)			
	SINAD	67.676		Peak+	28.51 k	-8.40	28.51 k	-8.40			
	Dist/Total Vrms	0.042		Peak-	-28.51 k	-8.40	-28.51 k	-8.40			
	THD	0.042		(Pk-Pk)/2	28.51 k	-8.40	28.51 k	-8.40			
		0.007		RMS	20.16 k	-11.41	20.16 k	-11,41			

**12.** View the RDS/RBDS results.

 Press Display, View, RDS/RBDS.

The figure below displays the BLER result and the information bits in the upper part and key RDS messages like basic tuning and switch information, radio text, and so on in the lower part. For more information, refer to "Basic Structure of RDS" on page 31 and "BLER" on page 31.

Analog Demod 1 FM Stereo / RDS KEYSIGHT	Input: RF Coupling: AC	Freq F		Atten: 10 dB (e0) Int Preamp: Off	Trig: Free Run De-emphasis: 50µs	LPF: Off HPF: Off	Avg Hold:>10/10 Channel BW: 400 ki	Ηz	Display View	Meas Display
LVI	Bus Out: Off	Align:	Auto	LNP: Not Enabled		BPF: Off	Meas Time: 280 ms		MPX	
RDS/RBDS									Mono (L+R)	Annotatio
	BLER		0.00E+000 ( 0	/ 192 )						View
	DEEK				00000 0101001001100	001 0110010001101	001		Stereo (L-R)	
	Information E			00001 01000000001	Left					
	Basic Tuning	and Sw	itching Info		Program Item	Number and Slo	w Labelling Code:			
	Traffic Annour	ncement	(TA)	Off	Link Actuator		Off		Right	
	Music/Speech	n (M/S)		Music	Extended Cour	ntry Code (ECC)	0xE1 (225)	)	RDS/RBDS	
	Program Serv	Program Service Name (PS)			Program Item I	Number Code	0:0:0 (0)	0:0:0 (0)		
	Alternative Fr	equency	State	On	Language Cod	e			Results Summary	
	Alternative Frequency Dynamic PTY Compressed Artificial Stereo			91.5MHz						
				Off		Clock Time and Date				
				Off	Modified Julian	Day (Y.M.D)	2008.8.8			
				Off	UTC Hour		0			
				On	UTC Minute		0			
					Local Time Off	fset (Half Hour)	-0			
	Radio Text									
	Text			Radio Text						

- **13.** View a summary of the numeric measurement results.
- Press **Display**, **View, Result Summary**.

