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W-LAN 802.11ac Measurement

Demonstration using Signal Analyzer and Vector Signal Generator

MX269028A WLAN (802.11) Measurement Software

MX269028A-002 802.11ac (160 MHz) Measurement Software

MX370111A WLAN IQproducer

MX370111A-002 802.11ac (160 MHz) Option

MS2690A/MS2691A/MS2692A Signal Analyzer

MG3710A Vector Signal Generator

Introduction

This application note explains the procedures for outputting an IEEE802.11ac signal from a vector signal generator and measuring the modulation accuracy and power using a signal analyzer.

The IEEE802.11ac PHY layer features 256QAM multi-level modulation compared to the IEEE802.11n PHY layer as well as both 80 MHz and 160 MHz (option) bandwidths, plus expandability for up to 8 MIMO streams.

This application note provides an understanding of the features of IEEE802.11ac through the following items:

- Generation and output of 256QAM, 80-MHz band signals and measurement of their Tx characteristics
- Generation and output of 256QAM, 160-MHz band signals and measurement of their Tx characteristics
- Generation and output of 8 x 8 MIMO signals and measurement of their Tx characteristics
- Sending of specified number of packets from vector signal generator (mainly for Rx tests)

Preparations

The instruments, etc., required for this demonstration are listed below.

 MG3710A Vector Signal Generator (Version 2.01.00 or newer firmware and IQproducer Version 14.01 or newer)

/	
Option-036	1stRF 100 kHz to 6 GHz
Option-066	2ndRF 100 kHz to 6 GHz
MX370111A	WLAN IQproducer
MX370111A-002	802.11ac (160 MHz) Option
MS2690A/MS2691A/MS26	92A Signal Analyzer (Version 5.05.00 or newer)
MX269028A	MX269028A WLAN (802.11) Measurement Software
MX269028A-002	802.11ac (160MHz) Measurement Software
MS2690A-077	Analysis Bandwidth Expansion 62.5 MHz (with MS2690A)
MS2690A-078	Analysis Bandwidth Expansion 125 MHz (with MS2690A)
MS2691A-077	Analysis Bandwidth Expansion 62.5 MHz (with MS2691A)

- MS2691A-078Analysis Bandwidth Expansion 125 MHz (with MS2691A)MS2692A-077Analysis Bandwidth Expansion 62.5 MHz (with MS2692A)MS2692A-078Analysis Bandwidth Expansion 125 MHz (with MS2692A)
- RF Cable 1 pc

Set-up the instruments as shown below.





To simplify the operations described in this application note, the cable attenuation settings and calibration procedures are omitted. To measure more accurately, refer to the Operation Manual for the additional required procedures.

This application note references the following IEEE802.11ac standard:

• IEEE P802.11ac/D2.0, January 2012

Generating and Measuring 80-MHz Band Signals

Generating and Outputting Signals using Vector Signal Generator

IEEE802.11ac 80-MHz bandwidth, one-packet signal can be output from the MG3710A Vector Signal Generator using the following procedure.

[Procedure]

- 1. Execute [Preset] \rightarrow [F3] Preset All.
- 2. Press [IQpro] to start IQproducer.
- 3. Select the [System (Non-Cellular)] tab.
- 4. Press the [WLAN] button.
- 5. Press the [System] button in the [Common] tab and select [11ac].
- 6. Press the [Bandwidth] button in the [Common] tab and select [80 MHz].
- 7. Press the [Number of Packets] button in the [Common] tab and select [1].
- 8. Press the [Repeat Count] button in the [Common] tab and select [1].
- 9. Select [MCS] in the [PHY] tab and set [9]. Refer to the appendix for a description of MCS.
- 10. Set [Package] to [WLAN_11ac] and [Pattern Name] to [80MHz_MCS9].
- 11. Press [Calculation & Play] at the bottom right of the screen to start waveform generation. Select [SG1] at the dialog for choosing the SG load destination.
- 12. Press [SG1].
- 13. Press [Frequency] and set the frequency to 5.21 GHz.
- 14. Press [Level] and set the level to -15 dBm.
- 15. Turn on RF Output [Mod On/Off] and [On/Off] to output the modulation signal.
- 16. Press $[I/Q] \rightarrow [F3]$ Internal Channel Correction to set [On].
- 17. Press $[I/Q] \rightarrow [F6]$ Wideband to set [On].

The above procedure repeatedly generates and outputs 80-MHz bandwidth, single-packet signal from the MG3710A Vector Signal Generator.

