

N9063A & W9063A Analog Demod Measurement Application Measurement Guide



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Demodulating AM, FM, ΦM, FM Stereo/RDS Signals

The Analog Demod measurement application provides the capability of demodulating AM (amplitude modulated), FM (frequency modulated), Φ 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 11 "Demodulating an FM Signal" on page 12 "Demodulating an FM Stereo/RDS Signal" on page 13

Setting Up and Making a Measurement

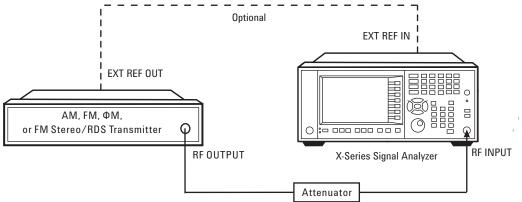
Making the Initial Signal Connection

Set the AM, FM, Φ M, or FM Stereo/RDS transmitter under test to transmit the RF power. Connect the transmitting signal to the signal analyzer as below.

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 front panel.

- 1. Connect the output AM, FM, Φ 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.

Figure 1-1 AM, FM, Φ M, or FM Stereo/RDS Measurement System



After making the connection, see the **Input/Output** 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 1-1The 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.
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 H	Functions for Making	Measurements
10010 1-2	man neys and I	unchons jor 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

NOTE

Table 1-2	Main Keys and Functions for Making Meas	uromonts
	main Reys and I unclions for making meas	aremenus

Step	Primary Key	Setup Keys	Related Keys
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

If you encounter a problem, or get an error message, see the guide "**Instrument Messages**", which is provided on the Documentation CD ROM, and in the instrument here:

 $C:\Program Files\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.$

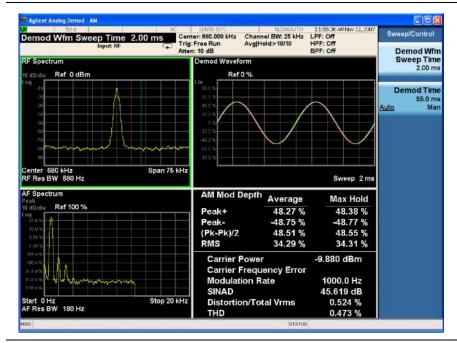
Demodulating an AM Signal

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.	Press Mode, Analog Demod.	
2 Preset the mode.	Press Mode Preset.	
3 Select AM measurement.	Press Meas, AM.	
4 Set the center frequency of the AM signal.	Press FREQ Channel, Center Freq, 680, kHz.	
5 Adjust the sweep time and view the measurement results as in the figure below.	Press Sweep/Control, Demod Wfm Sweep Time, 2, ms.	



6 Listen to the demodulated AM signal.

Press Meas Setup, Demod to Speaker.

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.	Press Mode, Analog Demod.	
2 Preset the mode.	Press Mode Preset.	
3 Select FM measurement.	Press Meas, FM.	
4 Set the center frequency to the center of the FM signal.	Press FREQ Channel, Center Freq, 300, MHz.	
5 Adjust the sweep time and view the measurement result as in the figure below.	Press Sweep, Demod Wfm Sweep Time, 2, ms.	

Input: RF Trig:	SENSE INT ALIGNAUTO D311144 PMNov 12,2007. er: 300.000 MHz Channel BW: 25 kHz LPF: Off Free Run Avg[Hold>10/10 HPF: Off : 10 dB BPF: Off	View/Display
	Demod Waveform	Display
In HB/div Ref 0 dBm	Ref 0 Hz	
-10 -70 -70 -70 -70 -70 -70 -70 -70 -70 -7	Lin (923)44 (639)47 353/40 153/40	Quad Vie
	0/02 351/02 393 ML 453/02 653/02 653/02	RF Spectru
Center 300 MHz Span 75 kHz RF Res BW 680 Hz AF Spectrum	Sweep 2 ms	Demo
Vesk 0 480/iv Ref 100 kHz 31 8 V2 100 kHz 100 kHz 10	Proceeding Average Max Hold Peak+ 10.03 kHz 10.04 kHz Peak- -9.894 kHz -9.908 kHz (Pk-Pk)/2 9.964 kHz 9.973 kHz	AF Spectru
100 Http:///////////////////////////////////	Carrier Frequency Error 65.86 Hz	Distortion THD Un % c
Start 0 Hz Stop 20 kHz FRes BW 190 Hz	Modulation Rate 1000.0 Hz SINAD 40.030 dB Distortion/Total Vrms 0.997 % THD 0.247 %	Metrics Settings

6 Listen to the demodulated FM signal.

Press Meas Setup, Demod to Speaker.