NOTE       In this view, the left to right separation result is displayed as "Left to Right" and the mono to stered crosstalk is displayed as "Mono to Stered". Normally, the left to right separation test is taken when the audio signal under test is L only or R only; mono to stereo crosstalk test is taken when the audio signal under test is L en or L=-R.         Normalized control of the Right Control	Step			A	ction					Notes		
Misseero /ROS         More To State         Main: 10 dB (eff)         The emphasis: 7 sign         LEF: Off         Angihodd-30/10         Meas	NOT	LE cro the	osstalk is c audio sig	displaye gnal und	d as "M ler test	ono to S is L only	Stereo".	Normal	ly, the le	ft to right sepa	ration test is taken when	
Image: Deviation (Ref. 76 000 Mz)         RMS         Mod Rate         SIMD         THD           MPX         73 51 Mzlz         0.17 dBFS         73 50 Mzlz         1.18 dBFS         44 39 Mzlz         4.45 dBFS         61 200 dB         Image: Deviation (Ref. 75 000 Mzlz)         Image:	FM Stereo / RDS KEYSIGHT	Input: RF Input Coupling: AC Freq I	Ref: Sense, Int Int Pre	eamp:Òff		5µs HPF:Off	Chan	nel BW: 400 kHz		View I MPX	Display	
Peakt         (Pk:Pk)/2         RMS         Mod Rate         SNAD         THD           MPX         73.51 kHz         -0.17 dBFS         73.50 kHz         -0.18 dBFS         44.93 kHz         -4.45 dBFS         61.200 dB         Image: Comparison of the compar	Result Metrics	۲									view	
MPX       73.51 kHz       0.17 dBFS       73.50 kHz       0.18 dBFS       44.93 kHz       44.45 dBFS       61.200 dB       m         Mono       63.02 kHz       1.51 dBFS       63.03 kHz       1.51 dBFS       44.56 kHz       44.25 dBFS       1001 kHz       70.858 dB       m <th<< td=""><td></td><td>Poakt</td><td></td><td></td><td>DI</td><td>49</td><td>Mod Rate</td><td>SINAD</td><td>THD</td><td>Left</td><td></td></th<<>		Poakt			DI	49	Mod Rate	SINAD	THD	Left		
Stereo       116 3 Hz       -56 19 dBFS       115 7 Hz       -56 24 dBFS       38.46 Hz       -65 80 dBFS       9.4081 kHz       Image: Constraint of the constra	MPX			,				61.200 dB		Right		
Stereo       116 3 Hz       56 19 dBFS       115 7 Hz       56 24 dBFS       38 46 Hz       66 80 dBFS       9 4081 kHz       Image: Comparison of the text of	Mono	63.02 kHz -1.51 dE	FS 63.03 kHz	-1.51 dBFS	44.56 kHz	-4.52 dBFS	1.0001 kHz	70.858 dB		RDS/RBDS		
Left       28.51 kHz       -8.40 dBFS       28.51 kHz       -8.40 dBFS       20.16 kHz       -11.41 dBFS       1.0001 kHz       67.998 dB       0.009 %         Right       28.51 kHz       -8.40 dBFS       28.51 kHz       -8.40 dBFS       20.16 kHz       -11.41 dBFS       1.0001 kHz       67.998 dB       0.009 %         Pilot       7.506 kHz       -19.99 dBFS       28.51 kHz       -8.40 dBFS       20.16 kHz       -11.41 dBFS       1.0001 kHz       67.961 dB       0.008 %         Pilot       7.506 kHz       -19.99 dBFS       5.303 kHz       -23.01 dBFS       19.000 kHz       -       -       -         RDS       4.465 kHz       -24.50 dBFS       4.464 kHz       24.51 dBFS       3.129 kHz       -27.59 dBFS       -       -       -         Left To Right       0.000 dB       RF Carrier Power       -29.909 dBm       RF Carrier Freq Error       -1.029 Hz       30 kHz Carrier Freq Error       -1.029 Hz       30 kHz Carrier Phase Error       0.05 deg         30 kHz Carrier Freq Error       45.88 Hz       30 kHz Carrier Phase Error       0.05 deg       0.05 deg       -       -	Stereo	116.3 Hz -56.19 dE	FS 115.7 Hz	-56.24 dBFS	38.46 Hz	-65.80 dBFS	9.4081 kHz					
Pilot       7.506 kHz       -19.99 dBFS       7.506 kHz       -19.99 dBFS       5.303 kHz       2.301 dBFS       19.000 kHz       Image: Comparison of the compar	Left	28.51 kHz -8.40 dE	FS 28.51 kHz	-8.40 dBFS	20.16 kHz	-11.41 dBFS	1.0001 kHz	67.998 dB	0.009 %	Results Summary		
RDS       4.465 kHz       24.50 dBFS       4.464 kHz       24.51 dBFS       3.129 kHz       -27.59 dBFS         Left To Right       0.000 dB       0.000 dB       Mono To Stereo       61.293 dB         RF Carrier Power       -229 909 dBm       RF Carrier Freq Error       -1.029 Hz         38 kHz Carrier Freq Error       45.88 Hz       38 kHz Carrier Phase Error       0.05 deg	Right	28.51 kHz -8.40 dE	FS 28.51 kHz	-8.40 dBFS	20.16 kHz	-11.41 dBFS	1.0001 kHz	67.981 dB	0.008 %			
Left To Right     0.000 dB     Mono To Stereo     61.293 dB       RF Carrier Power     -29 909 dBm     RF Carrier Freq Error     -1.029 Hz       38 kHz Carrier Freq Error     45 88 Hz     38 kHz Carrier Phase Error     0.05 deg	Pilot	7.506 kHz -19.99 dE	FS 7.506 kHz	-19.99 dBFS	5.303 kHz	-23.01 dBFS	19.000 kHz					
RF Carrier Power     -29 909 dBm     RF Carrier Freq Error     -1 029 Hz       38 kHz Carrier Freq Error     45 88 Hz     38 kHz Carrier Phase Error     0 05 deg	RDS	4.465 kHz -24.50 dE	FS 4.464 kHz	-24.51 dBFS	3.129 kHz	-27.59 dBFS						
RF Carrier Power     -29.909 dBm     RF Carrier Freq Error     -1.029 Hz       38 kHz Carrier Freq Error     45.88 Hz     38 kHz Carrier Phase Error     0.05 deg		Left To Right		0 000 dB	Mono To Si	tereo		61 293 dB				
		-	-29									
		38 kHz Carrier Freq E	ror	45.88 Hz	38 kHz Car	rrier Phase Erro	or	0.05 deg				
	<b>1</b> 76	Jun 03, 2 10:41:27	015 AM									
14. Listen to the demodulated FM stereo signal.       -       Press Meas Setup, Ad vanced Tab       You may need to adjust the volume as necessary.												