✓ MG3710A Vector Signal Generator SG2 1 000 000 000 00 0	u			ľ⁄Q
SG1 ARB PLAY	WIDE	INTCORR		I/Q Source
5.210 000 000	00 _{GHz}	-15.00	Mod RF ● dBm	Internal I/Q Output RF
				Internal Channel Correction Off <u>On</u>
ARB Info Package WLAN_11ac Pattern 80MHz_MCS9	Level -15.00dBm	Freq Offset	Ð	ې I/Q Calibration
B Not Selected			→	Wideband Off <u>On</u>
ARB On A : Off B : Off	eter S	BER top 0.000E+000 0	0 % / 0	
0		5/25	/2013 14:55:24	-> 1 of 2

Fig. 2. Vector Signal Generator Settings (80-MHz bandwidth)

Measuring with Signal Analyzer

The IEEE802.11ac 80-MHz bandwidth signal output from the MG3710A Vector Signal Generator is measured using the MS2690A/MS2691A/MS2692A Signal Analyzer.

(1) Measuring Modulation Accuracy

[Procedure]

- 1. Press [Application Switch] and select [WLAN].
- 2. Execute [Preset] \rightarrow [F1] Preset.
- 3. Press [Frequency] and set the frequency to 5.21 GHz.
- 4. Press [Amplitude] and set the level to -15 dBm.
- 5. Press [Measure] \rightarrow [F1] Modulation Analysis.
- 6. Press [F2] WLAN Standard \rightarrow [\rightarrow] (Function Menu page 2) \rightarrow [F1] IEEE802.11ac.
- Press [Measure] → [F1] Modulation Analysis → [F1] Analysis Time → [F5] Capture Length to set [1] ms.
 *This parameter is adjusted according to the burst length of the signal to be measured. If the set value is too large for the burst length, the time required for that part of the measurement is overhead.
- 8. Press [Measure] \rightarrow [F1] Modulation Analysis \rightarrow [F4] Channel Bandwidth to set [80] MHz.
- 9. Press [Trace] \rightarrow [F3] EVM Unit to set [dB].
- 10. Press [Trace] \rightarrow [F1] Trace Mode \rightarrow [F3] Spectral Flatness.

The above procedure measures the modulation accuracy such as the frequency offset, EVM, etc.

The MX269028A WLAN (802.11) Measurement Software and the MX269028A-002802.11ac (160 MHz) Measurement Software analyze the input signal PPDU (physical layer convergence procedure (PLCP) protocol data unit) by default, presuming a format based on the included training field and SIGNAL field. Consequently, if the correct information is set in the input signal PPDU, there is no need to set the signal format–other than the minimum parameters–in the above procedure.

The measurement results and their correspondence with the items specified in IEEE802.11ac are shown below.

IEEE802.11ac	Signal Analyzer
22.3.18 PMD Transmit Specification	
22.3.18.1 Transmit Spectrum Mask	[Measure] \rightarrow [F7] Spectrum Emission Mask (Swept)
22.3.18.2 Spectral Flatness	[Measure] \rightarrow [F1] Modulation Analysis
	[Trace] \rightarrow [F1] Trace Mode \rightarrow [F3] Spectral Flatness
	[F8] Spectral Flatness Type \rightarrow [F1] Amplitude
	Flatness (Outside/Inside with Max/Min)
22.3.18.3 Transmit Center Frequency Tolerance	[Measure] \rightarrow [F1] Modulation Analysis
	Frequency Error
22.3.18.4 Symbol Clock Frequency Tolerance	[Measure] \rightarrow [F1] Modulation Analysis
	Symbol Clock Error
22.3.18.5.2 Transmit Center Frequency Leakage	[Measure] \rightarrow [F1] Modulation Analysis
	Center Frequency Leakage
22.3.18.5.3 Transmitter Constellation Error	[Measure] \rightarrow [F1] Modulation Analysis
	EVM (rms)

Table 1. IEEE802.11ac (D2.0) Measurement Items and Items Displayed by Signal Analyzer