You may need to adjust the volume as necessary.

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 as below.

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%

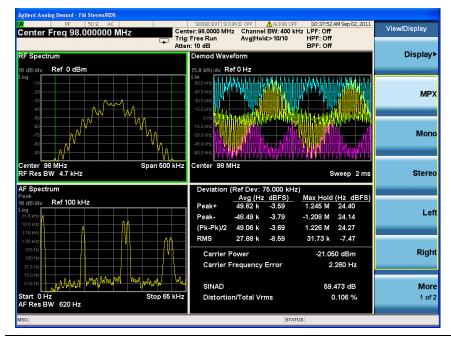
RDS frequency: 57 kHz

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

Step	Action	Notes
6 View the measurement result of the multiplexed signal.	Press View/Display, MPX.	To display only the current trace in the Demod Waveform window, press Meas Setup and toggle Avg/Hold Num to Off .

The figure below shows measurement results of the multiplexed signal, including 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 View/Display, Mono.

tep		Action		Note
Agilent Analog Demod - FM Stereo/RD) XI RF 50 Ω AC Center Freq 98.000000	MHz C	SENSE:EXT AL		View/Display
Demod Waveform 15.0 kHz/dv Ref 0 Hz		rig: Free Run Avg Hold: tten: 10 dB AF Spectrum Peak 10 dB/div Ref 100 kHz	>10/10 HPF: Off BPF: Off	Display▶
Lin 60.0 Hrz 45.0 Hrz 30.0 Hrz 15.0 Hrz		Log 31.6 kHz 10.0 kHz 3.16 kHz 1.00 kHz		МРХ
0 Hz -15 0 Hz -30 0 Hz -45 0 Hz -60 0 Hz		316 Hz 100 Hz 31.6 Hz 10.0 Hz 3.16 Hz		Mono
enter 98 MHz	Sweep 2	Start 0 Hz 2 ms AF Res BW 620 Hz	Stop 65 kHz	Stereo
Carrier Power Carrier Frequency Error Modulation Rate SINAD Distortion/Total Vrms	-19.259 dBm 4.233 Hz 1.0001 kHz 60.145 dB 0.098 %	Deviation (Ref Dev: 75.000 <u>Avg (Hz dBF</u> Peak+ 33.25 k -7.0 Peak33.26 k -7.0 (Pk-Pk)/2 33.26 k -7.0	S) Max Hold (Hz_dBFS) 7 33.32 k -7.05 6 -33.33 k -7.04 6 33.33 k -7.05	Left
		RMS 23.52 k -10.0	7 23.52 k -10.07	Right
				More 1 of 2
иsg			STATUS	

