Keysight Technologies
M9077A WLAN 802.11a/b/g/n/ac
X-Series Measurement Application for PXI Vector Signal Analyzers

Technical Overview

KEYSIGHT TECHNOLOGIES

- Perform WLAN spectrum and modulation measurements based on IEEE 802.11a/b/g/n/ac
- 802.11ac 20/40/80/160 MHz and 80+80 MHz
- Perform standard-based measurements with pass/fail tests
- PC-based SCPI remote interface and manual user interface
- Built-in, context-sensitive help with SCPI command reference
- Transportable license supports up to four PXI VSA channels in one mainframe

WLAN 802.11a/b/g/n/ac X-Series Measurement Application for Modular Instruments

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

The M9077A WLAN X-Series measurement application for modular instruments transforms the M9391A PXI VSA into IEEE 802.11 standards-based WLAN transmitter testers by adding fast RF conformance measurements that will help you speed up manufacturing of your WLAN transmitters. The software's capabilities are closely aligned with the IEEE standards—including a/b/g/n/ac as well as j/p/a-turbo—allowing you to stay on the leading edge of design and manufacturing challenges.

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

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

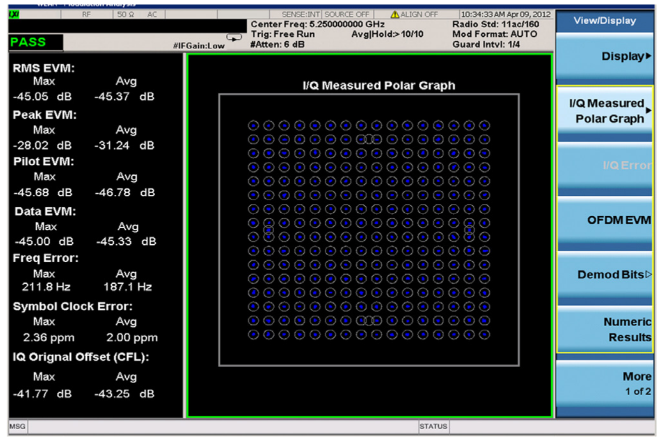

Figure 1. M9077A WLAN X-Series measurement application for modular instruments

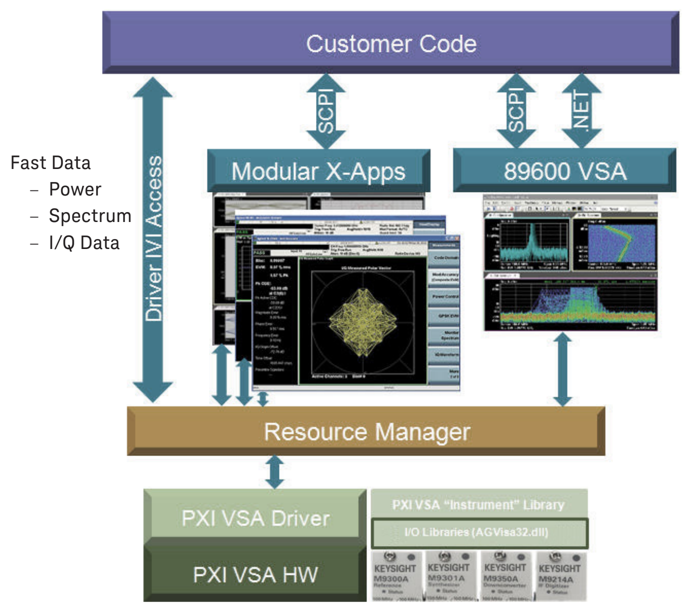

Figure 2. Resource manager included with all X-Series measurement applications for modular instruments.

WLAN Technology Overview

IEEE 802.11 standards were introduced in 1997 and are now more commonly referred to as Wi-Fi. The first published WLAN standard was 802.11-1997. The original standard received very little recognition due to its relatively low bit rate of 1 or 2 Mbps and high cost. It wasn't until the 802.11 standard was updated in 1999 with the "a" and "b" designations that the WLAN technology gained widespread acceptance.