Carrier Freq. 5 210 000 000 Hz Input Level 15.00 dBm Standard IEEE802.11ac ATT 4 dB Bandwidth 80MHz Measurement Mode Continuous Result Measuring MKR Q Symbol Number - 122 - 122 - 0.08662 Q -0.86647 Spectral Flatness(Amplitude vs Subcarrier) Sobcarrier - 122 (-38.125MHz) Amplitude 0.25 dB Flatness(Amplitude vs Subcarrier) MKR Subcarrier 122 (-38.125MHz) Amplitude 0.25 dB Flatness(Inside) Max: 0.36 dB (Sub:35) Min: -0.41 dB (Sub:121) Flatness(Inside) Max: 0.34 dB (Sub:35) Min: -0.41 dB (Sub:81) 1000 - 500 - 500 - 1000 - 122 (-38.125MHz) Amplitude 0.25 dB Flatness(Inside) Max: 0.34 dB (Sub:35) Min: -0.41 dB (Sub:121) Flatness(Inside) Max: 0.34 dB (Sub:35) Min: -0.41 dB (Sub:81) 1000 - 500 - 50	∕1 MS2692A WL.	AN					5/25/2013 15:08:49
Standard IEEE802.11ac ATT 4 dB Bandwidth 80MHz Measurement Mode Continuous Result Measurement Mode Continuous MKR Q	Carrier Freq.	5 210 000 000 Hz	lnput L	.evel -15.00 dBm			WLAN 🕋
Bandwidth 80MHz Measurement Mode Continuous EVMvs Subcarrier Result Measuring MKR Q -0.01 ppm -0.01 ppm Subcarrier -122 Symbol Clock Error -0.09 ppm -0.09 ppm Symbol Number -122 Symbol Clock Error -0.09 ppm Spectral Flatness Q -0.86547 -29.63 dB Symbol Number 20 Q -0.86547 -2560AM Subcarrier Number -105 Spectral Flatness(Amplitude vs Subcarrier) MKR Subcarrier -122 -38.125MHz) Amplitude 0.25 dB Flatness(Inside) Max: 0.35 dB (Sub::106) Min: -0.41 dB (Sub:121) Scale 10.0dB 500 -100 -122 -122 122 122 122	Standard	IEEE802.11ac	ATT	4 dB			
Result Measuring MKR Q Symbol Number -0.01 ppm 0 -0.01 ppm Subcarrier -122 -122 -122 -122 -1170 dB EVM(rms) -41.70 dB EVM(peak) -29.63 dB Symbol Number 20 Symbol Number 20 Subcarrier -105 Center Frequency Leakage -39.47 dB Spectral Flatness(Amplitude vs Subcarrier) -122 MKR Subcarrier -105 Center Frequency Leakage -39.47 dB Flatness(Amplitude vs Subcarrier) Min: MKR Subcarrier Flatness(Inside) Max: 0.36 dB (Sub:35) Min: -0.51 dB 10.00 -100 500 -100 -100 -12	Bandwidth	80MHz			Measurement Mode	Continuous	EVM vs Subcarrier
MKR Q Symbol Number -0.01 ppm Subcarrier -0.01 ppm -122 -122	Result		Measuring				
Symbol Number 0 Subcarrier -122 -12 -1	MKR	Q					
Subcarrier .122 Symbol Clock Error .0.09 ppm .122 .122 .1170 dB .1170 dB .122 .1170 dB .1170 dB .1170 dB .122 .1170 dB .1170 dB .1170 dB .122 .1170 dB .1170 dB .1170 dB .1170 dB .1170 dB .1170 dB .1170 dB .1170 dB .1170 dB .29,63 dB .1170 dB .1170 dB .1170 dB .1170 dB <t< td=""><td>Symbol Number</td><td></td><td></td><td>Frequency Error</td><td></td><td>-51.99 Hz -0.01 ppm</td><td>EVM vs Symbol</td></t<>	Symbol Number			Frequency Error		-51.99 Hz -0.01 ppm	EVM vs Symbol
Symbol Number 20 Subcarrier Number -105 Center Frequency Leakage -39,47 dB Spectral Flatness(Amplitude vs Subcarrier - MKR Subcarrier -122 (-38.125MHz) Amplitude 0.25 dB Flatness(Outside) Max: 0.35 dB (Sub:106) Min: -0.51 dB (Sub:121) Flatness(Inside) Max: 0.34 dB (Sub:35) Min: -0.41 dB (Sub:81) 1000 -500 -1000 -1000 -122 122 122 122 122	Subcarrier -122			Symbol Clock Error Transmit Power I EVM(rms) EVM(peak)		-0.09 ppm -16.42 dBm -41.70 dB -29.63 dB	Spectral Flatness
Modulation 2550AM Spectral Flatness(Amplitude vs Subcarrier) MKR Subcarrier -122 (-38.125MHz) Amplitude 0.25 dB Flatness(Outside) Max: 0.35 dB (Sub:-106) Min: -0.51 dB (Sub:121) Flatness(Inside) Max: 0.34 dB (Sub:35) Min: -0.41 dB (Sub:81) 10.0dB 000	l -0.08662 Q -0.85547			Symbol Number Subcarrier Numb Center Frequency L	er eakage	20 -105 -39.47 dB	Summary
Spectral Flatness(Amplitude vs Subcarrier) MKR Subcarrier -122 (-38.125MHz) Amplitude 0.25 dB Subcarrier Scale Scale 1000 Scale 10.0 dB Sca		Modulation	256QAM				
MKR Subcarrier -122 (-38.125MHz) Amplitude 0.25 dB Flatness(Outside) Max: 0.35 dB (Sub::106) Min: -0.51 dB (Sub::121) Flatness(Inside) Max: 0.34 dB (Sub:35) Min: -0.41 dB (Sub:81) 1000	Spectral Flatnes	ss(Amplitude vs Subca	arrier)				
Flatness(Outside) Max: 0.35 dB (Sub::106) Min: -0.51 dB (Sub::121) Flatness(Inside) Max: 0.34 dB (Sub:35) Min: -0.41 dB (Sub:81) 1000	MKR	Subcarrier -122	(-38.125MH	z) Amplitude	0.25 dB		
1000	Flatness	s(Outside) Max: 0.3 s(Inside) Max: 0.3	5 dB (Sub: M dB (Sub:	:-106) Min: :35) Min:	-0.51 dB (Sub:121)		Scale
500	10.00						10.0dB
000	5.00						
-500 -1000 -122 122 122 Type	0.00						
-500 -1000 -122 122 Type							
-1000122 Type	-5.00						Spectral Flatness
	-10.00	2				122	Туре
Ref.Int Pre-Amp Off	Ref.Int	Pre-Amp Off					