8 View the stereo part of the multiplexed signal which corresponds to L-R.

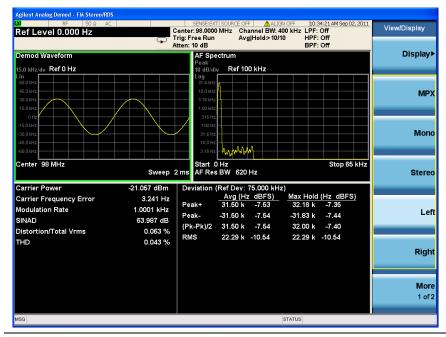
Agilent Analog Demod - FM Stereo/RDS		
	SENSE:EXT SOURCE OFF ALIGN OFF 10:38:53 AM Sep 02, 201: Center: 98.0000 MHz Channel BW: 400 kHz LPF: Off Trig: Free Run Avg Hold:>10/10 HPF: Off	View/Display
Demod Waveform 15.0 kHz/dv Ref 0 Hz	AF Spectrum Peak 10 d/Jdiv Ref 100 kHz	Display▶
Lin 600.04/2 300.04/2 150.04/2 01/2	Log 316 bits 316 bits 316 bits 100 bits 316 bits 100 bits 1	МРХ
-15.0 Mz -30.0 Hz -45.0 Hz -0.0 Hz	100 H2 31.6 H2 33.6 H2	Mono
Center 98 MHz Sweep Carrier Power -21.048 dBm	Start 0 Hz Stop 65 kHz 2 ms AF Res BW 620 Hz Deviation (Ref Dev: 75.000 kHz)	Stereo
Carrier Frequency Error 1.361 Hz Modulation Rate 1.0000 kHz	Deviation (Ver Dev. 75:000 m12) Max Hold (Hz dBFS) Avg (Hz dBFS) Max Hold (Hz dBFS) Peak+ 31.51 k -7.53 9eak- -31.54 k -7.52 -31.53 k -7.53 32.00 k (Pk-Pk)/2 31.53 k -7.53 8MS 22.30 k -10.64 22.30 k 10.64 22.30 k	Left
	TUIS 22.30 K -10.34 22.30 K -10.34	Right
		More 1 of 2
MSG	STATUS	

9 (Optional) Set the baseband Filters Meas Setup, Filters. Press Meas Setup, Filters. measurement results.

The highpass filter, lowpass filter, and bandpass filter can be combined as you like.

Step	Action	Notes
10 If pre-emphasis is used in the signal under test, set to use de-emphasis in the signal analyzer.	Press Meas Setup, Filters, De-Emphasis and choose the appropriate de-emphasis filter.	

11 View measurement results Press **View/Display**, **Left**. of the left channel.



12 View measurement results of the right channel.

Press View/Display, Right.

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.

Step	Action		Notes	
Aglient Analog Demod - FM Stereo/RM Center Freq 98.000000 Demod Waveform 15.0 ktf/dv Ref 0 Hz Lin 60.0 ktf/dv Ref 0 Hz 15.0 ktf/dv Ref 0 Hz 15.0 ktf 40.0 k	C SENSE:EXT SOURCE OFF	V: 400 kHz LPF: Off	View/Display Display≻ MPX Mono Stereo	
Carrier Power Carrier Frequency Error Modulation Rate SINAD Distortion/Total Vrms THD	-21.043 dBm 3.920 Hz 4.3229 kHz 2.890 dB 71.694 % 59.514 % Deviation (Ref Dev: 75.000 <u>Avg (Hz dBFS</u> Peak+ 21.30 -70.93 Peak- 47.97 - 63.88 (Pk-Pk)/2 34.64 -66.71 RMS 14.88 -74.05		Left Right More 1 of 2	

13 View the RDS/RBDS results.

Press View/Display, 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.

Agilent Analog Demod - FM Stereo/R					
🗶 RF 50Ω A Ava/Hold Number 10	IC	SENSE:EXT Center: 98.0000 MHz		F 11:36:14 AM Sep 01, 2011 LPF: Off	View/Display
		Trig: Free Run Atten: 10 dB	Avg Hold:>10/10	HPF: Off BPF: Off	
	RDS/RBDS	Decoding F	Results		RDS/RBDS
BLER: 0.00E+000	(0	/ 1196)		Result Metrics
Information Bits					
1000000000000001 0010000	000100001 0110111	100100000 0101010	001100101		
1000000000000001 0010000	000100010 0111100	001110100 0000110	100100000		Distortion THD Unit
					<u>%</u> dB
Basic Tuning and Swite	ching Info:		n Item Number and	d slow	
Traffic Announcement (TA):	Off	labeling	codes:		Metrics
Music/Speech (M/S):	Music	Link Actu	ator:	Off	Settings
Prgrame Service Name (PS):	RDS Test	Extended	Country Code (ECC):	0xE1 (225)	
Alternative Frequency State:	Off	Program	tem Number Code:	0:0:0 (0)	
Alternative Frequency:		Language	Code:	0x9 (9)	
Dynamic PTY:	Off	Clock-T	ime and date:		
Compressed:	Off	Clock-I	inte and date.		
Artificial:	Off	Modified	Julian Day (Y.M.D):	2008.8.8	
Stereo:	On	UTC Hou		0	
		UTC Minu	te:	0	
Radio Text:		Local Tim	e Offset (Half Hour):	-0	More
Text: Radio Text					2 of 2
MSG			STATUS		
mod			314103		

Step	Action	Notes
14 View a summary of the numeric measurement results.	Press View/Display, Result Metrics.	