Table 1 compares the elements of the standard at the various introduction dates.

802.11b inherited direct sequence spread spectrum (DSSS) from the original 802.11-1997 standard, along with an operating frequency of 2.4 GHz. This frequency is unregulated and therefore cheaper for manufacturers to implement. The major change in 802.11b was that the maximum data rate reached 11 Mbps, which was comparable to the traditional ethernet speeds widely available in 1999 and 2000.

802.11a was an improvement over 802.11-1997 because of its increased throughput. 802.11a could transmit data at 54 Mbps. This increase in the data transfer rate was due mostly to the use of the 5 GHz frequency band. Apart from the increase in speed, another advantage of using the 5 GHz frequency band was that not very many devices were using that frequency so there was less interference. However, since the 5 GHz frequency band uses shorter wavelengths, the technology had a shorter range and the signals could not easily pass through walls. Another major contribution of 11a was a new modulation technique called orthogonal frequency division multiplexing (OFDM), which allows higher data transmission rates in the smaller bandwidth. The 5 GHz U-NII bandwidth is not continuous—the sections are separated by 802.11a into 12 overlapping carriers spaced at 20 MHz intervals.

In 2003, IEEE ratified the 802.11g standard as Ethernet speeds increased. 802.11g operates at the 2.4 GHz frequency, like 802.11b, but it uses OFDM, as does 802.11a. As with 802.11a, OFDM allowed 802.11g to operate at 54 Mbps, a significant increase over 802.11b's 11 Mbps. Like 802.11b, 802.11g gained widespread adoption amongst consumers and businesses alike. The optional PBCC modulation type also supports data rates of 22 and 33 Mbps.

The 802.11n standard, ratified in 2009, includes multiple-input multiple-output (MIMO), 40 MHz channels in the PHY layer, and frame aggregation in the MAC layer. High-throughput (Greenfield) mode, non-HT (legacy) mode, and HT mixed mode are the three operating modes of 802.11n. 802.11n delivers higher speed, up to 600 Mbps, which is more than 10 times the throughput of 802.11a/g.

The latest WLAN technology, 802.11ac, as an extension of 802.11n, will provide a very high throughput (VHT) of 1 Gigbit/sec and only run on 5 GHz bands, as there is not enough spectrum available at 2.4 GHz for this level of performance. Like previous standards, 802.11ac builds on similar strategies of wider RF bandwidth (up to 160 MHz), higher order modulation types (up to 256 QAM), and more MIMO spatial streams (up to 8) to increase data rates over existing 802.11n products. The 11ac standard finalization is anticipated in late 2013, with final 802.11 working group approval in early 2014.

There are two other amendments to IEEE 802.11 which are not listed in Table 1—802.11j for Japan and 802.11p for vehicular applications, both use the half-clock rate as defined in the standard and are supported by M9077A with manual setup for modulation analysis..

Some new standards that are currently under development, but will not be covered in this technical overview, are 802.11ad for "very high throughput" in the 60 GHz band and 802.11af, which allows WLAN operation in the TV white space frequencies that are available with the transition from analog to digital TV. For more information on these standards, please refer to the application note, *Testing New-Generation Wireless LAN*, literature number 5990-8856EN.