Fig. 3. Modulation Accuracy Measurement (80-MHz bandwidth)



Fig. 4. Spectrum Mask Measurement (80-MHz band, spectrum analyzer function, sweeping method)

To zoom the 256QAM multi-level modulation constellation display: press [Measure] \rightarrow [F1] Modulation Analysis \rightarrow [Trace] \rightarrow [F6] Constellation Zoom to set [On].



Fig. 5. Zoomed Constellation Display (256QAM)

To display the in-band phase characteristics of the IEEE802.11ac signals: press [Measure] \rightarrow [F1] Modulation Analysis \rightarrow [Trace] \rightarrow [F1] Trace Mode \rightarrow [F8] Spectral Flatness Type to set [Phase].



Fig. 6. In-band Phase Characteristics Display (80-MHz band)

(2) Monitoring Spectrum

The following describes a method of monitoring the spectrum of burst-on segments of IEEE802.11ac signals.

[Procedure]

- 1. Press [Application Switch] and select [Spectrum Analyzer].
- 2. Execute [Preset] \rightarrow [F1] Preset.
- 3. Press [Frequency] and set frequency to 5.21 GHz.
- 4. Press [Amplitude] and set [Reference Level] to -15.00 dBm.
- 5. Press [Span] \rightarrow [F3] Zero Span.
- 6. Press [Trigger/Gate] \rightarrow [\rightarrow] (Function Menu page 2) \rightarrow [F1] Gate Sweep to set [On].
- 7. Press [F6] Gate Source to set [Wide IF Video].
- 8. Press [F8] Gate Level (Wide IF Video) to set [-30 dBm].
- 9. Press [Time/Sweep] \rightarrow [F2] Sweep Time to set [200 µs].
- 10. Press [F4] Trace Points to set [1001].
- 11. Press [Trigger/Gate] \rightarrow [\rightarrow] (Function Menu page 2] \rightarrow [F5] Gate Length to set [127 µs].



Fig. 7. Time Domain Display

- 12. Press [Span] to set the span to [200 MHz].
- 13. Press [Trigger/Gate] \rightarrow [\rightarrow] (Function Menu page 2) \rightarrow [F2] Gate View to set [On].
- 14. Press [Trace] \rightarrow [F3] Trace Mode to set [Lin Average].
- 15. Press [Trace] \rightarrow [F8] Detection to set [RMS].
- 16. Press [Marker] \rightarrow [F5] Off.



Fig. 8. Spectrum Display

(3) Displaying CCDF

When measuring a signal with a large crest ratio with burst, wideband, and multi-level modulation elements, sometimes it is necessary to reference the CCDF when designing and adjusting the characteristics of devices, such as amplifiers and circuits.

[Procedure]

- 1. Press [Application Switch] and select [Signal Analyzer].
- 2. Execute [Preset] \rightarrow [F1] Preset.
- 3. Press [Frequency] and set the center frequency to 5.21 GHz.
- 4. Press [Amplitude] and set [Reference Level] to -15.00 dBm.
- 5. Press [Span] and set the span to 100 MHz.
- 6. Press [Trace] \rightarrow [F1] Trace Mode \rightarrow [F5] CCDF.