NOTE In this view, the left to right separation result is displayed as "Left to Right" and the mono to stereo crosstalk is displayed as "Mono to Stereo". Normally, 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=R or L=-R.

		Numori	Atten: 10 dB	Summary		PF: Off	RDS/RBD
	Deviation Peak+	n (Ref Dev: 75 (Pk-Pk)/2		Mod Rate	SINAD	THD	
MPX	52.86 kHz -3.04 dBFS	51.47 kHz -3.27 dBFS	27.89 kHz -8.59 dBFS		59.567 dB		Result Metric
Mono	31.50 kHz -7.53 dBFS	31.50 kHz -7.54 dBFS	22.27 kHz -10.55 dBFS	1.0000 kHz	65.138 dB		Distortio THD Ur
Stereo	31.51 kHz -7.53 dBFS	31.50 kHz -7.53 dBFS	22.30 kHz -10.54 dBFS	1.0000 kHz			<u>%</u> c
Left	31.50 kHz -7.53 dBFS	31.50 kHz -7.53 dBFS	22.29 kHz -10.54 dBFS	1.0000 kHz	64.266 dB	0.040 %	Metrics Settings
Right	23.87 Hz -69.94 dBFS	25.30 Hz -69.44 dBFS	16.14 Hz -73.35 dBFS	2.0191 kHz	2.828 dB	91.213 %	
Pilot	7.509 kHz -19.99 dBFS	7.509 kHz -19.99 dBFS	5.309 kHz -23.00 dBFS	19.000 kHz			
RDS	4.368 kHz -24.69 dBFS	4.363 kHz -24.71 dBFS	3.124 kHz -27.61 dBFS				
Left to Ri	~			no to Stereo		-0.009 dB	
	er Power arrier Freq Eri	-21.05 or -0		Carrier Freq E Hz Carrier Pha		2.78 Hz 0.00 deg	Mo 2 of

15 Listen to the demodulated FM stereo signal.

Press Meas Setup, Demod to Speaker.

You may need to adjust the volume as necessary.

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.	Press Mode, Analog Demod.	
2 Preset the mode.	Press Mode Preset.	
3 Select FM Stereo/RDS measurement.	Press Meas, FM Stereo/RDS.	
4 Set the center frequency to the center of the signal and set the AF stop frequency.	Press FREQ Channel, Center Freq, 98, MHz. Press FREQ Channel, AF Stop Freq, 65, kHz.	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.	Press Meas Setup, Advanced, Ref Deviation, 75, kHz.	
6 View the measurement result of the multiplexed signal.	Press View/Display, MPX.	To display only the current trace in the Demod Waveform window, press Meas Setup and toggle Avg/Hold Num to Off .

Step	Action	Notes	
------	--------	-------	--

The figure below shows measurement results of the multiplexed signal, including 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.