Table 1. Comparison between the amendments to the IEEE 802.11 standards

	Standard name and release date				
	Sep 1999	Sep 1999	Jun 2003	Oct 2009	End-2012 Final Ratified
	802.11a	802.11b	802.11g	802.11n	802.11ac
Frequency band (GHz)	5.15 to 5.35 GHz 5.475 to 5.725 GHz 5.725 to 5.85 GHz	2.4 to 2.4835 GHz	2.4 to 2.4835 GHz	2.4 to 2.4835 GHz 5.15 to 5.850 GHz	5 GHz bands
Channel bandwidth (MHz)	20	22	20	20, 40	20, 40, 80, 160, and 80+80
FFT size	64	N/A	64	64 (20 MHz), 128 (40 MHz)	64, 128, 256, 512
Data rate per stream (Mbit/s)	6, 9, 12, 18, 24, 36, 48, 54	1, 2, 5.5, 11	Barker: 1, 2 CCK: 5.5, 11 PBCC: 5.5, 11, 22, 33 OFDM: 6, 9, 12, 18, 24, 36, 48, 54	See Table 2	
Modulation	BPSK QPSK 16QAM 64QAM	BPSK DQPSK	BPSK QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM	BPSK QPSK 16QAM 64QAM 256QAM
Transmit scheme	OFDM PBCC (option)	CCK PBCC (option)	OFDM CCK PBCC (option) Mixed CCK-OFDM (option)	OFDM MIMO	OFDM MIMO
Number of carriers per channel	48 data, 4 pilot	1 (DSSS)	48 data, 4 pilot	52 data, 4 pilot (20 MHz) 108 data, 6 pilot (40 MHz)	52 data, 4 pilot (20 MHz) 108 data, 6 pilot (40 MHz) 234 data, 8 pilot (80 MHz) 468 data, 16 pilot (160 MHz)
MIMO	1	1	1	4x4	8x8, Multi-user MIMO(MU-MIMO)

A new concept called modulation and coding scheme (MCS) has been defined for 802.11n. MCS assigns a simple integer to every permutation of modulation, coding rate, guard interval, channel width, and number of spatial streams. The 802.11ac physical layer is an extension of the 802.11n standard and maintains backward compatibility with it. Table 2 lists the PHY rates (not maximum) now supported by M9077A with single-antenna.

Table 2. Typical 1x1 (single-antenna) data rates currently supported by M9077A

MCS index	Type	Coding rate	Spatial streams	Data rate (Mbps) with 20 MHz BW		Data rate (Mbps) with 40 MHz BW		Data rate (Mbps) with 80 MHz BW		Data rate (Mbps) with 160 MHz BW	
				800 ns	400 ns (SGI)	800 ns	400 ns (SGI)	800 ns	400 ns (SGI)	800 ns	400 ns (SGI)
0	BPSK	1/2	1	6.5	7.2	13.5	15	29.3	32.5	58.5	65
1	QPSK	1/2	1	13	14.4	27	30	58.5	65	117	130
2	QPSK	3/4	1	19.5	21.7	40.5	45	87.8	97.5	175.5	195
3	16QAM	1/2	1	26	28.9	54	60	117	130	234	260
4	16QAM	3/4	1	39	43.3	81	90	175.5	195	351	390
5	64QAM	2/3	1	52	57.8	108	120	234	260	468	520
6	64QAM	3/4	1	58.5	65	121.5	135	263.3	292.5	526.5	585
7	64QAM	5/6	1	65	72.2	135	150	292.5	325	585	650
8	256QAM	3/4	1	78	86.7	162	180	351	390	702	780
9	256QAM	5/6	1	N/A	N/A	180	200	390	433.3	780	866.7

M9077A can automatically identify the MCS value, depending on the option (–2TP for 11n or –3TP for 11ac) and modular PXI VSA hardware analysis bandwidth. In the Table 2, the MCS value from 0 to 7 for data rates with 20 MHz (required) and 40 MHz (optional) are applied to 802.11n devices single stream. MCS 8 and 9 with 256QAM modulation are extended for 802.11ac, and bandwidth of 80 MHz (required), 160 MHz (optional) as well.