/1 MS2	692A Sig	nal Analyze	r								5/25/2013 16:17	.49
	CCDF								Data Cor	unt 206917488	📲 Signal Analyzer	•
N	IKR	10.00 dB	Meas.	0.383	9 %	Analysis	Start Tim	ie		0 s	Frequency	
						Analysis	Time Ler	ngth	100	.000 000 ms	Center	
						Filter BW	: Not	Filtered	Method	CCDF	5 210 000 0000	147
100%										رهم	3.210 000 0000	12
10%										رككل	Start	
10 /										رهيكم	E 400 000 0000	
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174										رهيكم	Stan	
0 1%										<u>ک ک</u> لا	этор	
0.17%		<u>ا کی ا</u>	le se	1997				A DOT		رهيمك	5.260 000 000G	iHz
0.01%										رووك		
0.01%		í se						A DOT		رصصک	Span	
0.001%										رويوكم	100 MHz	
0.001%		í se		Á THE				A DOT		رهيکم		
0.0001%										<u>م معالم الم</u>	Preselector	
	0 dB				Description in 11th a					20 dB	Auto Tune	
Powe	er				Probability			Distribu		1 0227.9/		
Avg	. Power	: -19.14 d	Bm, 30.49	919 %	1%	8.8	33 dB		4 dB : 1	4.2337 %		
Max	. Power	: -6.18 d	Bm		0.1 %	: 11.0	08 dB	1	12 dB :	0.0198 %		
Cres	t Factor	: 12.96 d	в		0.001 %	12.8	34 dB	1	6 dB :	0.0000 %		
					0.0001 %	: 12.8	9 dB	2	.0 dB :	0.0000 %	Char Sine	
Commo	on										Step Size	
Frequ	ency and	Time —		Level-				Trigger-			1.000GHz	
Cent	er Freq.	5.210 000	000 GHz	Ref. I	Level	0.00 dBm		Trigger		Free Run		.13
Freq	. Span		100 MHz								Frequency bar	nd
Capt	ure Leng	th 100.00	0 000 ms	Atten	nuator	10 dB	راكم				Normal	
Defi		Dro Am	05									
Ref.r	nt	Pre-Am	ρΟπ								1 of 2 🖃	

Fig. 9. CCDF Display

Generating and Measuring 160-MHz Bandwidth Signals

Generating and Outputting Signals with Vector Signal Generator

IEEE802.11ac 160-MHz bandwidth signals can be output from the MG3710A Vector Signal Generator using the following procedure.

[Procedure]

- 1. [Execute [Preset] \rightarrow [F3] Preset All.
- 2. [Press [IQpro] to start IQproducer.
- 3. [Select the [System (Non-Cellular)] tab.
- 4. [Press the [WLAN] button.
- 5. Press the [System] button in the [Common] tab and select [11ac].
- 6. Press the [Bandwidth] button in the [Common] tab and select [80 MHz].
- 7. Press the [Number of Packets] button in the [Common] tab and select [1].
- 8. Press the [Repeat Count] button in the [Common] tab and select [1].
- 9. Select [MCS] in the [PHY] tab and set [9].
- 10. Set [Package] to [WLAN_11ac] and [Pattern Name] to [160MHz_MCS9].
- 11. Press [Calculation & Play] at the bottom right of the screen to start waveform generation. Select [SG1] at the dialog for choosing the SG load destination.
- 12. Press [SG1].
- 13. Press [Frequency] and set the frequency to 5.25 GHz.
- 14. Press [Level] and set the level to -15 dBm.
- 15. Turn on RF Output [Mod On/Off] and [On/Off] to output the modulation signal.
- 16. Press $[I/Q] \rightarrow [F3]$ Internal Channel Correction to set [On].
- 17. Press $[I/Q] \rightarrow [F6]$ Wideband to set [On].

The above procedure repeatedly generates and outputs IEEE802.11ac 160-MHz bandwidth, single-packet signal from the MG3710A Vector Signal Generator.

↑ MG3710A Vector Signal Generator		Mod DE	I/Q
1. 000 000 0 SG1 ARB PLAY	00 00 _{GHz} -144 w	. 00 dBm	I/Q Source
Frequency		Amplitude Mod	Internal
5.250 000	000 00 _{GHz}	-15.00 _{dBm}	I/Q Output
			Internal Channel Correction Off <u>On</u>
ARB Info	Laual	FreqOffset	G
Package WLAN_ITac Pattern 160MHz_MCS9	- 15.00 dBm	смт	4 I/Q Calibration
		└ ─── →	Wideband
B Not Selected			Off <u>On</u>
_ ARB	Power Meter	_ BER	
On A	A : Off B : Off	Stop 0.000E+000 0 % 0 / 0	
0		5/25/2013 16:27:5	i6 🔁 💽 1 of 2

Fig. 10. Vector Signal Generator Settings (160-MHz bandwidth)

Measuring with Signal Analyzer

The IEEE802.11ac 160-MHz bandwidth signal output from the MG3710A Vector Signal Generator is measured using the MS2690A/MS2691A/MS2692A Signal Analyzer.

The procedure is basically the same as the 80-MHz bandwidth measurement described above, but the frequency is set to 5.25 GHz and the procedure in step 8 is:

Press [Measure] \rightarrow [F1] Modulation Analysis \rightarrow [F4] Channel Bandwidth to set [160 MHz].