RF 50Ω AC Ref Level -10.00 dBm	Trig:	SENSE:EXT SO ter: 98.0000 MH Free Run h: 10 dB			M Sep 02, 2011	View/Display
RF Spectrum		Demod Wave	eform	BPF: UIT		Display
0 dB/div Ref -10 dBm		15.0 kHz/dv Re	ef 0 Hz			
og .20 -30 -40 -50	h	Lin 60.0 kHz 45.0 kHz 30.0 kHz 15.0 kHz		Mar	John Market	MP)
-60 -70 -80 -90 -100	M	0 Hz -15.0 kHz -30.0 kHz -45.0 kHz -60.0 kHz		h M	Mary M	Mone
Center 98 MHz RFRes BW 4.7 kHz	Span 500 kHz	Center 98 M	Hz		weep 2 ms	Stere
F Spectrum						
eak		Deviation	(Ref Dev: 75.000 kł Avg (Hz dBFS)		(Hz dBFS)	
0 dB/div Ref 100 kHz		Peak+	71.93 k -0.36	75.20 k	0.02	
31.6 kHz		Peak-	-71.83 k -0.38	-75.23 k	0.03	Le
10.0 kHz		(Pk-Pk)/2	71.88 k -0.37	75.21 k	0.02	
1.00 kHz		RMS	44.93 k -4.45	44.94 k	-4.45	
316 Hz		Carrier F	ower	-21.08	6 dBm	Rigt
100 Hz			requency Error		1 mHz	
10.0 년2	A 8/ 18.00					
3.16 Hz	www.n hnu	SINAD		64.3	381 dB	Mo
Start 0 Hz	Stop 65 kHz		n/Total Vrms	0	.060 %	1 of
FRes BW 620 Hz						

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

Press View/Display, Mono.

ep Agilent Analog Demod - FM Stereo/RDS		Action		Note
Ref Level -10.00 dBm			100 kHz LPF: Off	,2011 View/Display
Demod Waveform 15.0 kHz/dv Ref 0 Hz .in	/ F	AF Spectrum Peak 10 dB/div Ref 100 kHz	BIT.OI	Display▶
60.0 kHz 45.0 kHz 30.0 kHz 15.0 kHz		3.1.6 kHz 3.1.6 kHz 3.16 kHz 1.00 kHz		МРХ
0 Hz -15.0 Hz -30.0 Hz -60.0 Hz		316 Hz 100 Hz 31.6 Hz 10.0 Hz 3.16 Hz		Mono
Center 98 MHz	Sweep 2 ms	Start 0 Hz AF Res BW 620 Hz	Stop 65	kHz Stereo
arrier Power arrier Frequency Error lodulation Rate INAD istortion/Total Vrms	115.1 mHz 1.0001 kHz 70.901 dB 0.029 %	<63.02 k -1.51 Pk)/2 63.02 k -1.51	<u>Max Hold (Hz dBFS</u> 63.03 k -1.51 -63.03 k -1.51 63.03 k -1.51) Left
	RMS	5 44.56 k -4.52	44.56 k -4.52	Right
				More 1 of 2
MSG			STATUS	

8 View the stereo part of the multiplexed signal which corresponds to L- R.

Press View/Display, Stereo.

Atten: 10 dB BPF: Off Demod Waveform AF Spectrum Paak 10 df data 0 df data Ref 100 kHz 10 df data Ref 100 kHz	XI RF 50 Ω AC Avg/Hold Number 10	C	sense:ext enter: 98.0000 MH rig: Free Run		UTO/NORF 04:53:25P 400 kHz LPF: Off /10 HPF: Off	M Sep 06, 2011	View/Display
2001tr2 376 Htz 100 Htz	15.0 kHz/dv Ref 0 Hz	A	AF Spectru Peak 10 dB/div		BPF: Off		Display
450 Htz 100 Hz	60.0 kHz 45.0 kHz 30.0 kHz		31.6 kHz 10.0 kHz 3.16 kHz				MP
Start 0 Hz Start 0 Hz Stop 65 kHz Star Start 0 Hz Start 0 Hz Stop 65 kHz Star Star Start 0 Hz Stop 65 kHz Star Star Star Deviation (Ref Dev: 75.000 kHz) Deviation (Ref Dev: 75.000 kHz) Star Deviation (Ref Dev: 75.000 kHz) Max Hold (Hz dBFS) Peak+ 117.7 - 56.09 321.3 - 47.36 Peak92.38 - 58.19 -321.347.36 RMS 65.3361.20 68.3360.81 R	-15.0 KHz -30.0 KHz -45.0 KHz		100 Hz 31.6 Hz 10.0 Hz	V/VV/			Mon
Avg (Hz dBFS) Max Hold (Hz dBFS) Modulation Rate 4.1270 kHz Peak+ 117.7 Peak- .92.38 92.38 .58.19 .321.3 .47.36 (Pk-Pk)/2 105.0 .47.36 (Pk-Pk)/2 105.0 .65.33 .51.20 .68.33 .60.81	Center 98 MHz		Start 0 Hz 2 ms AF Res BV	/ 620 Hz		top 65 kHz	Stere
R	Carrier Frequency Error	-196.3 mHz	 Peak+ Peak (Pk-Pk)/2	<u>vg (Hz dBFS)</u> 117.7 -56.09 92.38 -58.19 105.0 -57.08	<u>Max Hold (Hz</u> 321.3 -47.3 -321.3 -47.3 321.3 -47.3	36 36 36	Le
			RMS	65.33 -61.20	68.33 -60.8	31	Rigl
							Mo i 1 of