Choosing between X-Series Measurement Applications and 89600 VSA Software

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

www.keysight.com/find/89600B

RF Transmitter Tests

By using the modular PXI VSA with the WLAN measurement application, you can perform WLAN transmitter measurements in the time, frequency, and modulation domains. IEEE 802.11a, b, and g signals, 802.11n 20 MHz and 40 MHz signals, as well as 802.11ac 20/40/80/160 MHz and 80+80 MHz signals with all modulation formats, as shown in Tables 3-5, respectively, can be measured automatically. Manual settings for 802.11j, 802.11a-turbo mode, and 802.11p signals are also supported for modulation analysis.

Standard-based RF transmitter tests

RF transmitter test requirements for WLAN are defined in the IEEE 802.11 series standard. Table 3 shows the required transmitter tests along with the corresponding measurement applications.

Test reference numbers starting with 17 apply to 802.11a, those that start with 18 apply to 802.11b, and those starting with 19 apply to 802.11g, as well as some 802.11a and 802.11b items, due to forward compatibility requirements. Table 4 and Table 5 show the requirements for 802.11n and 802.11ac single-channel with test reference numbers that start with 20 and 22.

Table 3. Required 802.11a/b/g WLAN transmitter measurements and the corresponding measurements in the M9077A and 89600 VSA software

IEEE 802.11a	IEEE 802.11b	IEEE 802.11g	Transmitter test	M9077A Option 2FP WLAN (802.11a/b/g) measurement application	89601B Option B7R WLAN modulation analysis
17.3.9.1	18.4.7.1	19.4.7.1 18.4.7.1	Transmit power	Channel power	Can be performed using band power marker
17.3.9.2	18.4.7.3	17.3.9.2 18.4.7.3	Spectrum mask	Spectrum emission mask	Not available[1]
17.3.9.3	18.4.6.8	17.3.9.3	Transmission spurious	Spurious emission	Not available[1]
17.3.9.4	18.4.7.4	19.4.7.2	Center frequency tolerance	Frequency error[2]	Frequency error[2]
17.3.9.5	18.4.7.5	19.4.7.3	Symbol (chip) clock frequency tolerance	Symbol (chip) clock error[2]	Symbol clock error[2]
17.3.9.6.1		17.3.9.6.1	Center frequency leakage	IQ origin offset[2]	IQ offset[2]
	18.4.7.6		Power on/down ramp	Power vs time	Not available
	18.4.7.7		RF carrier suppression	Carrier suppression[2]	Not available
17.3.9.6.2		17.3.9.6.2	Spectral flatness	Spectral flatness	OFDM equalized channel frequency resp.
17.3.9.6.3		17.3.9.6.3	Constellation error (EVM rms)	RMS EVM	EVM (rms)
17.3.9.7	18.4.7.8	17.3.9.7	Modulation accuracy test[3]	Modulation analysis	Modulation analysis

1. If 89601B with Option B7R is used with a Keysight spectrum or signal analyzer, these measurements are available as part of the spectrum analyzer mode under the power suite measurements.
2. For the M9077A application, these values are found in the "numeric results" trace under the modulation analysis view. For 89601B with Option B7R, these values are found under the "Syms/Errs" trace.
3. The standard describes the procedure for making this measurement, but doesn't specify test limits.

Table 4. Required 802.11n WLAN transmitter measurements and the corresponding measurements in M9077A and 89600 VSA software

IEEE 802.11n	Transmitter test	M9077A Option 3FP WLAN (802.11n) measurement application	89601B Option B7Z 802.11n MIMO modulation analysis
20.3.21.1	Transmit spectrum mask	Spectrum emission mask	Not available
20.3.21.2	Spectral flatness	Spectral flatness	OFDM equalized channel frequency resp.
20.3.21.3	Transmit power	Channel power	Can be performed using band power marker
20.3.21.4	Transmit center frequency tolerance	Frequency error[1]	Frequency error[1]
20.3.21.6	Symbol clock frequency tolerance	Symbol (chip) clock error[1]	Symbol clock error[1]
20.3.21.7.2	Center frequency leakage	IQ origin offset[1]	IQ offset[1]
20.3.21.7.3	Constellation error (EVM rms)	RMS EVM	EVM (rms)
20.3.21.7.4	Modulation accuracy test[2]	Modulation analysis	Modulation analysis