Currently, the MS2690A/MS2691A/MS2692A Signal Analyzer hardware supports a maximum analysis bandwidth of 125 MHz (with Opt-078 installed). The MX370111A-002 802.11ac (160 MHz) option uses this 125-MHz analysis bandwidth to measure a 160-MHz band IEEE802.11ac signal by measuring two parts 80 MHz above and below the center frequency in one measurement sequence. In most cases, this measurement method causes no problems because the RF characteristics are displayed continuously and not repeatedly. However, there is a restriction when measuring 160-MHz bandwidth signals—captured signals cannot be saved or replayed or analyzed using the signal analyzer function.



Fig. 11. Modulation Accuracy Measurement (160-MHz bandwidth)

∕1 MS2692A Sp	ectrum Analyzer	(WLAN)				_0	5/25/2013 16:44:35
							📙 Spectrum Analyzer 🚡 SEM
Reference	e Level -11.00	dBm		_ABS1_	_ABS2	REL	Spectrum Emission Mask On Off
-21.0							
-31.0							Pafaranas Satur
-41.0							Reference Setup
-51.0							l,
-61.0		+	4				Offset Setup
-71.0	+	\square					
-81.0	A ALLAN HALLAND BANK			<u>\</u>		🗸 fasta da status la sua marca da s	ų.
-91.0			<u> </u>	and the state of t		and the second se	Limit Setup
-101 0			-	a History	die likelogen zie		
-111.0							پ Limit Side
Center 5.250 0	00GHz					Span 800.0MHz	Both
Spectrum Emis	ssion Mask						
Booult	Off	set 1-6		ower	U	pper	Result Type
Result	Start (MHz)	Stop (MHz)	Peak (dBm)	Freq (MHz)	Peak (dBm)	Freq (MHz)	Peak Margin
PASS	79.000 000	160,000,000	-03.12	5 168 842 000	-73.35	5 331 079 000	
Pafaranca	160.000 000	240.000 000	-84.37	5 019.680 000	-87.75	5 488,800 000	Load Standard *
Kererence	240.000 000	400.000 000	-85.01	4 970.960 000	-87.04	5 516.880 000	802.11ac
-37.53 dBm	240.000 000	400.000 000	-81.16	4 968.225 800	-81.94	5 594.193 500	TOUMHZ BW
	12.500 000						Back To
AW Max 100.00%	B-	0-	D-	E-	[a–	WLAN
Ref.Int	Pre-Amp Off					WLAN	0

Fig. 12. Spectrum Mask Measurement (160-MHz bandwidth, spectrum analyzer function, sweeping method)

MIMO Signal Generation and Measurement

The IQproducer MX370111A-002 802.11ac (160 MHz) option features the IEEE802.11ac standard supporting up to 8 transmit chains, as well as single-user and multi-user modes for 8 spatial streams.

When measuring MIMO IEEE802.11ac signals using the MX269028A-002 802.11ac (160 MHz) measurement software, each antenna signal is measured separately. When using only a single MS2690A/MS2691A/MS2692A Signal Analyzer, measurement is performed by switching each antenna. Now, when measuring MIMO signals using the MX269028A-002 802.11ac (160 MHz) Measurement Software, it is necessary to use the single-user mode with direct mapping method as well as the number of channels and transmit chains. Eight antennas (Antenna 0 to Antenna 7) can be measured.

The MX269028A-002 802.11ac (160 MHz) Measurement Software can analyze the power, modulation accuracy and spectrum characteristics at the transmitter test measurement points of the MIMO model shown below. It cannot analyze receiver test measurement point signals, meaning the mixed signals output from each antenna.



Fig. 13. MIMO Conceptual Model and Measurement Points



Fig. 14. MIMO Transmitter Test Setup

The Anritsu signal analyzer and vector signal generator can be configured as follows to test MIMO signals.

■MX269028A-002 802.11ac (160 MHz) Measurement Software

- Maximum of 8 Antennas
- Single-User MIMO (Multi-User MIMO not supported)
- Direct Mapping Method
- Same Number of Transmit Chains and Channels
- No Precoding Processing
- Measurement of Each Antenna Signal (Analysis of Multiple Antenna Mixed Signals, No Antenna ID Function)

■MX370111A-002 802.11ac (160 MHz) Option

- Maximum of 8 Antennas (Four units required when outputting from MG3710A Vector Signal Generator with two RF ports each)
- Single-User and Multi-User MIMO

■Fading IQproducer

• 4 x 4 MIMO Maximum

In this section, one MG3710A Vector Signal Generator is used to generate a 40-MHz bandwidth, direct-mapping, single-user MIMO signal for 8 transmit chains/8 channels. Then, the antenna signal output from the RF ports of SG1 is selected and measured using the MS2690A/MS2691A/MS2692A Signal Analyzer.