9 (Optional) Set the baseband Press Meas Setup, Filters. filters to improve the measurement results.

The highpass filter, lowpass filter, and bandpass filter can be combined as you like.

Step	Action	Notes
10 If pre-emphasis is used in the signal under test, set to use de-emphasis in the signal analyzer.	Press Meas Setup, Filters, De-Emphasis and choose the appropriate de-emphasis filter.	

11 View the measurement results of the left channel.

Press View/Display, Left.

In this test case, the left channel equals to the right channel.

Ref Level -10.00 dBm	Cer	SENSE:EXT SOURCE OFF nter: 98.0000 MHz Channel g: Free Run Avg Hol		2011 View/Display
Demod Waveform 15.0 kHz/dv Ref 0 Hz	Atte	AF Spectrum Peak 10 dB/div Ref 100 kH	BPF: Off	Display
Lin 60.0 kHz 45.0 kHz 30.0 kHz 15.0 kHz		Log 31.6 kHz 10.0 kHz 3.16 kHz 1.00 kHz		MP
0 Hz -15 0 Hz -300 Hz -45 0 Hz		316 Hz 100 Hz 31 6 Hz 10.0 Hz 3.16 Hz 3.16 Hz		Mon
Center 98 MHz	Sweep 2 n	Start 0 Hz ns AF Res BW 620 Hz	Stop 65 P	Hz
Carrier Power Carrier Frequency Error Modulation Rate SINAD Distortion/Total Vrms	-415.2 mHz 1.0001 kHz 64.807 dB 0.057 %	Deviation (Ref Dev: 75.00 <u>Avg (Hz dB</u> Peak+ 31.52 k -7. Peak31.52 k -7. (Pk-Pk)/2 31.52 k -7.	FS) <u>Max Hold (Hz dBFS)</u> 53 31.53 k -7.53 53 -31.54 k -7.53 53 31.54 k -7.53 53 31.53 k -7.53	Le
THD	0.028 %	RMS 22.28 k -10.	54 22.28 k -10.54	Righ
				Mor 1 of
⊿sg 🤳 File <lr mono.png=""> sav</lr>			STATUS	

12 View the RDS/RBDS results.

Press View/Display, RDS/RBDS.

Notes

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.

Agilent Analog Demod - FM Stereo/RI					
vg/Hold Number 10	C	SENSE:EXT Center: 98.0000 MHz	Channel BW: 400 kHz		View/Display
Ŭ.		Trig: Free Run Atten: 10 dB	Avg Hold:>10/10	HPF: Off BPF: Off	
	RDS/RBDS	Decoding R	esults		RDS/RBDS
BLER: 0.00E+000	(0	/ 1196)		Result Metrics
					Distortion THD Unit <u>%</u> dB
Basic Tuning and Swite	ching Info:	Progran labeling	n Item Number and	d slow	
Traffic Announcement (TA):	Off	-			Metrics
Music/Speech (M/S):	Music	Link Actua	tor:	Off	Settings
Prgrame Service Name (PS):	RDS Test	Extended	Country Code (ECC):	0xE1 (225)	
Alternative Frequency State:	Off	Program It	em Number Code:	0:0:0 (0)	
Alternative Frequency.		Language	Code:	0x9 (9)	
Dynamic PTY:	Off	Clock-T	ime and date:		
Compressed:	Off				
Artificial:	Off			2008.8.8	
Stereo:	On	UTC Hour		0	
		UTC Minut	te:	0	
Radio Text:		Local Time	e Offset (Half Hour):	-0	More
Text: Radio Text					2 of 2
MSG			STATUS		

Action

13 View a summary of the numeric measurement results.

Press View/Display, Result Metrics.