Table 5. Required 802.11ac WLAN transmitter measurements and the corresponding measurements in M9077A and 89600 VSA software

IEEE 802.11ac (D0.2)	Transmitter test	M9077A Option 4FP WLAN (802.11ac) measurement application	89601B Option BHJ 802.11ac and MIMO modulation analysis
22.3.18.1	Transmit spectrum mask	Spectrum emission mask	Not available
22.3.18.2	Spectral flatness	Spectral flatness	Channel freq resp.
22.3.18.3	Transmit center frequency tolerance	Frequency error[1]	Frequency error[1]
22.3.18.4	Symbol clock frequency tolerance	Symbol (chip) clock error[1]	Symbol clock error[1]
22.3.18.5.2	Transmit center frequency leakage	IQ origin offset[1]	IQ offset[1]
22.3.18.5.3	Transmit constellation error (EVM rms)	RMS EVM	EVM (rms)
22.3.18.5.4	Modulation accuracy test[2]	Modulation analysis	Modulation analysis

1. For the M9077A application, these values are found in the "numeric results" trace under the modulation analysis view. For 89601B with Option B7R and Option BHJ, these values are found under the "Syms/Errs" trace.
2. The standard describes the procedure for making this measurement, but doesn't specify test limits.

Measurement Consistency You can Trust

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

www.keysight.com/find/measurementconsistency

Measurement details

All of the RF transmitter measurements as defined in the IEEE standard, as well as a wide range of additional measurements and analysis tools, are available with the press of a button. These measurements are fully remote controllable via the IEC/IEEE bus or LAN, using SCPI commands. A detailed list of supported measurements is shown in Table 6.

Table 6. List of one-button measurements provided by the M9077A measurement application

Technology	IEEE 802.11b/g (DSSS/CCK/PBCC)	IEEE 802.11a/g (ERP-OFDM, DSSS-OFDM), 11p, 11j	IEEE 802.11n (20 MHz and 40 MHz)	IEEE 802.11ac (20/40/80/160, 80+80 MHz)
Modulation analysis				
RMS EVM	●	●	●	●
Peak EVM	●	●	●	●
Pilot EVM		●	●	●
Data EVM		●	●	●
1K chips EVM	●			
RMS magnitude error	●			
Peak magnitude error	●			
RMS phase error	●			
Peak phase error	●			
Frequency error	●	●	●	●
Chip clock error	●			
Symbol clock error		●	●	●
I/Q origin offset (CFL)	●	●	●	●
Quadrature skew	●	●	●	●
I/Q gain imbalance	●	●	●	●
Carrier suppression	●			
Average burst power	●	●	●	●
Peak burst power	●	●	●	●
Pk-to-avg power ratio	●	●	●	●
Modulation format	●	●	●	●
Bit rate	●	●	●	●
Preamble frequency error			●	●
OFDM data burst info			●	●
OFDM HT-sig info			●	●
Channel power	●	●	●	●
Occupied bandwidth	●	●	●	●
CCDF	●	●	●	●
Spectrum emission mask (SEM)	●	●	●	●
Spurious emissions	●	●	●	●
Power vs. time	●	●	●	●
Spectral flatness	●	●	●	●
Monitor spectrum	●	●	●	●
I/Q waveform	●	●	●	●