Generating and Outputting Signals with Vector Signal Generator

[Procedure]

- 1. Execute [Preset] \rightarrow [F3] Preset All.
- 2. Press [IQpro] to start IQproducer.
- Press the [Normal Setup] button at the top right of the screen.
 *The Multi-antenna setting cannot be made at the Easy Setup display.
- 4. Set [System] of the [Common] row displayed at the screen center to [11ac].
- 5. Set [Bandwidth] of the [Common] row displayed at the screen center to [40 MHz].
- 6. Set [User Mode] of the [Common] row displayed at the screen center to [Single User].
- 7. Set [Number of Transmit Chains] of the [Common] row displayed at the screen center to [8].
- 8. Select Common \rightarrow USER#0 \rightarrow MPDU at the left side of the screen.
- 9. Set [Number of Spatial Streams] of the [USER#0 (MPDU)] row displayed at the right side of the screen to [8].
- Set [Spatial Mapping] of the [Common] row displayed at the screen center to [Direct Mapping].
 *When [Number of Transmit Chains] and [Number of Spatial Streams] are the same value, [Spatial Mapping] can be set to [Direct Mapping].
- 11. Press [Calculation].
- 12. Set [Package] to [WLAN_11ac] and [40MHz_8Tx] and press the [OK] button.
- 13. Press [SG1].
- 14. Press the [Load] key.
- 15. Move the scroll bar to the bottom of [Packages] at the left side of the screen and select the [WLAN_11ac] package.
- 16. Select [40MHz_8Tx_0] from [Patterns in Package] at the right side of the screen.
- 17. Press [F6] Load Pattern.
- 18. Press the [Select] key.
- 19. Move the scroll bar to the bottom of [Packages] at the left side of the screen and select the [WLAN_11ac] package.
- 20. Select [40MHz_8Tx_0] from [Patterns in Package] at the right side of the screen.
- 21. Press [F6] Select.
- 22. Press [Frequency] and set the frequency to 5.21 GHz.
- 23. Press [Level] and set the level to -15 dBm.
- 24. Turn on RF Output [Mod On/Off] and [On/Off] to output the modulation signal.

The above procedure outputs the Antenna-0 signal from the 8 antenna signals. In this example, the antenna signal and waveform pattern names are as follows:

Antenna 0	40MHz_8Tx_0
Antenna 1	40MHz_8Tx_1

Antenna 7 40MHz_8Tx_7

Measuring with Signal Analyzer

The MIMO signal generated and output by the MG3710A Vector Signal Generator is measured by the MS2690A/MS2691A/MS2692A Signal Analyzer.

[Procedure]

. . .

- 1. Press [Application Switch] and select [WLAN].
- 2. Execute [Preset] \rightarrow [F1] Preset.
- 3. Press [Frequency] and set the frequency to 5.21 GHz.
- 4. Press [Amplitude] and set the level to -15 dBm.
- 5. Press [Measure] \rightarrow [F1] Modulation Analysis.
- 6. Press [F2] WLAN Standard \rightarrow [\rightarrow] (Function Menu page 2) \rightarrow [F1] IEEE802.11ac.
- 7. Press [Measure] \rightarrow [F1] Modulation Analysis \rightarrow [F1] Analysis Time \rightarrow [F5] Capture Length to set [1 ms].
- 8. Press [Measure] \rightarrow [F1] Modulation Analysis \rightarrow [F4] Channel Bandwidth to set [40 MHz].
- 9. Press [Trace] \rightarrow [F1] Trace Mode \rightarrow [F4] Summary.

The above procedure captures the following measurement results as an example.

[Stream ID] displayed in [Detect Parameter] at the right side of the screen indicates the number of the measured target antenna.

∕I MS2692A WLA	N					5/29/2013 19:59:2	9
Carrier Freq.	5 210 000 000 Hz	Input Level	-15.00 dBm			WLAN	Ō
Standard	IEEE802.11ac	ATT	4 dB			Trace Mode	
Deschwighte	40MU			Manager Mode	Continuous		
Bandwidth	401VIH2			Measurement wode	Continuous	EVM vs Subcarrie	er
Result	IVIC	easuring					
Frequency	Fror	105 31	2.1.1-				
Frequency		0.01	2 000			EVM vs Symbo	
Symbol Clor	ck Error	0.79	9 ppm				
Transmit Po	wer	-16.5	5 dBm				
						Spectral Flatnes	s
							-
Summary						Summanı	
EVM(rms)		0.39	% De	tect Parameter		Summary	
Data EV	M(rms)	0.41	%	MCS Index	8		
Pilot EV	M(rms)	0.34	%	Stream ID	8		
L-SIG EV	√M(rms)	0.44	%	Length			
VHT-SIG	S-A EVM(rms)	0.49	%	GI	Long		
VHT-SIG	S-B EVM(rms)	0.49	%				
EVM(Peak)		1.45	%				
Symbol	Number	1					
Subcarr	ier Number	-55					
Quadrature	Error	0.03	deg.				
IQ Gain Imb	alance	0.01	dB				
Center Free	quency Leakage	-41.49	dB				
Ref.Int							e