Step	Action	Notes
NOTE	crosstalk is displayed as "Mono to Stereo". Norn	displayed as "Left to Right" and the mono to stereo nally, left to right separation test is taken when the to stereo crosstalk test is taken when the audio

ef Leve	r⊧ 50Ω el -10.00 dBm		Center: 98.00 Trig: Free Ri Atten: 10 dB		IBW: 400 kHz LF d:>10/10 HF	L0:58:12 AM Sep 02, 2011 PF: Off PF: Off PF: Off	View/Display
		Numeri	: Results	Summary			RDS/RBD
	Deviation Peak+	n (Ref Dev: 75. (Pk-Pk)/2	000 kHz) RMS	Mod Rate	SINAD	тно	
MPX	71.84 kHz -0.37 dBFS	71.81 kHz -0.38 dBFS	44.92 kHz -4.45 dBFS		64.521 dB		Result Metri
Mono	63.02 kHz -1.51 dBFS	63.02 kHz -1.51 dBFS	44.56 kHz -4.52 dBFS	1.0001 kHz	70.922 dB		Distortio THD U
Stereo	33.32 Hz -67.05 dBFS	29.05 Hz -68.24 dBFS	27.58 Hz -68.69 dBFS	7.6030 KHz			<u>%</u>
∟eft	31.52 kHz -7.53 dBFS	31.52 kHz -7.53 dBFS	22.28 KHz -10.54 dBFS	1.0001 KHz	64.350 dB	0.028 %	Metric Setting
Right	31.51 kHz -7.53 dBFS	31.51 kHz -7.53 dBFS	22.28 kHz -10.54 dBFS	1.0001 kHz	65.239 dB	0.026 %	
Pilot	7.492 kHz -20.01 dBFS	7.492 kHz -20.01 dBFS	5.302 kHz -23.01 dBFS	19.000 kHz			
RDS	4.302 kHz -24.83 dBFS	4.313 kHz -24.81 dBFS	3.121 kHz -27.62 dBFS				
eft to Ri	9			no to Stereo		64.167 dB	
	er Power arrier Freq Err	-21.084 or -2003		Carrier Freq E Hz Carrier Pha		0.14 Hz -0.07 deg	Mc 2 c
sg					STATUS		

14 Listen to the demodulated FM stereo signal.

Press Meas Setup, Demod to Speaker.

You may need to adjust the volume as necessary.

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

Demodulating an AM Signal Using the Analyzer as a Fixed Tuned Receiver (Time-Domain) on page 32

Demodulating an FM Signal Using the Analyzer as a Fixed Tuned Receiver (Time-Domain) on page 33

"Demodulating an FM Stereo/RDS Signal Using the Analyzer as a Fixed Tuned Receiver (Time-Domain)" on page 34

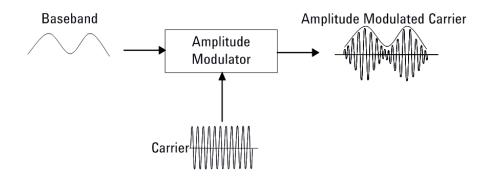
Modulation Distortion Measurement Concepts on page 35

Modulation SINAD Measurement Concepts on page 36

Concepts AM Concepts

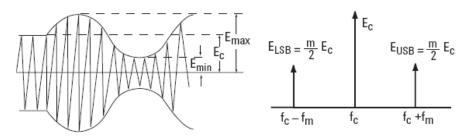
AM Concepts

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:

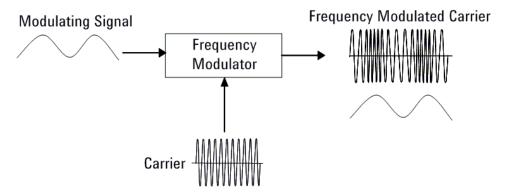
Equation 2-2

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

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

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

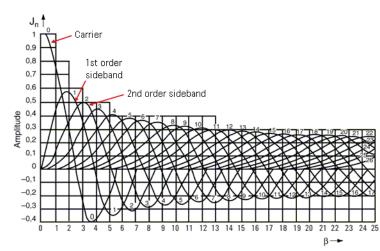
Where Δfp is the peak frequency deviation, fm is the frequency of the modulating signal, and $\Delta \phi p$ is the peak phase deviation.