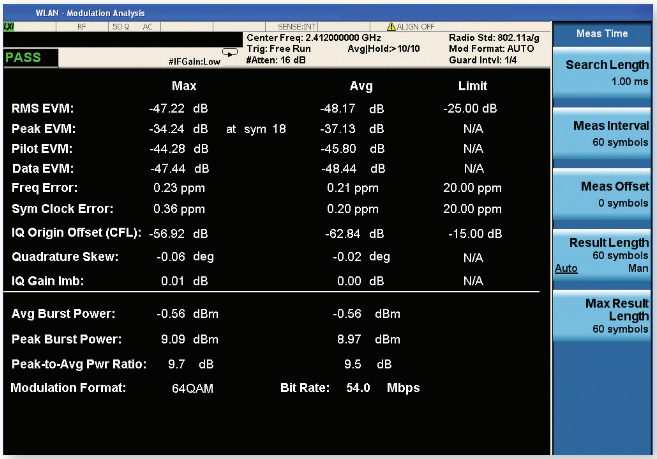

Figure 3. Numerical results summarize modulation accuracy parameters for WLAN signals.

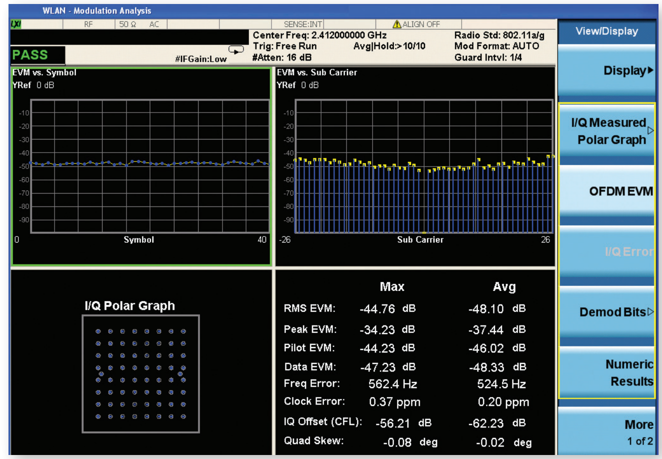

Figure 4. “OFDM EVM” displays four traces with EVM vs. symbol, EVM vs. subcarrier, constellation, and measurement results.

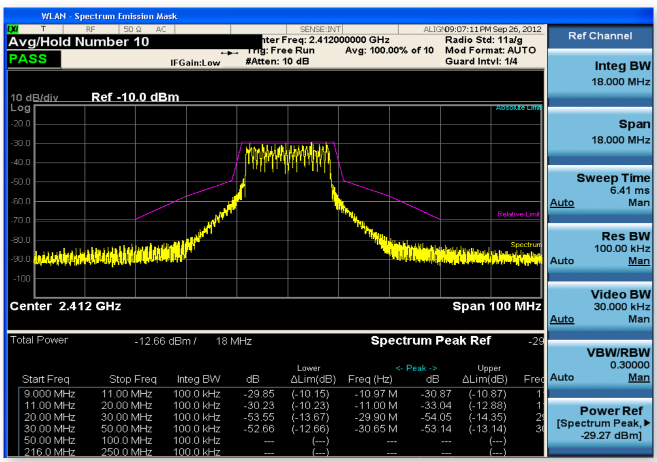

Figure 5. Transmit spectrum mask measurement showing IEEE defined limits.

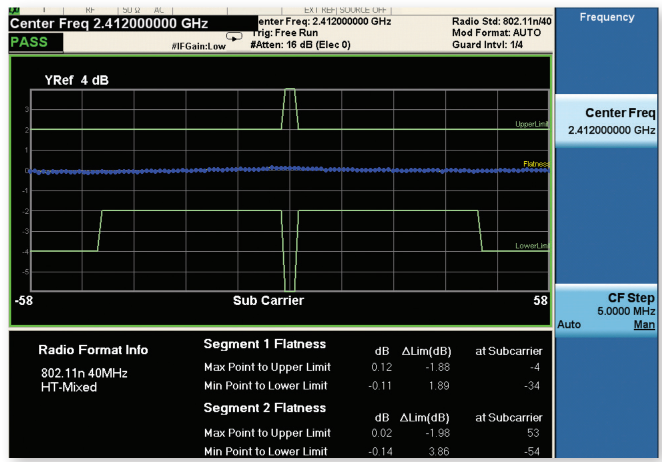

Figure 6. Spectrum flatness of a 40 MHz IEEE 802.11n signal (Greenfield mode).