Fig. 15. Measurement Results for 8 Antenna Setup (Tx7)

Sending Specified Number of Packets with Vector Signal Generator

W-LAN IEEE802.11ac signals are bursts of data packets. When measuring the Tx characteristics of wireless transmitters, in most cases burst waveforms are sent repeatedly at a constant cycle to simplify measurement. On the other hand, receiver tests usually use the packet error rate (PER) index counted at the receiver. In this case, measurement is simpler if only a specified number of packets is input to the wireless appliance. The MG3710A Vector Signal Generator has a function for outputting a W-LAN signal with excellent accuracy as a specified number of packets.

The following procedure continues from the previously described procedure for generating and outputting signals with the MG3710A Vector Signal Generator.

[Procedure]

- 1. Press [Mode] \rightarrow [\rightarrow] (Function Menu page 2) \rightarrow [F2] Start/Frame Trigger \rightarrow [F1] Start/Frame Trigger to set [On].
- 2. Press [F2] Mode to set [Frame].
- 3. Press [F3] Source to set [Trigger Key].
- 4. Set the number of packets to send at [F7] Frame Count. In this example, set [10].
- 5. Press [F8] Trigger Key.

The MG3710A Vector Signal Generator replays the waveform pattern for the specified number of frames when the trigger is input. If the specified number of frames is replayed with only one packet per frame, the same number of packets is sent.

When sending the waveform pattern for the specified number of frames (packets), the MG3710A Vector Signal Generator displays [PLAY] to indicate that it is replaying. It displays WAIT when replay stops and while waiting for trigger input.

↑ MG3710A Vector Signal Generator		Start/Frame Trigger
SG1 AR PLAY	WIDE INTCORR Amplitude Mod RF	Start/Frame Trigger Off <u>On</u>
5.250 000 000 00 GHz	-15.00 dBm	Mode Start <u>Frame</u>
		Source Trigger Key
ARB Info	Freq Offset	Delay 0.00 2sampl
Pattern 160MHz_MCS9 -15.00dBm	снт	Edge <u>Rise</u> Fall
B Not Selected	L,	یا Event No Retrigger
		Frame Count 10 Frame
ARB On A B: Off B: Off	BER Stop 0.000E+000 0 % 0 / 0	Trigger Key
0	5/25/2013 17:04:19	

Fig. 16. Replay Display (During Packet Sending)

↑ MG3710A Vector Signal Generator				Start/Frame Trigger 🕋
^{SG2} 1,000,000 0				
SGI AR WAIL	W1	DE INTCORR		Start/Frame
Frequency		Amplitude	Mod RF	Off On
5.250 000	000 00 _{GHz}	-15.00	dBm	Mode Start <u>Frame</u>
SG1 Frame Count		10	Frame	Source
	Increment	1	Frame	Trigger Key
ARB Info	level	FreqOffset	Ð	Delay 0.00 2sampl
Package WLAN_TITEC Pattern 160MHz_MCS9	- 15.00 dBm	смт		Edge <u>Rise</u> Fall
B Not Selected			→	Event
				Frame Count
ARB On A	Power Meter A: Off B: Off	BER Stop 0.000E+000 0 0 / 0) %	Trigger Key
0		5/25/20	13 17:04:07	- t

Fig. 17. Trigger Wait Display



Fig. 18. Results when Sending Burst of 10 W-LAN Packets

Appendix

About MCS Index

The Modulation and Coding Scheme (MCS) index is a value combining the modulation method and coding rate. Note that the meanings are different from the IEEE802.11n values.

MCS Index	Modulation Method	Coding Rate
0	BPSK	1/2
1	QPSK	1/2
2	QPSK	3/4
3	16QAM	1/2
4	16QAM	3/4
5	64QAM	2/3
6	64QAM	3/4
7	64QAM	5/6
8	256QAM	3/4
9	256QAM	5/6

The MCS range is as shown below, depending on the number of channels and the channel bandwidth.

No. of Channels	20-MHz Bandwidth	40-MHz Bandwidth	80-MHz Bandwidth	160-MHz Bandwidth
1	0 to 8	0 to 9	0 to 9	0 to 9
2	0 to 8	0 to 9	0 to 9	0 to 9
3	0 to 9	0 to 9	0 to 5, and 7 to 9	0 to 8
4	0 to 8	0 to 9	0 to 9	0 to 9
5	0 to 8	0 to 9	0 to 9	0 to 9
6	0 to 9	0 to 9	0 to 8	0 to 9
7	0 to 8	0 to 9	0 to 5, and 7 to 9	0 to 9
8	0 to 8	0 to 9	0 to 8	0 to 9

/incitsu

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