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.



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.

Figure 2-4

Carrier and sideband amplitude for angle-modulated signals

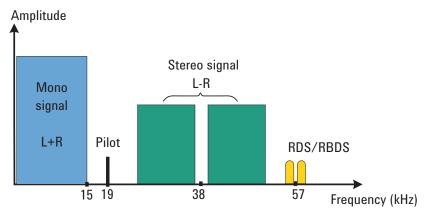
FM Stereo/RDS Concepts

FM stereo is an enhancement of FM by using stereo multiplexing. An FM stereo signal carries stereophonic programmes 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.

Figure 2-5 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 ~ 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).

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 programmes.

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 (programme identification), PS (programme service) name display, and if applicable, automatic tuning for portable and car radios.

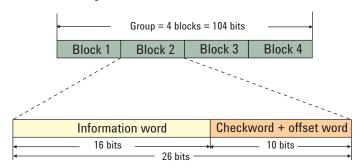
As shown in Figure 2-5, RDS/RBDS uses the 57 kHz subcarrier to carry the data at 1.1875 kbps bitrate. The 57 kHz is chosen to be the third harmonic of the pilot tone. The deviation range of the FM carrier due to the unmodulated RDS/RBDS subcarrier is from $\pm 1.0 \ kHz$ to $\pm 7.5 \ kHz$.

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%.

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:

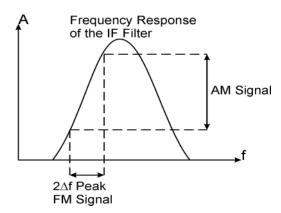
- Triggering stabilizes the waveform trace by triggering on the modulation envelope. If the modulation of the signal is stable, video trigger synchronizes the sweep with the demodulated waveform.
- Sweep time to view the rate of the AM signal.
- RBW and VBW are selected according to the signal bandwidth.

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

To recover the frequency modulated signal, an 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 2–7.

Figure 2-7

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.

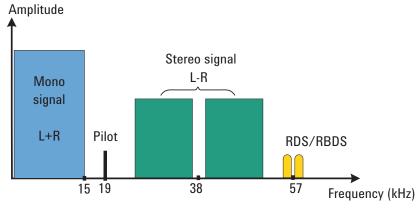
Demodulating an FM Stereo/RDS Signal Using the Analyzer as a Fixed Tuned Receiver (Time-Domain)

FM Stereo/RDS signal contains mono part, stereo part, RDS/RBDS, and pilots. The process of demodulating FM Stereo/RDS signal is more complicated than simple FM signal and is described as below.

1. Perform the FM demodulation to obtain the baseband modulating signal. The demodulating method is the same to Demodulating an FM Signal Using the Analyzer as a Fixed Tuned Receiver (Time-Domain) on page 33.

The baseband modulating signal should look like Figure 2-8.

Figure 2-8 Baseband modulating signals of the FM Stereo/RDS signal



- 2. Recover the L (left channel) and R (right channel) of the audio signal.
 - a. Demodulate the L+R part.
 - b. Extract the 19 kHz pilot and multiply it to recover the 38 kHz subcarrier.
 - c. Perform the DSBSC (Double-Sideband Suppressed Carrier) AM demodulation to get the L-R signal.
 - d. Get the L and R signals from (L-R) and (L+R).
- 3. Multiply the 19 kHz pilot to recover the 57 kHz subcarrier, demodulate the RDS /RBDS bits, and then calculate the BLER.
- 4. Apply the de-emphasis or audio filters including highpass, lowpass, bandpass (CCITT, A-Weighted) filters to the audio signal (L and R).
- 5. Calculate measurement parameters like SINAD, Distortion, THD and so on.

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.