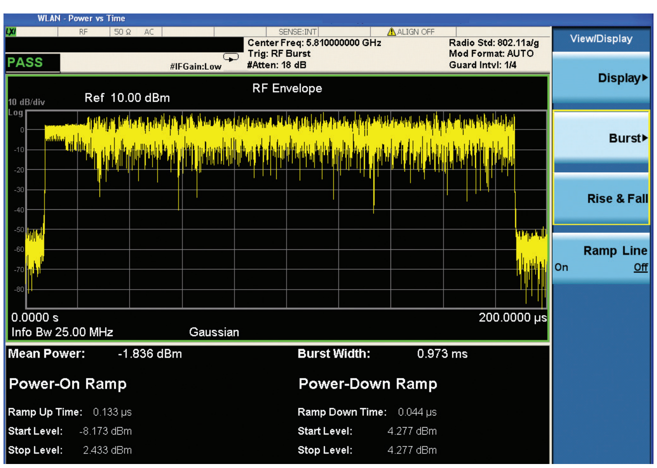

Figure 7. Time-domain view of an 802.11a burst.

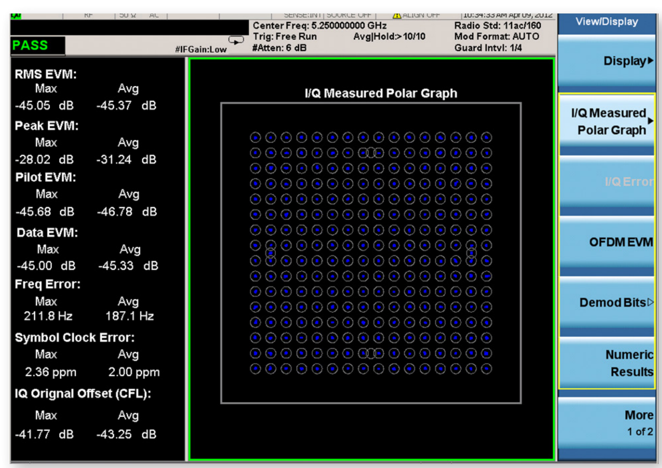

Figure 8. Modulation analysis of a 160 MHz 802.11ac signal with MCS 9 256QAM signal.

Key Specifications

This section contains specifications for the M9077A WLAN 802.11 measurement applications. The specifications below are limited to modulation accuracy, channel power, power versus time, and spectrum emission mask measurements.

Definitions

– Specifications describe the performance of parameters covered by the product warranty.

– 95th percentile values indicate the breadth of the population (≈2σ) of performance tolerances expected to be met in 95% of cases with a 95% confidence. These values are not covered by the product warranty.

– Typical values are designated with the abbreviation "typ." These are performance beyond specification that 80% of the units exhibit with a 95% confidence. These values are not covered by the product warranty.

– Nominal values are designated with the abbreviation "nom." These values indicate expected performance, or describe product performance that is useful in the application of the product, but is not covered by the product warranty.

Data subject to change.

Supported devices and standards

Device type	
Standard version	802.11a, 802.11g ERP-OFDM, 802.11g DSSS-OFDM, 802.11b/g DSSS/CCK/PBCC, 802.11j, 802.11p, 802.11-a turbo mode
	802.11n (20 MHz, 40 MHz) HT Mixed, HT Greenfield, Non-HT, MCS = 0-7
	802.11ac 20/40/80/160 MHz, 80+80 MHz, MCS=0-9
Modulation formats	BPSK, QPSK, 16QAM, 64QAM, 256QAM