- Toggle **Demod to Speaker** 

to **On** 

Keysight X-Series Signal Analyzer N9063C Analog Demod Measurement Application

Measurement Guide

# 2 Concepts

The following topics can be found in this section:

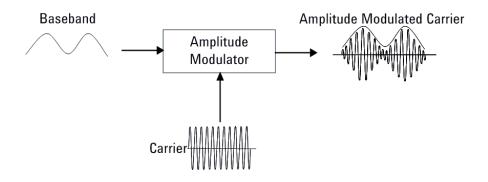
AM Concepts on page 26 FM Concepts on page 28 FM Stereo/RDS Concepts on page 30 Modulation Distortion Measurement Concepts on page 32 Modulation SINAD Measurement Concepts on page 33



Concepts AM Concepts

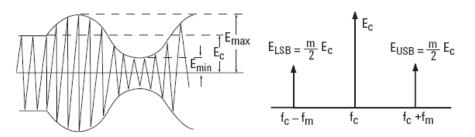
### AM Concepts

### Figure 2-1 AM waveform



In AM (Amplitude Modulation), the instantaneous amplitude of the modulated carrier signal changes 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 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

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

Concepts AM Concepts

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

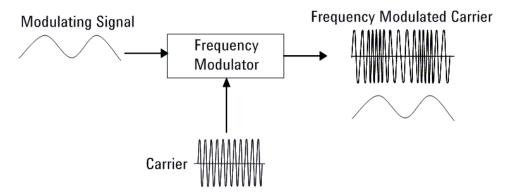
 $(E_{SB} \S E_c)dB + 6dB = 20\log m$ 

Concepts FM Concepts

### 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 changes 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,  $\beta$ , is expressed by this equation:

Equation 2-3

$$\beta = \Delta \times f_p / f_m = \Delta \Phi_p$$

Where  $\Delta fp$  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  $\beta$ , 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.

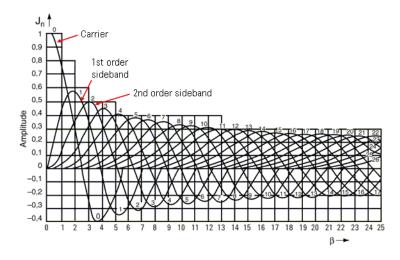
Concepts FM Concepts

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 the modulation index,  $\beta$ . 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.

Concepts FM Stereo/RDS Concepts

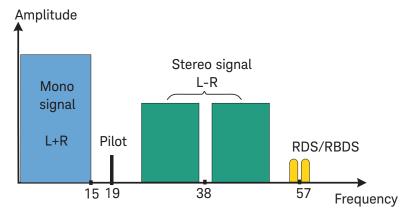
# FM Stereo/RDS Concepts

FM stereo is an enhancement of FM using stereo multiplexing. An FM stereo signal carries stereophonic programs in which different contents are transmitted for L (left) and R (right) audio channels.

RDS (Radio Data System) is the text information such as traffic, weather, and radio station information carried in FM signals. This information can be displayed on the screen of the end-user's device.

The following figure shows the baseband spectrum of the FM stereo signal including RDS data.

Figure 2-5 Baseband spectrum of the FM Stereo/RDS signal



### FM Stereo

The FM stereo multiplexed signal consists of a mono (L+R) signal, a stereo (L-R) signal, and a pilot signal.

As shown in Figure 2.5, the mono (L+R) signal occupies the lower part of the baseband spectrum (50 Hz  $\sim$  15 kHz) to keep backward compatibility with the previously monophonic FM systems. The (L-R) signal 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, the (L+R) signal is added to the (L-R) signal to get the L signal, and subtracts the (L-R) signal to get the R signal.

### RDS/RBDS

The standard documents for RDS and RBDS are as follows:

- IEC 62106: Specification of the radio data system (RDS) for VHF/FM sound broadcasting in the frequency range from 87.5 to 108.0 MHz.
- EIA/NAB NRSC: United States RBDS standard Specification of the radio broadcast data system (RBDS).

Concepts FM Stereo/RDS Concepts

RBDS is the United States version of RDS. Both RDS and RBDS are intended for application to VHF/FM sound broadcasts in the range 87.5 MHz to 108.0 MHz which may carry either stereophonic or monophonic programs.

The main objectives of RDS/RBDS:

- 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.

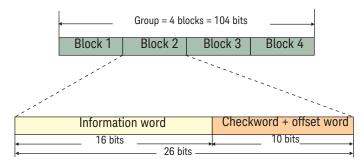
As shown in Figure 2-5, RDS/RBDS uses the 57 kHz subcarrier to carry the data at 1.1875 kbps bitrate. The 57 kHz is chosen to be the third harmonic of the pilot tone. The deviation range of the FM carrier due to the unmodulated RDS/RBDS subcarrier is from  $\pm 1.0$  kHz to  $\pm 7.5$  kHz.

### **Basic Structure of RDS**

The basic structure of RDS is shown in **Figure 2-6**, in which the largest element is called a group including 4 blocks of 26 bits each. Each block comprises an information word (16 bits) and a checkword (10 bits).

The information word is used to transmit information to the end user. The 10-bit checkword plus offset word are used to provide error protection and block and group synchronization information.

#### Figure 2-6 Basic structure of RDS



### BLER

BLER (block error rate) is the ratio of the number of un-correctable blocks to the total number of blocks received. Normally, BLER should be less than 5%.

# 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<sub>signal</sub> = the power of the wanted modulating signal, and

 $\mathsf{P}_{total}$  -  $\mathsf{P}_{signal}$  = 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 the 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 the 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.



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