Performance specifications

Description	PXI VSA (M9391A)
Modulation accuracy (nominal) (modulation type 64QAM Phase Noise Optimization set to "Wide Offset")	
802.11a/g/j/p (OFDM), Code rate: 3/ 4; Equalizer training = channel est seq only, Track phase: On; RF input level = 0 dBm, Range = 0 dBm	
Center frequency in 2.4 GHz band[1] EVM floor (802.11g)	–52 dB
Center frequency in 5.0 GHz band[2] EVM floor (802.11a)	–48 dB
802.11n (40 MHz), Code rate: 3/4; Equalizer training = channel est seq only, Track phase: On; RF input level = 0 dBm, Range = 0 dBm	
Center frequency in 2.4 GHz band EVM floor	–50 dB
Center frequency in 5.0 GHz band EVM floor	–48 dB
802.11ac (80 MHz); Code rate: 3/4; Track phase: On; RF input level = 0 dBm, Range = 0 dBm	
Center frequency in 5.0 GHz band EVM floor (Equalizer training = channel est seq only)	–46 dB
EVM floor (Equalizer training = channel est seq & data)	–49 dB
802.11ac (160 MHz); Code rate: 3/4; Track phase: On; RF input level = 0 dBm, Range = 0 dBm	
Center frequency in 5.0 GHz band EVM floor (Equalizer training = channel est seq only)	–45 dB
EVM floor (Equalizer training = channel est seq & data)	–48 dB

1. 2.4 GHz band for radio standards 802.11a/g(OFDM), 802.11(DSSS-OFDM), and 802.11n (20 MHz or 40 MHz) is applied at channel center frequency = 2407 MHz + 5xk MHz (k = 1,...,13).
2. 5.0 GHz band for radio standards 802.11a/g(OFDM), 802.11g(DSSS-OFDM), and 802.11n(20 MHz or 40 MHz) is applied at channel center frequency = 5000 MHz + 5xk MHz (k = 0,1,2,...200).

Ordering Information

Software licensing and configuration

Transportable, perpetual license allows you to run the application using an embedded PXI controller or external PC, plus it may be transferred from one controller or PC to another. One software license supports up to four M9391A PXI VSA channels in one PXI mainframe.

Model-Option	Description	Notes
M9077A-2TP	WLAN 802.11a/b/g measurement application, transportable perpetual license	
M9077A-3TP	Add 802.11n measurement application, transportable perpetual license	2TP is required
M9077A-4TP	Add 802.11ac measurement application, transportable perpetual license	2TP and 3TP are required

Hardware configuration

M9391A PXI VSA

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

M9393A PXI performance VSA

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

Related Literature

RF Testing of Wireless Products, Application Note 1380-1, literature number 5988-5411EN

IEEE 802.11 Wireless LAN PHY Layer (RF) Operation and Measurement, Application Note 1380-2, literature number 5988-3762EN

Testing New-generation Wireless LAN, Application Note, literature number 5990-8856EN

Keysight MIMO Wireless LAN PHY Layer [RF] Operation & Measurement, Application Note 1509, literature number 5989-3443EN

M9391A PXIe Vector Signal Analyzer Datasheet, literature number 5991-2603EN

M9391A & M9381A PXIe Vector Signal Analyzer & Generator Configuration Guide, literature number 5991-0897EN

X-Series Measurement Applications for Modular Instruments Brochure, literature number 5991-2604EN

Web

M9391A PXIe Vector Signal Analyzer: www.keysight.com/find/m9391a

M9393A PXIe Performance Vector Signal Analyzer: www.keysight.com/find/m9393a

X-Series measurement applications for modular instruments: www.keysight.com/find/M90XA

X-Series signal analyzers: www.keysight.com/find/X-series

Application pages: www.keysight.com/find/wlan

Try before you buy!

Free 30-day trials of X-Series measurement applications provide unrestricted use of each application's features and functionality on your modular PXI VSA.

See www.keysight.com/find/M90XA for more information.

You can upgrade!

Options can be added after your initial purchase.

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

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